To face the title.

J. Devoto Inv. G. Vandergucht Sc.

Terraï Corpus, & Humor
Aurarumq; leves animæ calidiq; Vapores
Equibus hæc rerum consistere Sūma videtur
Omnia nativo ac mortali Corpore constant:

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A COMPLEAT

SYSTEM

OF

General Geography:

EXPLAINING

The Nature and Properties of the EARTH;

VIZ.

It's Figure, Magnitude, Motions, Situation, Contents, and Division into Land and Water, Mountains, Woods, Desarts, Lakes, Rivers, *&c.*

With particular Accounts of the different Appearances of the Heavens in different Countries; the Seasons of the Year over all the Globe; the Tides of the Sea; Bays, Capes, Islands, Rocks, Sand-Banks, and Shelves.

The State of the Atmosphere; the Nature of Exhalations; Winds, Storms, Tornados, *&c.*

The Origin of Springs, Mineral-Waters, Burning Mountains, Mines, *&c.*

The Uses and Making of Maps, Globes, and Sea-Charts.

The Foundations of *Dialling*; the Art of *Measuring Heights and Distances*; the Art of Ship-Building, *Navigation*, and the Ways of *Finding the* LONGITUDE AT SEA.

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By *BERNHARD VARENIUS*, M.D.

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I HAVE perused this SYSTEM of GENERAL GEOGRAPHY; and I do recommend it as the most Useful Book upon this Subject.

JAMES HODGSON,

Master of the Royal Mathematical School; *And* Fellow of the Royal Society.

Christ-Hospital,
Dec. 14. 1732.

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THE

TRANSLATOR's

PREFACE.

THE Original of this Work was Re-printed at *Cambridge* in the Year 1672, for the Use of the Students in *that University*; and an Advertisement was given of it, the Beginning of the Year following, in the *Philosophical Transactions* (*a*).

THE *Dutch* Edition being then out of Print, was carefully corrected, in many

(*a*) Phil. Transact. No. 91. Pag. 5172. BERNHARDI VARENII, *M. D.* Geographia Generalis; *in qua Affectiones generales Telluris explicantur, summa cura quam plurimis in Locis emendata, & 33 Schematibus novis, ære incisis, una cum Tabulis aliquot, quæ desiderabantur, aucta & illustrata: ab* ISAACO NEWTON *Mathes. Professore* Lucasiano *apud* Cantabrigienses. *e Societate Regia.* Cantab. 1672. in 8vo.

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Places enlarged and improved, and the necessary *Tables and Schemes* supplied by the Illustrious Sir ISAAC NEWTON, at that Time *Lucasian Professor of Mathematics* in that University.

THE Reason why this great Man took so much Care in Correcting and Publishing our Author, was, because he thought him necessary to be read by his Audience, *the Young Gentlemen of Cambridge*, while he was delivering Lectures upon the *same Subject* from the *Lucasian Chair*. And tho' many Hundreds were then printed at *Cambridge*, and from that Edition often reprinted abroad; yet by being frequently read in *both Universities*, all the Impressions were in Time sold off; so that their *Scarcity* among the Booksellers was observed by the Reverend Dr BENTLEY to be a great Detriment to the *Young Gentlemen of Cambridge* in perfecting their Studies *(b)*.

WHERE-

(b) Appendix Jurin. Pag. 1. *Cum frustra jam ubique fere quærerentur, apud Bibliopolas* Varenii *exemplaria, idque judicaret magno cum Juventutis Academicæ detrimento fieri Vir Reverendus, nec mihi nisi summo cum Honore nominandus,* RICHARDUS BENTLEIUS - - - - *is me de quo majorem æquo pro bonitate sua & Humanitate opinionem conceperat, hortatus est ut novæ hujusce Editiones adornande curam susciperem. Simul monuit utile futurum ut quæ inventa, dimidii amplius seculi post* Varenium *spatio, satis multa fuerant, ea, in Tyronum Gratiam, in Appendicem conferrem, breviturque explicarem. Ejus*

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WHEREUPON this worthy Encourager and Advancer of all Sorts of Literature, *importuned* the Learned Dr JURIN (as being the fittest Person) to take *particular* Care of a new Impression; and, for the Benefit of the younger Students, to supply the Defects of *Varenius* with an *Appendix*, containing the later Discoveries and Improvements.

TO Him therefore is owing that *correct Edition* of *Varenius*, with an excellent *Appendix*, printed in the Year 1712. and *Dedicated* to Dr BENTLEY: which is the Edition from whence the *following Translation* was made (*c*).

I beg leave to insist the more upon this because the Authority of our Author, back'd with three such Great and Learned Men, as Sir ISAAC NEWTON, Dr BENTLEY, and Dr JURIN, will doubtless make an *English* Edition of this Work more acceptable to an *English* Reader.

jus ego auctoritati, tanti Viri, & cujus eram beneficiis ornatus maximis, non obtemperare omnino non potui, &c.

(*c*) Bernhardi Varenii Geographia Generalis, *&c.* adjecta est Appendix præcipua Recentiorum inventa, ad Geographiam spectantia, continens, a JACOBO JURIN, A. M. *Collegii S. Trinitatis Socio, & Scholæ publicæ Novocastrensis Archididascalo. Cantabrigiæ* 1712. in 8vo.

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IT is therefore unneceſſary to add any thing farther in Recommendation of the Author; or enter into an Encomium of the Work, ſince they have both of them ſo well recommeded themſelves to the Public already. All that remains is only to indicate what has been farther done in our preſent *Engliſh* Edition.

AND firſt, in the Geometrical Part, we have given Demonſtrations to ſeveral Propoſitions, where they were wanting, and in a conciſe Manner explained ſeveral *tedious Demonſtrations*; or at leaſt have directed the Reader where he may find them ready demonſtrated: ſo that we hope by this Means to incite the Studious to purſue the *Mathematical Studies*, by giving them certain *Specimens* of their Excellency.

2. IN the *Aſtronomical Part*, we have ſtrengthened our Author's Arguments in Favour of the *Copernican* Hypotheſis; and corrected or illuſtrated his Aſſertions and Propoſitions, by others taken from later Authors, or built upon more accurate Obſervations made ſince his Time.

3. IN the *Philoſophical and Phyſical Part*, we have rejected the improbable Conjectures of the Antients, and the unwarrantable Suppoſitions of *Des Cartes*, which our Author ſeems to be fond of: Inſtead

Instead whereof, we have (with the learned Dr JURIN) introduced the *Newtonian Philosophy* to solve the *Phænomena*, as being much more eligible than the *Cartesian*, for the *Agreeable* and *Geometrical* Manner of it's Conclusions. Wherefore we have frequently made use of this *New Philosophy*, in the Way of *Annotations* upon our Author, where he has used that of *Des Cartes*.

4. IN the *Geographical and Hydrographical Part*, there is often not the least *Consonance* or *Similitude* between the *Latin* and *modern English Names* of several *Countries*, *Islands*, *Seas*, *Streights*, &c. And very often their Names are changed by *later Discoverers*, and their *Figures* and *Situations* better discovered since our Author's Time. Wherefore, in such Cases, we have taken the Liberty to *alter their Names*, *Situations*, *and Descriptions*, in order to make them conformable to our latest and best *English* Maps; *deviating* as little as possible from our Author's Sense; and making use of the *same Words* as 'tis likely he would have done, had he writ at the *same Time*, and in the *same Language*. We have done this to avoid, in some Measure, *Marginal Notes*, which must necessarily have been inserted to have explained *a strict Translation*; but would have been neither entertaining nor instru-

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ctive to an *English* Reader. These Alterations are included in *Brackets*, and for the most part distinguished by a different Character.

5. WE have translated Dr JURIN's *Appendix*, and added it to the several Passages of our Author, whereto each Part of it properly belongs.

6. WE have, as much as possible, endeavoured after our Author's *singular Plainness of Expression*, and perhaps in this may be thought to have imitated him to a Fault; but considering that we were not speaking to the Learned; but to those less skilled in Language; we thought it necessary to *endeavour* to make the Author *understood*, even by Persons of ordinary Capacities, rather than to render him *abstruse* and *unintelligible* by being too concise and curious in Words and Phrases.

TO conclude, we have endeavoured to give the *English* Reader an useful Edition of the Work, rather than one that was Elegant and Polite. And to this Purpose, we have added, what was never added before, an *Alphabetical Index* to the whole.

THE

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THE

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THE

ABSOLUTE PART

OF

Universal Geography.

SECT. I.

PRELIMINARIES.

CHAP. I.

Of the DEFINITION, DIVISION, METHOD, *&c.* *of* GEOGRAPHY.

IT hath been an antient Custom for those that fully treat of any Art, or Science, to premise somewhat of it's *Origin*, *Nature*, *Constitution*, &c. And this Procedure is not improper, provided it be clear of all sophistical Equivocation; because from such Preliminaries the Reader may conceive an Idea of the Work, or at least the Substance thereof, and so proceed more advisedly therein. We shall therefore here offer a few Particulars as to the Nature, Use, and Design of *Geography*.

The Definition of Geography.

GEOGRAPHY is that part of *mix'd Mathematics*, which explains the State of the Earth, and of it's Parts, depending on Quantity, *viz.* it's Figure, Place, Magnitude, and Motion, with the Celeſtial Appearances, *&c.*

BY ſome it is taken in too limited a Senſe, for a bare Deſcription of the ſeveral Countries; and by others too extenſively, who along with ſuch a Deſcription would have their Political Conſtitution. But the Authors who proceed thus are excuſable, becauſe they do it only to excite and delight the Reader, who might otherwiſe be the leſs attentive to a bare Enumeration and Deſcription of the Countries, without ſome Knowledge of the Manners, and Cuſtoms of the Inhabitants.

The Diviſion of Geography.

WE divide *Geography* into *General* and *Special*, or *Univerſal* and *Particular*. *Golnitzius* ſays, *Geography* is to be explained externally and internally; but theſe Terms are improper, and ill choſen, *Univerſal* and *Particular* being much more pertinent. We call that *Univerſal Geography* which conſiders the whole Earth in general, and explains it's Properties without regard to particular Countries: But *Special* or *Particular Geography* deſcribes the Conſtitution and Situation of each ſingle Country by itſelf; which is twofold, *viz. Chorographical*, which deſcribes Countries of a conſiderable Extent; or *Topographical*, which gives a View of ſome place or ſmall Tract of the Earth.

IN this Book, we ſhall exhibit *Univerſal Geography*, which may be divided into three Parts, *Abſolute*, *Relative*, and *Comparative*. In the *Abſolute*

Part

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Part we shall handle what respects the Body of the Earth itself, it's Parts and peculiar Properties; as it's Figure, Magnitude, and Motion; it's Lands, Seas, and Rivers, *&c.* In the *Relative Part* we shall account for the Appearances and Accidents that happen to it from Celestial Causes: and, lastly, the *Comparative Part* shall contain an Explication of those Properties, which arise from comparing different Parts of the Earth together (*a*).

The Subject of Geography.

THE Object, or Subject, of *Geography* is the *Earth*; especially it's Superficies and exterior Parts.

The Properties of Geography.

THE Things which seem to be most worthy of Observation in every Country are of three kinds, *viz.* *Celestial*, *Terrestrial*, and *Human.* The *Celestial Properties* are such as affect us by reason of the apparent Motion of the Sun, and Stars. These are eight in Number: 1. *The Elevation of the Pole, or the Distance of a Place from the Equator.* 2. *The Obliquity of the Diurnal Motion of the Stars above the Horizon of that Place.* 3. *The Time of the longest and shortest*

(*a*) The Honour of reducing *Geography* to Art and System was reserved to *Ptolemy*; who by adding Mathematical Advantages to the Historical Method, in which it had been treated of before, has described the World in a much more Intelligible Manner: he has delineated it under more certain Rules, and by fixing the Bounds of Places, from Longitude and Latitude, hath both discovered others Mistakes, and hath left us a Method of discovering his own.

There is one thing yet very lame in our *Geography*, the fixing the true Longitude of Places; and tho' several new Ways have been lately tried, to redress this Inconvenience, both from exact Pendulums, and from Observations upon the Immersions and Emersions of *Jupiter's Satellites*, yet they have not altogether proved effectual.

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Day. 4. *The Climate and Zone.* 5. *Heat, Cold, and the Seasons of the Year; with Rain, Snow, Wind, and other Meteors:* and tho' these may seem Terrestrial Properties, yet because they chiefly depend upon the Motion of the Sun, and the four Seasons of the Year, we have reckoned them among the Celestial Matters. 6. *The Rising, Appearance, and Continuance, of the Stars above the Horizon.* 7. *The Stars that pass thro' the Zenith of a Place.* 8. *The Celerity of the Motion with which, according to the* Copernican *Hypothesis, every Place constantly revolves.* And according to Astrologers a *ninth* Property may be added; for they assign some Country or other to every one of the twelve Signs of the Zodiac, and the Planets which are Lords of these Signs; but such imaginary Qualities seem superstitious and vain to me; nor do I perceive any reasonable Foundation for them (*a*). Thus far the *Celestial Properties.*

WE call those *Terrestrial Properties* that are observed in the Face of every Country; which are ten in Number. 1. *The Limits and Bounds of each Country.* 2. *It's Figure.* 3. *It's Magnitude.* 4. *It's Mountains.* 5. *It's Waters,* viz. *Springs, Rivers, and Bays.* 6. *It's Woods and Desarts.* 7. *The Fruitfulness and Barrenness of the Country, with it's various kinds of Fruits.* 8. *The Minerals and Fossils.* 9. *The living Creatures there.* 10. *The Longitude of the Place:* which might be comprehended under the first of these Properties.

(*a*) Tho' this Art be of great Antiquity, it is rejected and exploded by most knowing People of this Age; and only Impostors, or some weak Pretenders to Learning, now practise it, in these Parts of the World. It is however, even to this Day, venerated in most *Eastern Countries*, especially among the *Indians*; where nothing is done of any Consequence, before the Astrologer determines a fortunate Hour to undertake it. *See Rohault's Physics Part* 2. *Chap.* 27.

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THE third kind of Observations, to be made in every Country, we call *Human*, because they chiefly respect the Inhabitants of the Place; and these are also ten in Number. 1. *Their Stature, Shape, Colour, and the length of their Lives; their Origin, Meat, and Drink.* 2. *Their Arts, and the Profits which arise from them; with the Merchandise and Wares they barter with one another.* 3. *Their Virtues and Vices, Learning, Capacities, and Schools.* 4. *Their Ceremonies at Births, Marriages, and Funerals.* 5. *The Language which the Inhabitants use.* 6. *Their Political Government.* 7. *Their Religion and Church Government.* 8. *Their Cities and famous Places.* 9. *Their remarkable Histories.* 10. *Their famous Men, Artificers, and the Inventions of the Natives.*

THESE are the three kinds of Occurrences to be explained in *Special Geography*; and tho' the last Sort seem not so properly to belong to this Science, yet we are obliged to admit them for Custom sake, and the Information of the Reader.

IN *Universal Geography* (which is the Subject of this Book) the absolute Division of the Earth, and the Constitution of it's Parts, will first be examined; then the Celestial Phænomena, in general, that are to be applied to their respective Countries, in *Special Geography*; and lastly there will follow in the *Comparative Part* such Considerations as occur from comparing the Phænomena of one Place with another.

The Principles of Geography.

THE Principles from which Arguments are drawn for proving Propositions in Geography are of three sorts. 1. Geometrical, Arithmetical, and Trigonometrical Propositions. 2. Astronomical Precepts and Theorems (tho' it may seem strange

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we ſhould have Recourſe to the Celeſtial Bodies, which are diſtant from us ſo many Millions of Miles, for Underſtanding the Nature of the Earth we inhabit). 3. Experience; becauſe the greateſt Part of Geography, and chiefly the *Special*, is founded only upon the Experience and Obſervations of thoſe who have deſcribed the ſeveral Countries.

The Order of Geography.

THE Order we have thought moſt convenient to follow in General *Geography*, is already mentioned in the Diviſion and Explication of it's Properties; yet there remains a Doubt as to the Order to be obſerved in explaining theſe Properties: *viz.* whether we ſhould apply them to their relative Countries in which they are found, or refer the Countries themſelves to the Properties accounted for, in general. *Ariſtotle*, in his firſt Book of Animals, moves the ſame Doubt; and argues at large, whether the Properties ſhould be adjuſted to the general Account of Animals, or the Animals ranked under the Account of their Properties. The like Difficulty occurs in other Parts of Philoſophy. However we ſhall here firſt explain ſome general Properties; and after apply them to their reſpective Countries.

The Proof of Geography.

IN proving Geographical Propoſitions we are to obſerve; that ſeveral Properties, and chiefly the Celeſtial, are confirmed by proper Demonſtrations: But in *Special Geography* (excepting the Celeſtials) almoſt every Thing is explained without Demonſtration; being either grounded on Experience and Obſervation, or on the Teſtimony of

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our Senses: nor can they be proved by any other Means. For Science is taken either for that Knowledge which is founded on Things highly probable; or for a certain Knowledge of Things which is gained by the force of Argument, or the Testimony of Sense; or for that Knowledge which arises from Demonstration in a strict Sense, such as is found in Geometry, Arithmetic, and other Mathematical Sciences; excepting Chronology and Geography; to both which the Name of Science, taken in the second Sense, doth most properly belong.

THERE are also several Propositions proved, or rather exposed to view, by the artificial Terrestrial Globe, or by Geographical Maps; most of which might be confirmed by a strict Demonstration; tho' omitted on Account of the Incapacity of some Readers. Other Propositions cannot be so well proved, yet are received as apparent Truths. Thus tho' we suppose all Places on the Globe, and in Maps, to be laid down in the same Order as they really are on Earth; nevertheless in these Matters we rather follow the Descriptions that are given by Geographical Authors. Globes and Maps, indeed, made from such Observations, serve well enough for Illustration, and the more easy Comprehension of the Thing.

The Origin of Geography.

THE *Origin of Geography* is not of late Date, nor was it brought into the World as it were at one Birth; neither was it invented by one Man: but it's Foundations were laid many Ages ago. It is true, indeed, the old *Geographers* were employed only in describing particular Countries, either in whole, or in part. The *Romans*, when they had overcome and subdued any Province, used to ex-

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pose the *Chorography* thereof to the Spectators in their Triumphs, delineated upon a Table, and flourished round with Pictures. There were also at *Rome*, in the *Portico* of *Lucullus*, several *Geographical* Tables exposed to public View. The Senate of *Rome*, about one hundred Years before the Birth of Christ, sent Geographers and Surveyors into the several parts of the Earth, that they might measure the whole; tho' they scarce visited a twentieth Part of it. *Neco*, also, King of *Egypt*, many Ages before Christ, commanded that the Extremities of *Africa* should be diligently searched into; which was performed by the *Phœnicians* in the space of three Years. *Darius* commanded that the Mouths of the River *Indus*, and the whole *Æthiopic* Sea, to the eastward, should be diligently examined into. *Alexander* the Great, as *Pliny* tells us, in his *Asiatic* Expedition, carried along with him two *Geographers*, *Diogenes* and *Beto*, to measure and delineate to him his Journies; from whose Journals and Observations the *Geographers* of succeeding Ages borrowed many Things. And tho' the Study of all other Arts was almost abolished by the Wars, *Geography* and *Fortification* were improved thereby.

NEVERTHELESS the *Geography* of the Antients was very imperfect, and commonly full of false Relations; because they knew little or nothing of those Places of the Earth which are of most Consequence to be known; or at least they had no certain Experience about them. For, 1. all *America* was entirely unknown to them. 2. So were the remotest Northern Countries. 3. The *South Continent* and the Country of *Magellan*. 4. They knew not that the World could be sailed round, or that the Earth was surrounded by the Ocean, in an uninterrupted Continuity: Some indeed of the Antients I confess were of this Opinion, but I deny they had any Certainty of it. 5. They knew not that

that the *Torrid Zone* was inhabited, by an almost infinite number of People. 6. They were ignorant of the true Measure of the Earth, tho' they writ a great deal on that Subject. 7. They did not think that *Africa* could be failed round, (*b*) because the South Parts thereof were unknown to them. 8. Both the *Greeks* and *Romans* wanted true Descriptions of the Countries remote from them, and have left us a great many forged and fabulous Stories, concerning the People that live in the Borders of *Asia*, and those that inhabit the Northern Parts of the Earth (*c*). 9. They were ignorant of the general Motion of the Sea, and the Difference of Currents in particular Places. 10. The *Grecians*, even *Aristotle* himself, did not know the Reason of the Ebbing and Flowing of the Sea. 11. Few of them understood the Variation of the Winds; and the

(*b*) It is likely the antient *Egyptians* had some Knowledge of the extream Parts of *Africa*, as appears from what *Herodotus* relates, *viz.* "That *Neco*, King "of *Egypt*, (2200 Years ago) "having furnished certain *Phœnicians* with Ships; these setting Sail for the *Red-Sea*, and "coasting along *Africa*, doubled the *Cape of Good Hope*; "and after two Years spent "in the Voyage entered the "Streights of *Gibraltar*, in "the third. *Herod. Lib.* 4.

(*c*) *C. Plinii Nat. Hist. Lib.* 5. *Cap.* 8. *Blemmyis traduntur capita abesse, ore & oculis pectori affixis.* The *Blemmyi* are said to be without Heads, having their Mouths and Eyes fixed in their Breasts. *Ibid. Lib.* 7. *Cap.* 2. *Arimaspi uno oculo in fronte media insignes: quibus assidue bellum esse circa metalla cum Gryphis. Et alibi, cauda villosa homines nasci pernicitatis eximiæ.* The *Arimaspi* are famous for having only one Eye fixed in the middle of their Foreheads, between whom and the *Gryffons* there is a continual War carried on about their Metals. In another Place there are a sort of grinning Apish People, born with long hairy Tails, and very swift of Foot. From which Romantic Stories of *Pliny*, Sir *J. Mandeville* took his lying Reports, of his meeting (in his Travels,) with these very People, and also some, in the *Torrid Zone*, that to guard themselves against the Scorching Heat of the Sun, had one of their Feet so large, that by lying on their backs, and holding it up against the Sun, would screen them against it's immoderate Heat; with other the like whimsical Relations.

Periodical,

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Periodical, or *Trade-Winds*, were never dreamt of by them. 12. The noble Property of the Load-Stone, which shews the North and South, was unknown to them; tho' they knew it's Virtue of attracting Iron. And *Anaximander*, who lived about 400 Years before Christ, was the first that attempted to give the *Dimensions of the Earth* (*a*).

The Excellency of Geography.

THERE are three Things that recommend the Study of *Geography*. 1. It's Dignity; and in that it greatly adorns Man, the Inhabitant of the Earth endowed with Reason above all other Animals, to understand the Nature of Countries, and the Constitution of the Earth. 2. It is as well a pleasant, as an innocent Recreation. 3. There is an absolute necessity for the Knowledge of it; because neither *Divines*, *Physicians*, *Lawyers*, *Historians*, nor other *Men* of *Letters*, can well proceed in their Studies without interruption, unless they have some Knowledge of *Geography*; as it hath been observed by others, and illustrated by several Examples.

HERE follow two Tables, whereof the first may serve for the Contents of this *Book*; which contains

(*a*) The Moderns have detected many Errors of the Antients, and very much improved *Geography*, by opening a Passage to a New World, and by discovering that those Parts of the Old which were thought uninhabitable, to be inhabited; the *Torrid Zone* is known to be temperate, and, by refreshing Showers and constant Breezes, and cold Nights; and the Globe itself has been compassed by several, both *English* and *Foreign* Sailors. But there yet remains much of the Globe undiscovered. There is a vast Southern Continent, as yet scarce lookt into. The northern parts of *America*, are yet undiscovered: *Africa*, tho' it hath been compassed round and round from the Mediterranean to the Red-Sea, yet little more than it's Coasts are throughly known, except *Egypt* and *Abassia*. It's inland parts have been either not sufficiently viewed or imperfectly described.

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contains *Universal Geography*: the other shews the Order that ought to be observed by those that treat of *Special Geography*.

WE divide *Universal Geography* into *three Parts*, *viz.*

I. THE *ABSOLUTE PART*, subdivided into six Sections, whereof

SECTION I. contains two Chapters of *PRELIMINARIES*.

Chap. I. The Introduction or Preface.
Chap. II. Some Geometrical Propositions of use in the Work.

SECT. II. In which the Nature of the Earth is explained, in five Chapters.

Chap. III. Of the Figure of the Earth.
Chap. IV. Of it's Measure and Magnitude.
Chap. V. Of it's Motion.
Chap. VI. Of it's Situation in the System of the World.
Chap. VII. Of it's Substance and Matter.

SECT. III. In which the Constitution of the Earth and it's Parts are explained, in four Chapters.

Chap. VIII. Of the Division of the Earth by Water.
Chap. IX. Of Mountains in general.
Chap. X. Of the Differences of Mountains.
Chap. XI. Of Woods, Desarts, and Mines.

SECT.

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SECT. IV. Of *Hydrography*, in which the Constitution of the Waters, and their Properties are explained, in six Chapters.

Chap. XII. Of the Division of the Waters by the Earth.
Chap. XIII. Of the Ocean and Sea.
Chap. XIV. Of the Motion of the Sea, *viz.* it's Flux and Reflux.
Chap. XV. Of Lakes, Meres, and Morasses.
Chap. XVI. Of Rivers.
Chap. XVII. Of Mineral Waters.

SECT. V.

Chap. XVIII. Of the extraordinary Changes of the Sea into Land, and dry Places into watery.

SECT. VI. Of the Atmosphere.

Chap. XIX. Of the Atmosphere and Air.
Chap. XX. Of Winds in general.
Chap. XXI. Of the different sorts of Winds.

II. THE *RELATIVE PART* explains the Celestial Properties, in nine Chapters.

Chap. XXII. Of the Celestial Properties in general
Chap. XXIII. Of the Latitude of the Place, or the Elevation of the Pole.
Chap. XXIV. Of the Division of the Earth into Zones.
Chap. XXV. Of the Length of Days, and the Division of the Earth into Climates.

Chap.

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III. THE *COMPARATIVE PART* considers the Particulars arising from comparing the Phænomena of one Place, with those of another.

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Special Geography exhibits three kinds of Particulars. Ten of them are Terreſtrial.

1. The Limits and Bounds of the Country.
2. The Longitude and Situation of Places.
3. The Figure of the Country.
4. It's Magnitude.
5. It's Mountains; their Names, Situations, Altitudes, Properties, and Things contained in them.
6. It's Mines.
7. It's Woods and Deſarts.
8. It's Waters; as Seas, Rivers, Lakes, Marſhes, Springs; their Riſe, their Origin, and Breadth; the Quantity, Quality, and Celerity of their Waters, with their Cataracts.
9. The Fertility, Barrenneſs, and Fruits, of the Country.
10. It's living Creatures.

The Celeſtial Properties are eight.

1. The Diſtance of the Place from the Equator and Pole.
2. The Obliquity of the Motion of the Stars above the Horizon.
3. The Length of the Days and Nights.
4. The Climate and Zone.
5. The Heat and Seaſons: Wind, Rain, and other Meteors.
6. The Riſing and Continuance of the Stars above the Horizon.
7. The Stars that paſs thro' the Zenith of the Place.
8. The Celerity with which each Place revolves, according to the *Copernican Syſtem.*

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THE Human Particulars are ten.

1. The Stature of the Inhabitants; their Meat, Drink, and Origin.
2. Their Arts, Profits, Commodities, and Trade.
3. Their Virtues and Vices; their Capacities and Learning.
4. Their Ceremonies at Births, Marriages, and Funerals.
5. Their Speech and Language.
6. Their Political Government.
7. Their Religion and Church Government.
8. Their Cities.
9. Their memorable Hiſtories.
10. Their famous Men and Women, Artificers and Inventions.

CHAP. II.

Some Propoſitions in Geometry and Trigonometry, of uſe in Geography.

PLATO very juſtly called *Geometry* and *Arithmetic* the two Wings whereby the Minds of Men might mount up to Heaven; that is, in ſearching after the Motions and Properties of the Celeſtial Bodies. Theſe Sciences are no leſs uſeful in *Geography*; if we deſire to underſtand it's ſublime and intricate Parts, without any Hinderance. It is true, a leſs ſhare of Mathematics will ſerve for *Geography*, than *Aſtronomy*: but becauſe ſeveral are taken with the

the Study of *Geography*, who do not understand these Sciences, we shall here set down a few Propositions from them, such as we think most necessary; that the Reader may proceed the more readily without Interruption in his Study. Tho', by the way, we do not at all encourage that bad Custom some young Gentlemen have got, in applying themselves unadvisedly to other Parts of Philosophy, before they have a competent Knowledge in *Arithmetic* and *Geometry*. The Fault is very often in their Masters and Tutors, who are for the most Part ignorant of these Things themselves, and therefore cannot admonish Youth to shun so pernicious a Custom. In *Arithmetic* we suppose the Reader to know the four common Rules of Numeration, *viz.* *Addition*, *Substraction*, *Multiplication*, and *Division*, with the *Golden Rule*, or *Rule* of *Three*; and therefore shall not treat of them here. If any one understand them not, he may learn them much better from some able Teacher, than from Books.

1. BUT as to *Geometry*, it treats of three sorts of Magnitudes, by which every Thing is measured; *viz. Lines*, *Superficies*, and *Solids*: neither can there be found in Nature a Body of any other Dimension.

2. A LINE is either straight or curved; and a Curve again is either uniform as circular, or dissimilar and variable, as the Ellipse, the Conchoid, and Spiral Line.

3. A *CIRCLE* is a Space or plain Superficies bounded with a curve Line, wherein there is a Point from which all right Lines drawn to the Curve are equal. The curve Line which bounds that Space is called the *Circumference*, or *Periphery* of the Circle; and the middle Point is called the *Center* (*a*).

(*a*) *Euclid Lib.* 1. *Def.* 15, 16.

4. THE

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4. THE Diameter of a Circle is a right Line drawn thro' the Center, and terminated at both ends by the Periphery: one half of which is called the *Semidiameter*, or *Radius* (*a*).

5. AN *Arch* is part of the Periphery of a Circle. A *Quadrant* is a fourth Part of the whole Periphery. What an Arch wants of a Quadrant is called the *Complement* of that Arch: and it's Difference from a Semicircle is called it's *Supplement* (*b*).

PROBLEM.

6. *HAVING a right Line given and a Point either in, or out of it, to draw thro' that Point a Line perpendicular to the former.*

LET the Line given (*Fig.* 2.) be AB, and the Point C: open the Compaſſes ſo, that ſetting one Foot in C, you may with the other cut the Line given in *df*; then one Foot being placed at *d*, with the other deſcribe an Arch, as *gh*; alſo make *f* the Center, and with the ſame Radius deſcribe another Arch, which will cut the former in *g* and *h*; ſo draw the Line *gh*; which will be the Perpendicular required.

7. *TO divide a Circle and it's Periphery into four equal Parts.* Draw a Diameter, and from the Center raiſe to it a Perpendicular, which prolong'd will be alſo a Diameter; whereby both the Circle and it's Periphery will be divided into four equal Parts (*c*).

8. *TO divide the Periphery of a Circle into Degrees.* A Degree is the 360th Part of the Circumference. Mathematicians always divide the Periphery into

(*a*) *Euclid Lib.* 1. *Def.* 17.
(*b*) *Ib. Prop.* 11, 12. *Lib.* 1.
(*c*) *Ibid. Prop.* 4. *Lib.* iv.

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so many equal Parts (*d*); and each of these Parts into 60 smaller Divisions, called *first Minutes*; also each Minute into 60 Seconds, &c. commonly writ thus, 3 *degr.* 2. *min.* 5 *sec.* that is, 3 Degrees, 2 Minutes, 5 Seconds. Hence the Quadrant containeth 90 Degr. the Semicircle 180, and the sixth Part of a Circle 60 Degrees.

THEREFORE to solve this Problem, divide the Periphery into Quadrants, then take off the Semidiameter, and with it's Length cut an Arch from the Periphery (*e*), which will be equal to 60 Degr. so there remains in the same Quadrant 30 Degr. which being bisected you will have 15 Degr. this again mechanically trisected will give 5 Degr. which divided into five equal Parts make so many Degrees, Q. E. F. But this is done more artificially by mathematical Instruments (*f*).

9. *TO find the Area of a Quadrangle, or a Space contained in a Figure of four Sides, and four Right Angles.* Multiply one side by the other, and the Product is the Area. It is to be observed that Lines are measured by Lines, and Superficies, by Measures that are Superficies, or Squares; also the Contents of solid Bodies, which have their Dimensions, are computed in solid Measure, or so many Cubes. Thus we measure the Sides of a House by a lineal Foot, the Floors and Wainscot by a

(*d*) This Division of a Circle into 360 Parts, or Degrees, is because that number can be divided into more Aliquot Parts, than any other convenient Number, *viz.* into 2, 3, 4, 5, 6, 8 and 9 Parts.

(*e*) *Euclid. Prop.* 15. *Lib.* iv.

(*f*) By a Line of Chords truly divided; thus, from any Point in the Periphery lay on the Chord of one Degr. then from the same Point lay on the Chord of two Degr. so of three Degr. &c. 'till you come to 90 Degr. then begin again as before, 'till the whole Periphery is divided. By this means you will avoid the Errors which may arise from the intermediate Divisions; and tho' these Errors singly considered are very small, yet in so many Degr. they will produce one very sensible.

ſquare Foot, and the Space it encloſeth; conſidered as a Solid, by a cubical Foot.

10. *HAVING the Diameter or Semidiameter of a Circle, to find the Periphery in the ſame Meaſure: and converſly, having the Periphery given, to find the Diameter as near as poſſible* (*g*). The Solution of this Problem depends upon the determined Proportion of the Diameter to the Periphery, which is nearly as 7 to 22; as is demonſtrated by *Archimedes*; or more accurately, as 1000000000 is to 3141592653 5 (*h*). For Example, let the Diameter be 12 Foot; by the *Golden Rule*, as 7 is to 22: ſo is 12 to the Periphery of the Circle; or if you uſe the other Proportion it will be much the ſame.

BUT if the Periphery be given, and the Diameter be required, ſay; as 22 is to 7, or as 31415926535 to 10000000000, ſo is the Periphery given to the Diameter required.

11. *THE Diameter and Periphery of a Circle, or either of them, being given in Miles or Feet, to find*

(*g*) See *Tacquet*'s ſelect Theorems of *Archimedes*, *Prop.* 5.

(*h*) Tho' it be well known that the Periphery of a Circle is incommenſurable to the Diameter, yet either of theſe Proportions will ſerve well enough for common Uſe. But no Proportion in ſmall Numbers is ſo exact as that of *Andrew Metius*, *viz.* of 113 to 355, which is found not to differ from the Truth above $\frac{3}{10000000}$. But if the Reader deſireth the niceſt Computation of the Proportion of the Diameter of a Circle to the Circumference (altho' that of *Metius* comes very near), let him have recourſe to the laborious *Calculus* of *Van Ceulen*, who carried his Calculation to 35 places of Decimal Fractions. Or if he would ſtill be more nice and curious, he may have recourſe to Mr *Abr. Sharp*'s Calculation, to double the Number of *Van Ceulen*'s Fractions. By which Exactneſs, the Circumference of the Terraqueous Globe, may be computed to a Degree leſs than the Breadth of a Grain of Sand: yea, more than this, the number of the Grains of Sand, that would be contained in a Space as big as the Sphere of the Fixt Stars, might be truly computed by this means. Vid. *Math. Tables* printed for Mr *Mount*, page 53, &c.

the Area of that Circle in square Miles, or square Feet. Multiply one half of the Periphery into the Semidiameter, and the Product will be the Area required (*i*): but if you have only one of them given, you may find the other by the last Problem: Or it may be done without it (*k*).

12. *THE Diameter, or Semidiameter, of a Globe being given; to find it's Superficies in Square, or it's Solidity in Cubic Measure.*

A Globe is a round solid Body, having a certain Point in the Center of it, from whence all right Lines drawn to the Surface are equal: and a Line drawn thro' this Point is the Diameter, about which if the Globe be revolved it is called it's Axis (*l*). Moreover if a Globe be cut any how by a right Line, the Section is a Circle; if thro' the Center the Circle will have the same Diameter as the Globe itself; and such are called the greater Circles of the Sphere or Globe, and the rest lesser Circles. To solve the Problem (*m*): By the tenth *Article*, find the Periphery; then multiply the Diameter into this Periphery, and the Product will be the Superficies of the Globe in square Measure, which multiplied into the $\frac{1}{6}$ of the Diameter, will produce the Solidity of the Globe in cubic Measure.

(*i*) As is demonstrated by *Archimedes, Prop.* 1. *De Dimensione Circuli.*

(*k*) By saying, as the Square of 1 (which is 1) is to .7854 (the Area of a Circle whose Diameter is 1) so is the Square of any other Diameter to it's Area; *By Prop.* 2. *Lib.* ii. *of Euclid.* The famous *M. Leibnitz* has demonstrated that if the Diameter of a Circle be 1, the true Area will be $\frac{1}{1}$ —

$$\frac{1}{3} + \frac{1}{5} - \frac{1}{7} + \frac{1}{9} - \frac{1}{11} + \frac{1}{13} - \frac{1}{15} + \frac{1}{17} - \frac{1}{19} + \frac{1}{21}, \&c.$$

(*l*) *Euclid. Lib.* ii. *Def.* 14, 15, 16, 17.

(*m*) See this demonstrated in *Tacquet's Select Theorems* of *Archimedes, Scholium* 2 of *Prop.* 24. and that of *Prop.* 28.

13. *A*

13. *A RIGHT angled Triangle hath two sides perpendicular to each other* (or make an Angle of 90 Degr.) which two sides are called the *Catheti*, or Perpendiculars, and the third side the *Hypotenuse*.

THE Measure of an Angle is the Length of an Arch described from the angular Point as a Center: that is, as many Degrees as the Arch between the Legs of the Angle doth contain; so many Degrees the Angle is said to be of. Thus a right Angle is 90 Degr. because the Arch so described is a Quadrant.

THE right *Sine* of an Arch is a right Line drawn from the one end of the Arch perpendicular to the Diameter, which passeth thro' the other end (*n*).

THE *Tangent* of an Arch is a right Line which touches the Arch at one end, and is bounded at the other with a Line drawn thro' the Center, and the other end of the Arch; which Line is called the *Secant* of that Arch.

MOREOVER, the *Sine*, *Tangent*, and *Secant*, of an Angle, are the same of the Arch which measureth the Angle.

(*n*) Mr *Whiston* in his Notes upon *Tacquet's Euclid*, has neatly explained the Origin of Sines, Tangents, and Secants. *Coroll.* to the 47th *Prop. Lib.* i. which we shall here transcribe. *Let* A C *the Semidiameter of a Circle (Fig.* 3.) *be of* 100.000 *Parts, and the Angle* B A D *of* 30 *Deg. because the Chord or Subtense of* 60 *Degr. is equal to* A C *the Semidiameter (by Prop.* 15. *Lib.* iv. *Euclid)* B D *the Sine of* 30 *Degrees shall be equal to one half the Semidiameter, or* ½ A C; *and therefore shall contain* 50.000 *Parts. But now in the right-angled Triangle* A B D, *the Square of* A B *is equal to the Square of* A D *and* B D. *Therefore let the Semidiameter* A B *be squared, and from that Square substract the Square of* B D: *The Remainder will be the Square of* A D *or of the Co-sine* B F *equal to it: out of which extract the square Root, and you will have the Line* B F *or* A D. *Then by this Analogy as* A B : B D : : A E : C E *or* A D : B D : : A C : C E, *so you have the Tangent* C E. *And if the Square of* A C *be added to the Square of* C E, *the Root of the Sum being extracted will be the Secant* A E. *Q. E. I.*

 IT

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IT is also necessary to be known that Tables have been calculated by the great Labour and Industry of some Mathematicians, in which the Diameter being taken for 100000, *&c.* the Sines, Tangents, and Secants, are found out in proportional Numbers; as of 2 Degr. 10 Degr, 20 Degr. 32 Min. *&c.* These Tables are called mathematical *Canons*, and are of extraordinary use in all mathematical and physical Sciences; wherefore I am willing to give some Hints of these things to the young Geographer. But because spherical Triangles have some Difficulty in their management, and regard none but those who desire to be deeper skilled in this Science, we shall pass them by; and only treat of right-angled Triangles, the measuring of which is as easy as necessary.

Two THEOREMS.

14. *THE three Angles of every Triangle, taken together, are equal to two right Angles, or* 180 *Degr.* and therefore the two acute *Angles* of a right angled Triangle make exactly 90 Degr. (*o*). *Also if a right Line touch a Circle, and there be drawn from the Point of Contact another right Line to the Center, that Line makes a right Angle with the Tangent* (*p*).

15. THE most necessary Problems are these.

I. *THE Hypotenuse and one side of a right angled Triangle being given, to find either of the acute Angles,* Say by the Golden Rule; As the given Hypotenuse is to the given side: so is the Radius 100000 (which Number is assumed equal to the Semidiameter in the Tables) to the Sine of the opposite Angle; which Sine being found in the Tables

(*o*) *Euclid. Prop.* 32. *Lib.* i. (*p*) *Ibid. Prop,* 18. *Lib.* iii.

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will shew the Quantity of the Arch or Angle opposite to the Side given; and the other Angle is the Complement of that now found, to 90 Degr.

II. *ONE side and the acute Angle next it being given, to find the Hypotenuse.* Say as before; As the Sine of the Complement of the given Angle is to the Radius 1000000: so is the Side given to the Hypotenuse sought.

III. *HAVING two Sides given, to find either of the acute Angles.* Say, As either of the Sides is to the other, so is the Radius 100000 to the Tangent of the Angle adjacent to the Side first assumed.

IV. *HAVING the Hypotenuse and one acute Angle given, to find either of the Sides:* Say; As the Radius 100000 is to the Sine of the Angle opposite to the Side required: So is the given Hypotenuse to that Side.

Of Divers Measures.

BECAUSE the use of Measures is frequent in Geography, and since divers Nations use different Measures, 'tis proper to premise somewhat concerning them; partly that the Reader may the better understand the Writings of the antient Geographers and Historians; and partly that he may compare together those in use at this Day.

THE Length of a *Foot* is almost universally made use of, tho' a Foot in one Place differs from that in another. Mathematicians frequently measure by the *Rhinland* Foot of *Snellius*, which he proves to be equal to the old *Roman* Foot. And because *Snellius* was very diligent and accurate in measuring the Earth, that *Rhinland* Foot

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of his is deservedly taken as a Standard for all other Measures (*q*). See half it's Length, *Fig.* 1.

A *PERCH* or *Pole* ought to consist of ten such Feet. But the Surveyors in *Holland* make 12 Feet a *Rhinland* Perch, and in *Germany* they compute 16; which is very incommodious in *Calculation*. *Snellius* makes the *Holland Mile* equal to 1500 *Rhinland* Perches (each Perch being 12 Foot) or 1800 *Rhinland* Feet.

THESE two Measures, a Perch and a Mile, arise from the repetition of a Foot; but a *Palm*, an *Inch*, and a *Barley-Corn* (which are sometimes used in *Holland*) proceed from it's Division. An Inch is the twelfth Part of a Foot. A Palm is 4 Inches. A Barley-Corn is the fourth Part of an Inch. However it would be much better to divide the Foot into 10 Inches, and the Inch into 10 Subdivisions or Seconds, *&c.*

THESE are the Measures now made use of by the *Dutch* in Geography. It remains that some others be also taken Notice of; *viz.* those of the antients, whether *Greeks*, *Romans*, *Persians*, *Ægyptians*; and those also of later Times as of the *Turks*, *Polanders*, *Germans*, *Moscovites*, *Italians*, *Spaniards*, *French*, and *English*.

(*q*) Because the Knowledge of an *English*, *French*, and *Rhinlandish* Foot will be of use in what follows, we will here give their Proportions; to which we shall add the Measure of the old *Roman* Foot, taken from Dr *Bernard's Treatise of Weights and Measures*, where he most learnedly confutes the great Error of *Snellius* in this Matter.

If an *English* Foot be divided into 1000 Parts, and a *French* Foot into 1440. Then

			Eng. Parts		*Fr.* Parts	
A Foot	*English*	contains	1000	and	1350	*Jurin's Appendix.*
	French		1066		1440	
	Rhinland		1030		1390	
	Roman		970		1309	

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THE *Grecian Stadium*, or *Furlong*, is supposed to be 600 of their Feet, which make 625 *Roman*, or *Rhinland*, Feet; their Foot being a little larger than the *Roman*.

A *GERMAN Mile* (15 of which Geographers allow to a Degree) contains 22800 *Rhinland* Feet, and is accounted 4000 Paces, or 32 Furlongs. It is in Proportion to the *Rhinland* Mile, as 19 to 15.

THE *Italian* or *Roman* Mile is 1000 Paces, which is equal to 4000 *Rhinland* Feet. *Note*, The *Romans* used to call their Mile *Lapis*, because a Stone was erected at the end of every Mile; especially in Places adjacent to the City.

A *GEOMETRICAL Pace* is exactly 5 Feet; and a *Fathom* 6 Feet; which is thought by some to have been the Pace of the *Grecians*.

A *CUBIT* is supposed to be a Foot and a half.

THE *Parasange*, or *Persian* Mile, is thought to be 30 Furlongs, or 3000 *Persian* Paces.

THE *Schœnus*, or *Ægyptian* Mile, according to *Herodotus*, contains 60 Furlongs, tho' only 40 according to *Pliny*. Perhaps their Length differed in divers Places, or the Furlongs of the Authors might be unequal: Or very likely their Books are corrupted.

THE *French League* is in Proportion to the *Rhinlandish* Mile, as 19 to 25; and the *Spanish* League is to the same Mile, as 19 to 27½: But because in several Parts of *France* and *Spain* their League is found to differ, we cannot be well assured of the Length of these Measures.

THE *English* Mile is in Proportion to the *Rhinlandish*, as 19 to 55, or as 19 to 60 (*r*). But there

(*r*) The least Part of *English* Measure is a Barley-Corn, taken out of the middle of the Ear and well dryed; whereof 3 in Length make an Inch, *&c.* as in the following Table.

A Table

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there are three sorts of *English* Miles, whereof $27\frac{1}{2}$ of the longest, 50 of the middle Kind, and 60 of the shortest, make a Degree or 19 *Dutch* Miles.

THE *Danish* and *Swedish* Mile is to the *Rhinlandish* Mile as 19 to 10; tho' in some Places they use the *German* Mile.

THE *Vorest*, or *Russian*, Mile is as 19 to 80.

THE *Turkish* League or Mile is said to be equal to the *Italian* Mile; of which 60 make a Degree.

THE *Arabian* League was formerly accounted the twenty fifth Part of a Degree, or 19 *Holland* Miles: but they now use another of which 56 make a Degree.

A HUNDRED *Indian* Miles are thought to equal a Degree. Tho' the *Indians* commonly describe Distances by a Day, or an Hour's Journey.

THE Inhabitants of *Cambaya* and *Guzarat*, use a Measure which they call *Cossa*, of which 30 make a Degree.

THE *Chinese* observe three Measures in their Journies, which they call *Li*, *Pu*, and *Ucban*. *Li* is the Distance at which a Man's loud Voice may be heard on a Plain, in a calm Air; which is accounted 300 Geometrical Paces. Their *Pu* contains 10 *Li*'s; so

A Table of English Measure.

Bar. C.								
3	*Inches*							
36	12	*Feet.*						
108	36	3	*Yard.*					
180	60	5	$1\frac{2}{3}$	*Pace.*				
216	72	6	2	$1\frac{1}{5}$	*Fath.*			
594	198	$16\frac{1}{2}$	$5\frac{1}{2}$	$4\frac{1}{10}$	$2\frac{3}{4}$	*Poles*		
23760	7920	660	220	132	110	40	*Furl.*	
180090	63360	5280	1700	1056	880	320	8	*Mile*

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so that 20 *Pu*'s make a Degree. And 10 *Pu*'s make an *Ucban*, or 30000 Paces; which they account a day's Journey.

Note, A Square *Rhinland* Mile consists of Square Feet, and a Cubic Mile of Cubic Feet. Also a Mile multiplyed into itself makes a Square Mile; and that again by a Mile makes a Cubic Mile. The same is to be understood of a Square and Cubic Foot.

SECT. II.

Containing some general and absolute Properties of the Earth, in five Chapters.

CHAP. III.

Of the Figure of the Earth.

THE first and noblest Property of the Earth (as exceeding the rest in being more useful and necessary) is it's Figure; without the Knowledge of which there can be nothing well understood or demonstrated in this Science; and all the following Propositions almost entirely depend on, or immediately flow, from this; which for that Reason ought to be first treated of.

THERE have been, and are to this Day, several Opinions about the Figure of the Earth; for the Vulgar that understand not Geography, imagine it to be extended into a vast Plain bounded with a Circular Line; except where Mountains and Vallies interpose. Of this strange Opinion was *Lactantius* and others of the Fathers, who strenuously argued that the Earth was extended infinitely downwards,

wards, and eſtabliſhed upon ſeveral Foundations (*a*). This they were inclined to think from ſome Places of *Scripture* which they either ill underſtood or wrong interpreted. *Heraclitus*, that ancient Philoſopher, is ſaid to have been of their Opinion: tho' others ſay, he ſuppoſed the Earth to be in the Shape of a Skiff or *Canoo*, very much hollowed. But what is more ſtrange *Francis Patricius* (a modern Philoſopher of no ſmall Repute in the laſt Age) ſtrenuouſly endeavoured to prove, that the Earth was horizontally ſtretched out and plain under Foot. *Anaximander* is ſaid by *Peucerus* to have ſuppoſed the Earth like a Cylinder; tho' that is not ſo probable, becauſe he tried to meaſure it, and alſo invented a ſort of a Dial at *Lacedæmon*, upon which the Top of the *Gnomon* by it's Shadow marked out the Days of the Equinoxes, and *Solſtices*: which ſhewed him to have been tolerably ſkilled in *Aſtronomy*, conſidering the Time he lived in. *Leucippus* alſo thought the Earth to be in the Shape of a Drum. Theſe with a great many other abſurd Opinions, are by *Ariſtotle* and others attributed to the Antients: of which ſee *Ariſtotle Lib.* ii. *Cap.* 13. *de Cælo.*

BUT the true and undoubted Opinion, which is defended by all Mathematicians, and almoſt all Philoſophers, is, That the Earth is of a globular or ſpherical Figure (*b*).

THE

(*a*) See *Lactantius Lib.* iii. *Chap.* 24. and *Auguſtin Lib.* xvi. *Chap.* 9. *De Civit. Dei.* They thought their Opinion was favoured by the *Pſalmiſt*. *Pſal.* xxiv. 2. and cxxxvi. 6.

(*b*) Among the many excellent and wonderful Inventions of the modern Philoſophers, this here is not certainly in the laſt Place, nor hath the leaſt Honour and Admiration in it; that the true Figure of the *Earth*, which Men have inhabited for ſo many thouſand Years, is but now begun to be known a few Years ago. For that which all Men thought to be globular and truly ſpherical, is now found to imitate rather an oval Figure, or that of an Ellipſis revolved about it's leſſer Axis:

Axis: So that those Diameters are longest which come nearest the Equator, and lessen as they become more remote, but the least Diameter of all is the Axis which joineth the two Poles. The Thing will perhaps be better understood if it be represented by a Figure.

Let *æpqp* (*Fig.* 4.) be a circular Section of the Earth made by the Meridian, such as it was thought to be formerly and *pp* the Axis or Diameter joining the Poles, and *æq* the Diameter of the Equator: then the oval Line ÆPQP, described upon the Diameters ÆQ and PP, will represent the Section or true Meridian Line, which for Distinction sake is made here to differ more from a Circle than it really ought to do; but in truth, the Proportion is as 692 to 689. So that the Line CQ measuring the Altitude of the Earth at the Equator, exceeds CP the Altitude at the Pole 85200 *Paris* Feet, or about 17 Miles.

This Affair is well worthy to be traced to it's Original, and to be backed by a Demonstration, so far as our Purpose will permit. *See the History of the Royal Academy of Sciences by du Hamel. Pag.* 110, 156, 206. Also *Hist. de l' Acad. Roy.* 1700, 1701.

The *French* made an Experiment about forty Years ago, shewing that a Pendulum (which is a well known Instrument for measuring of Time) vibrates so much the slower, by how much the nearer it is brought to the Equator: that is, the Gravity, or Celerity of Descent of the Pendulum, and of all other Bodies, is less in Countries approaching the Equator than in Places near either Pole. The two famous Philosophers *Newton* and *Huygens* being excited by the Novelty of the Thing, and seacrhing more narrowly into the Cause of it, found thereby that the Earth must have some other Figure than what was known; and also demonstrated that this Diminution of Weight doth naturally arise from the Rotation of the Earth round it's Axis; which Rotation, according to the Laws of circular Motion, repels all heavy Bodies from the Axis of Motion: so that this Motion being swifter under the Equator than in Parts more remote, the Weight of Bodies must also be much less there than nearer the Poles. Therefore the Parts of the Ocean under the Equator being made lighter, and according to the Nature of all Fluids, pressed and forced on either side by the Waters nearer the Poles, they must be raised up to a greater Height, that so they may better support and balance the greater Weight of the contiguous Waters. Which mutual Libration is demonstrated upon Supposition of that Inequality of the Diameters which we mentioned above. The Figure of the Sea being resembled by the Lands adjacent, which are every where raised above the Sea, the aforesaid Form must be attributed to the whole terraqueous Globe. They that would be more fully informed in this Matter may consult *Newton*'s *Principia Lib.* iii. *Prop.* 19. or *Huygen*'s *Treatise of the Cause of Gravity.*

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THE Arguments indeed which Authors offer to confirm the Truth of this, are handled ſo obſcurely and confuſedly, that they are almoſt inſufficient to convince the ſtrenuous and obſtinate Defenders of the contrary Opinion. We ſhall therefore as much as is poſſible, clear up and examine theſe Arguments; that the Reader may have a diſtinct Knowledge of them, and know the better how to uſe them.

WE ſhall not here take notice of ſuch Reaſons as are of leſs Weight, and at beſt only probable, or perhaps ſophiſtical. Such as, 1. A ſpherical Figure is the moſt capacious; and therefore the Earth ought to have ſuch a Figure. 2. All the Parts of the Earth tend to the ſame Center; therefore all theſe

The ſame Inequality of Diameter is alſo found in the Planet *Jupiter*, by the Obſervations of thoſe excellent Aſtronomers *Caſſini* and *Flamſtead*, and that much more than in our Earth; becauſe the diurnal Rotation of that Planet is more than twice as ſwift as the Rotation of the Earth: which plainly proves, that the Difference ariſes from no other Cauſe than the circular Motion.

Jurin's Appendix.

Dr Derham (in his *Phyſico-Theol.* B ii. C 1. Note *a*) doth not ſeem to entertain any doubts concerning the terraqueous Globe, and the other Planets, being of a prolate ſpheroidal Figure; but he ſaith, That altho' he hath often viewed *Jupiter*, and other Planets, with very good Glaſſes, which he hath of 72 feet, and the Royal Society's Glaſs of above 120 feet, yet he never could perceive them to be otherwiſe than perfectly globular. And he thinks it next to impoſſible, to take an exact meaſure of the Polar and Æquatorial Diameters, by reaſon of the Smallneſs of their apparent Diameters in a Micrometer, and their Motion all the time of meaſuring them.

And as to the *Variation* of the Vibrations of *Pendulums*, under the Line, and in the Northern and Southern Latitudes, he hath no doubt, but different Diſtances from the Earth's Center, may cauſe different Vibrations; but yet he ſhews, from good Experiments he made with Pendulums in the Air-Pump, that thoſe Alterations might, in ſome meaſure, be from the Rarity and Denſity of the Air, in the different Zones. And I may add to *Dr Derham's* Experiments, the Lengthening of Iron Rods by Heat, and their Shortening by Cold; which I have found to be very conſiderable, by very exact Experiments.

Parts ought to make up a globular Figure. 3. When at the first Creation the Waters were confusedly mixed with the Earth, it was then without doubt moist and soft; but the Figure of all moist and liquid Bodies is spherical: and so ought the Earth to remain after the separation of the moist Parts from the dry.

I SAY, neglecting these and such like Arguments, let us look out for better; which are of three kinds. Of the first there is only one deduced *à priori*, as they call it: those of the other two kinds are demonstrated *à posteriori*; or from Celestial or Terrestrial Observations and Appearances.

THE first Argument is taken from the Nature of Water, and borrowed either from *Aristotle* or *Archimedes*. *Aristotle* in his second Book *de Cælo*, chap. 5th, proposes it as his own, after this manner, (tho' it is likely he borrowed it from some Philosopher before him). If we take it for granted (says he) that Water of it's own Nature tends always down to the most concave or lowest Place; it will necessarily follow, that the Superficies of the Water is round or spherical; but that Place is most concave that is nearest the Center of the Earth, therefore let there be drawn from the Center α two right Lines $\alpha\beta$ and $\alpha\gamma$; and from β to γ the Line $\beta\gamma$; to which from α let fall the Perpendicular $\alpha\epsilon$. (*c*) It is plain the Line $\alpha\delta$ (*Fig.* 5.) is less than $\alpha\beta$ or $\alpha\gamma$, and therefore the Place δ is lower and more concave then β or γ; therefore the Water must flow downwards from β and γ 'till the Lines $\alpha\beta$, $\alpha\gamma$, and $\alpha\delta$ are equal, that is, 'till $\alpha\delta$ becomes $\alpha\epsilon$ equal to $\alpha\beta$, and $\alpha\gamma$; hence β, ϵ, and γ being in the Periphery of the same Circle, must make the true Superficies of the Water of a round Figure.

(*c*) *Euclid. Lib.* i. *Prop.* 18.

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THIS is *Aristotle's* Demonstration, in which, besides the Incoherency of it, which might be easily amended, I observe these greater Errors. 1. He supposeth the Universe to have a certain Center. 2. That Places are higher or lower in respect to that Center. Now he who denies the spherical Figure of the Earth, will perhaps grant neither of these Postulata: Tho' the Universe may be easily proved to have a Center, because the apparent Motion of the fixed Stars obligeth us to suppose that they themselves either revolve by a diurnal Motion, or that the Earth is turned about it's Center. If the Stars be really moved, then the Point about which they will revolve will certainly be the Center of the Universe. If the Earth; then the middle Point round which it moves, may, in the Demostration, be taken for *Aristotle's* central Point. But the chief Difficuly is in the second Supposition; *viz.* that Places are higher or lower in respect of that Center; because he who will have the Superficies of the Earth to be a Plane, or some other Figure, not round, will deny this Suppsition, and say that Places appear higher or lower in respect of the horizontal Plane, perpendicular to which the Earth is infinitely extended downwards; or will perhaps explain the Declivity some other way: so that the Argument would not be conclusive except it were first granted that the Elevation of one Place above another is only in respect of some Center, about which the Stars have their apparent Motion. And tho' this were true, and all other Notions of Declivity by which Water is depressed were confuted, yet it could scarcely be admitted for a Principle; because it precariously supposes the Earth to be of a spheric Figure, which is begging the Question.

THEREFORE some prefer *Archimedes's* Demonstration (found in the *first Book of his De Insidentibus Humido*) which is indeed more artificial than that

that of *Aristotle*; yet labours under the same Difficulties, in previously supposing the Earth to be of a spheric Figure, to whose Center the pressure of the Water is made. But we are far from supposing that the divine *Archimedes* could be guilty of any false Reasoning! No, his Design in that Book was not to demonstrate the spherical Figure of the Earth (for then he had indeed begged the Question) but only to explain the Nature of Water and other Liquids; in order to which he pre-supposes the Earth to be of a spherical Figure, or to have a Center, to which all heavy Bodies in general tend; and this he takes as a Principle before known and demonstrated from other Phænomena: So that I wonder *Clavius* did not observe this, who, in his Commentary upon *Joannes de Sacro Bosco*, uses this Demonstration of *Archimedes* for the spheric Figure of the Earth: *Snellius* also does the same in his *Eratosthenes Batavus*. But it was *Aristotle*'s Design in the Place before cited to demonstrate the spheric Figure of the Earth, Sea, and Heavens; wherefore he could not assume a Center to the Universe, or Earth, without being guilty of a manifest *Paralogism*.

SO that this Argument taken from the Nature of Water, tho' it be proposed by almost all Authors, yet labours under some Difficulties, which more learned Mathematicians have endeavoured to remove, if possible. I have myself spent some Time upon this Matter, and tryed several Methods, but could not bring them to bear. I was induced to attempt the Thing, because it would be an elegant and unquestionable Demonstration of the spherical Figure of the Earth.

THEREFORE waving this; we shall now propose some Arguments *à posteriori*, taken first from celestial Phænomena. Let us conceive a Section made by a plane or a meridian Line (which is called the Line of Latitude) to pass thro' a Place B, or any other Part of the Earth, and also thro' the two Poles M, N; as A B C D. And suppose another Section (or Line of Longitude) (*Fig.* 3.) to pass thro' the same Point B, perpendicular to the former, and parallel to the Equator; as E B F C. I say these two Sections or Lines on the Surface of the Earth may be proved to be circular. And it is a plain geometrical *Theorem*, that any Superficies whatever, when it is cut with perpendicular Planes, intersecting each other in one common Line or Axis, if the Lines produced on the Surface be circular, the Body can be no other than spherical.

THEREFORE if we can prove, that the two perpendicular Sections are circular, which pass thro' any Point, B, taken at Pleasure; we may also by the aforesaid *Theorem* conclude the Superficies of the Earth to be of a spherical Figure, and the Earth itself a globular Body.

NOW it is proved from divers celestial Phænomena. that a Section made from one Pole to another, according to the Latitude of the Earth, is circular. 1. If in the Line A B C D, a Person go from any Point, as B, towards either Pole, as M, or the Star near it; he will find that by equal Journies he will equally approach nearer the Pole; which would be impossible if the Line he travelled in was not circular; as is plainly shewed by the *artificial terrestrial Globe*. 2. The Line A B C D is the *meridian Line*, into which when the Sun comes it is Noon or Mid-Day with us; and all the People who inhabit that Line, as we know by Experience; and they that sail in the *Torrid Zone* testify, that the Sun at some Time of the Year is perpendicular to some Place in the Line A B C; for Example, to P. If we take equal Spaces B Q, P Q (or any other) we shall find the Distance of the Sun from the Zenith of Q, equal to the Interval, by which the Distance of the Sun from the Zenith of B exceeds the Distance of the ſame from that of Q; which could by no means happen if the Line B P Q was not circular. 3. In like manner all the Stars when they come to the Meridian A B C, have their Diſtances from the Zeniths of P, Q, B, in the ſame Proportion as the Diſtances Q P, P B, Q B. Moreover when our Mariners ſail towards the South, the Stars which before were depreſſed under the Horizon, and could not be ſeen, begin to appear, and by degrees are elevated in proportion to their Courſe. 4. If ſeveral Places be obſerved in the ſame Meridian, and the Stars that paſs thro' their Zeniths be noted; the Diſtances of theſe Places have the ſame Proportion one to another, as the Diſtances of the meridional Points, wherein the ſeveral vertical Stars make their ſouthing.

ALSO to prove that the Line of Longitude E B F C is circular, and that the Earth riſes into a globular Figure, according to that other Dimenſion, we need but obſerve that the Sun and Stars riſe and ſet ſooner to thoſe that inhabit eaſtward of us, but later to them that are more to the weſt; and alſo that the Difference of Time is in proportion to the Diſtances of their Meridians from ours. Thus, if we ſuppoſe two Places directly Eaſt, the one diſtant from us 225 Miles, the other 450, twice as much; we ſhall find that in this laſt Place the Sun riſeth two Hours ſooner, and in the other one Hour ſooner than with us. The Argument will be more clear, if it be propoſed about the Sun's approaching the Meridians of divers Places; for their Diſtances in reſpect of ours are in Proportion to the Time of the Sun's apparent Motion (or an Arch of the Equator intercepted between our Meridian and theirs) as is evident in Eclipſes. Theſe Facts agree preciſely to the Demonſtrations upon the *Artificial Globe*: which could not happen if the Earth had any other Figure.

SO that the Earth is found to have a ſpherical Form, both in *Longitude* and *Latitude*.

BUT ſince there ſeems to be a Difficulty in handling the Longitude, all this may be proved by the Latitude only. For it is manifeſt, that the Figure of the Earth is ſpherical, ſince all the Sections, or Lines of Latitude, are circular; and paſs thro' the ſame Point or Pole. Becauſe any ſolid Body whatſoever being cut with innumerable Planes, all paſſing thro' the ſame Point; if the Peripheries of theſe Sections are circular, the Body itſelf muſt be ſpherical: as is known and allowed by all Geometricians.

THERE is another Reaſon of no leſs Force, taken from the *Shadow of the Earth* upon the Face of the Moon in *Lunar Eclipſes*. For ſince the obſcured Part of the Moon, cauſed by the *conical Shadow of the Earth*, ſeems always to be bounded with a circular Line; the Earth itſelf, for that Reaſon, muſt needs be ſpherical (*d*). Becauſe it is manifeſt from *Optics* that a ſolid Body being every way oppoſed to the Sun; if the Shadow be always conical, the Body itſelf is ſpherical.

IF theſe Arguments are not ſufficient, we might produce a great many more, from the conſideration of the Earth itſelf, which perfectly prove the Earth's Rotundity: ſuch as theſe;

(*d*) *Tacquet (in his Aſtronomy Lib.* iv.*)* hath demonſtrated that the Shadow of the Earth never reaches ſo far as the Moon; ſo that the Moon is darkened not by the Shadow of the Earth, but by that of it's *Atmoſphere* only; which was obſerved, tho' not ſo exactly demonſtrated, by *Kepler* and *Ricciolus*. But whether the Shadow proceed from the Earth itſelf, or the *Atmoſphere*, (tho' the latter indeed be the Truth) the Thing is the ſame in the preſent Caſe: for if the Shadow of the *Atmoſphere* be circular, the Shadow of the Earth which is encloſed on every Side thereby muſt be circular too. *Whiſton's Aſtron. Lect. Pag.* 2

1. FROM

1. FROM Circumnavigation; for the *Europeans* have several times set Sail from *Europe*, and steer'd their Course directly South and West, 'till they came to the *Magellanic* Sea; and from thence to the North and West 'till they returned to *Europe* from the East; and all the Phænomena, which should naturally arise from the Earth's Rotundity, happened to them. Their Method of sailing also was founded upon this Hypothesis; which could never have succeeded so happily if the Earth had been of any other Figure *.

2. WHEN we take our Departure from high Mountains and Towers; first the lower Parts, then those that are higher, and lastly, their Tops are by degrees depressed, as it were, and hid from us: On the other Hand, when we approach towards them, from a Place at a great Distance, first the Top appears, then the middle Part, and lastly, when we come pretty near, the very Foot of the Mountain is discovered. So that this gradual Appearance and Occultation, is such as must necessarily happen from the spherical Figure of the the Earth.

3. IF we measure the Altitude of any Mountain upon this Supposition, that the Earth is globular; the Practice is always found to justify the Truth of the Theory.

WE might demonstrate many of these Arguments geometrically; but (because it would be both

* *Ferdinando Magellan* was the first who sailed round the Earth, in the Year 1519. he performed it in 1124 Days. Sir *Francis Drake* was the next, in the Year 1577. and he performed it in 1056 Days. The same was afterwards done by Sir *Thomas Cavendish*, in the Year 1586; in the Space of 777 Days. It was done again by Mynheer *Simon Cordes* in the Year 1590. By *Oliver Noort*, *Anno* 1598. By *Cornel Scharten*, *Anno* 1615, And by *Jacob Heremites*, *Anno* 1623; and all by directing their Course constantly from *East* to *West*; and thus returned into *Europe*, having all along observed the Phænomena which necessarily arise upon supposing the Earth a *spherical Body*.

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laborious and difficult to prove this, or that Line circular, from such Principles, *&c.*) we shall content ourselves with those evident Proofs above delivered: which being collected into one Sum, will sufficiently demonstrate the Earth to be *globular*. As, first, the celestial Phænomena (*viz.* The different Elevation of the Pole; the unequal Altitude of the Sun, at the same Instant, in different Countries; the Earth's Shadow on the Moon; the vast Increase of the longest Day towards the Poles; the Rising and Setting of the Stars; their perpetual Appearance near the Pole, *&c.*) do all equally prove the Earth's Rotundity. Also the terrestrial Appearances (*viz.* The Art of Navigation; the Appearance and Occultation of Mountains and Towers; the Distances of Places; the Winds and Points of the Compass, *&c.*) can only be accounted for by this Figure and no other. Also the *artificial Globe*, which we make to represent the Earth, exhibits all these Things as they really are on the Earth; which would certainly, in some Cases, be different, except this was it's true Representation. The Earth is not of a plane Figure, as is manifest from the aforesaid Arguments; nor of a hollow Figure; for then the Sun and Stars would appear sooner to the western Inhabitants than to those of the East: But we see the Rising Sun every Day illuminates the Vallies, before it shines upon the back Parts of the opposite Mountains *.

* Another Argument is drawn from the commodious and equal Distribution of the Waters in the Earth. 'For 'since, by the Law of Gravity, the Waters will possess the lowest place; therefore, if the Mass of the Earth 'was cubic, prismatic, or any 'other angular Figure, it would 'follow, that one (too vast a 'Part) would be drowned; and 'another too dry. But being 'thus orbicular, the Waters 'are equally and commodiously 'distributed here and there according as the Divine Providence saw most fit. *Derham's* '*Physico-Theology*, Book 2. Ch. '1. Art. 2.

A spherical Body also is the only one that is similar, or hath all it's Parts alike among themselves; so that they may be mutually applied one to another. For if two equal Parts of a Sphere be considered, the Properties of each are the same; which will not hold in any other Body. Thus in measuring the Earth in different Places; if it be performed by the same Method, it is always found of the same Magnitude: which doth not a little contribute to the Proof of these Assertions.

ANY impartial Person may easily perceive of how little Weight their Reasons are, who believe the Earth to be of a plane Figure. For which they argue, 1. Because on a clear Day the Earth seems to be plane, as well as the Sea, if we look every way round about us (*e*). 2. If the Surface of it was not plane, it would be more easily moved, and more subject to fall to pieces; whereas flat Figures are more firm and stable (*f*). 3. The Rising or Setting *Sun* and *Moon* are cut, as it were, with right Lines; but if the Earth was spherical, they ought to be divided by circular ones. Thus the Ancients reasoned, ridiculously, as *Aristotle* tells us. 4. Some argue that the many high Mountains must, of necessity, deface it's Rotundity. 5. Others believe the Sea to be higher than the Earth. 6. Some again think it impossible that Men should stand upon the opposite

(*e*) This Argument is confuted by what is said above, about the Appearance and Disappearance of Mountains.

(*f*) A spherical Body is not so liable to decay and fracture as another, because all the Parts of the Surface are equidistant from the Center. And we are taught by Sir *Isaac Newton*'s *Principles*, that the Divine Being at the Creation, bestowed the Power of Attraction upon all the Matter in the Universe, whereby all Bodies, and all the Parts of Bodies, mutually attract themselves and one another; which, as the Rev. Dr *Derham* observes, is the natural Cause of the Sphericity of our common Globe. See *Newton*'s *Principia, Lib.* 3. *Prop.* 7. Also *Derham*'s *Physico-Theol.* *p.* 40.

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Part of the Earth to us; and not fall headlong into the Sky. This last has created a Scruple not only with the Vulgar, but even with some Men of Letters; which I could scarce have believed, had I not heard them confess, that tho' they could not deny the *spherical Figure of the Earth* for many urgent Reasons; yet they could not remove this one Objection out of their Minds; not to mention the Taunts and Scoffs of St *Augustine*, and other Fathers upon this Subject. These and such like Reasons are soon confuted by any one: and that the highest Mountains have scarce any Proportion to the Semidiameter of the Earth, we shall afterwards demonstrate (*g*).

THEREFORE, since the spherical Figure of the Earth is plainly proved and demonstrated, we ought to make ourselves acquainted with those Definitions and Properties which are applied to, and found in the *Sphere*, or *Globe*, by Geometricians, and accommodate them to the Earth; as the Center, the Diameter, the Axis and Poles, the greater and lesser Circles of the Sphere, *&c.* (*h*).

WHO

(*g*) The highest Mountains are so inconsiderable to the Semidiameter of the Earth; that they alter the Figure of it no more than Dust upon the Surface of our common Globes, as is proved below, *Ch.* 9. *Prop.* 7.

(*h*) *Tacquet* (*Lib.* 1. *Chap.* 2. *of his Astronomy*) has drawn some very neat Coonsequences from the roundness of the Earth; which we shall here transcribe from Dr *Clarke's Notes upon* Rohault's *Physics*. *Vol.* ii. *Pag.* 5.

1. If any Part of the Earth's Superficies were plane, Men could no more stand upright upon it, than upon the side of a mountain.

2. Because the Superficies of the Earth is globular, the Head of a Traveller goes a longer Journey than his Feet: and he who rides on Horseback, goes a longer Journey than he who walks the same Way on Foot. So, likewise, the upper Part of the Mast of a Ship goes more Way than the lower; *viz. Because they move in Part of a larger Circle.*

3. If a Man goes the whole Circumference of the Earth's Orb; the Journey which his Head travels exceeds that of his Feet, by the Circumference of a Circle whose Radius is the Man's height.

4. If

WHO it was that first found out the Earth's spherical Figure, lies hid in the dark Ruins of Antiquity. Certainly the Opinion is very ancient (*i*); for when *Babylon* was taken by *Alexander*, Eclipses were there found calculated and foretold, for many Years before Christ: which could not be done without the Knowledge of the *Earth's Figure.* Nor can *Thales* the *Grecian* be thought to have been ignorant of it, by his foretelling an *Eclipse,*

CHAP. IV.

Of the Mensuration and Magnitude of the Earth.

THE Mensuration of the Earth is founded upon the Solution of these three Problems. 1. To measure the Diameter or Semidiameter, and also the Circuit or Periphery. 2. To find the Area or

4. If a Vessel full of Water be raised perpendicularly, some of the Water would continually run over, and yet the Vessel would be always full. *viz. Because the Superficies of the Water is continually depressed into Part of a larger Sphere.*

5. If a Vessel full of Water were carried directly downwards tho' none of it run over, yet the Vessel would not be full, *viz. Because the Superficies of the Water is continually raised into Part of a less Sphere.*

6. Whence it follows, that the same Vessel will hold more Water at the Foot of a Mountain than at the Top; and more in a Cellar than in a Chamber.

To which may be added, lastly, that two Threads upon which two Steel Balls hang perpendicularly (*or two Walls of a House raised by a Plumb Line*) are not parallel to each other, but Parts of two Radius's which meet at the Center of the Earth.

(*i*) *Ptolemy, in his Almagest*, tells the Times of three Lunar Eclipses, observed by the *Babylonian* Astronomers. The first on the 19th of *March* 721 Years before Christ: The next on or Extent of the Superficies. 3. To compute the Solidity, Mass, or Magnitude. These have such a Relation among themselves, that one being known the rest are obtained by Geometrical Propositions, supposing the Earth a Sphere; as is shewn in *Chap.* 2.

THIS Proposition has been esteemed so advantageous and useful, that it hath employed and exercised the greatest Genius's for many Ages: so that whole Volumes have been writ only upon this Subject. Wherefore I thought it would not unacceptable to the Students in Geography, to give a short History of the *Mensuration of the Earth.*

DIOGENES Laërtius highly commends *Anaximander*, a Disciple of *Thales*, for that, beside other Astronomical Inventions, he first discovered the Perimeter or Circuit of the terraqueous Globe. This *Anaximander* lived about 550 Years before the Birth of our Saviour: and Authors mention no other Measure but his, to be used by the Mathematicians of succeeding Ages, even 'till the Time of *Eratosthenes*: so that it is (very likely) his Measure, which *Aristotle* mentions in the end of his second Book *De Cœlo.* "Mathematicians, says he, who "have attempted to measure the Earth say it is "400,000 Furlongs round." Hence we have the Dimensions of the Earth according to *Anaximander*. But besides this one Testimony of *Diogenes Laërtius*, we are entirely in the dark by what Invention, Artifice,

on the 8th of *March* 720 Years before Christ; and the third on *September* 1, 710 Years before the same *Æra.* And *Herodotus* (*in his History, Lib.* 1. *Sect.* 74. *Pag.* 30.) *says*, "*That* "*after the War had been carried on six years between the* "Medes *and* Lydians; *as they* "*were going to battle, the* "*Day became presently as dark* "*as the Night; which Change* "*had been predicted by* Thales "*to the* Ionians." This was about 594 Years before Christ; which shews us that the Philosophers in these early Times were not ignorant of the true Figure of the Earth.

tifice, or Method, *Anaximander* found out this Measure. Therefore *Eratosthenes* (who attempted it next after him, and lived about 200 Years before Christ; being perfectly skilled in Mensuration, and other Parts of Mathematics) is justly celebrated and esteemed by all, as the first and most accurate Measurer of the Earth. He discovered the Perimeter of it to be about 250000 Furlongs; or, as others say, 252.000; which are, as *Pliny* tells us, 31.500.000 *Roman* Paces, equal to 31.500 Miles of 1000 Paces each.

STRABO relates the Contents of three Books of Geography that had been writ by *Eratosthenes*, which are now lost, thro' the Injury of Time. *Cleomedes* also mentions the Method he used in measuring the Earth; which we shall explain afterwards. However, this Measure of *Eratosthenes* was judged by several Mathematicians (and first by *Hipparchus* about 100 Years after) to deviate something from the Truth: tho' *Hipparchus* himself has not left us his Method of Mensuration; but only added 25.000 Furlongs to *Eratosthenes*'s Perimeter. After him *Posidonius* (an excellent practical Astronomer, and also well skilled in Philosophy; a little before Christ, in the Time of *Cicero* and *Pompey*) set about it, and found, by his Mensuration, the Circumference of the Earth to be 240.000 Furlongs, as *Cleomedes* tells us. But *Strabo* differs from him, and says it was 180.000: whence there arose great Doubts and Disputes about the Cause of this Difference. It is true, *Strabo*'s Method is delivered in few Words, and is in Fact much nearer the Truth than the other: but because *Cleomedes* both read and taught *Posidonius*'s Geography, we shall explain his Method hereafter.

NEVERTHELESS, the Dimensions of *Eratosthenes* were made use of by many; even 'till the Time of *Ptolemy*. And he, in the year of Christ 144, used 180.000 Furlongs as the Perimeter, and affirmed

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affirmed it to be most agreeable to the Truth; insomuch that this Invention was, by *Theon*, ascribed to him. We gather also from the Writings of *Ptolemy*, that *Marinus*, a famous Geographer, by whose Writings he himself was very much instructed, had attempted something in this Matter.

PTOLEMY (in *Lib.* 1. *Chap.* 3, of his *Geography*) tells us, that he also had tried this Method, not the same Way with his Predecessors; but in Places of different Meridians: tho' he does not tell us how much he found the Perimeter to be, but contents himself with the Measure he had received from *Marinus* and his Predecessors, *viz.* 180.000 Furlongs.

AFTERWARDS, when the Cultivation of Arts by degrees disappeared in *Greece*, nothing was done in this Business; neither did the *Romans* trouble themselves about it.

BUT the *Arabs* and *Saracens* having wrested the Glory of Empire and Arts out of the Hands of the *Grecians*, did not neglect this Part of Mathematics. For (as *Snellius* tells us from *Abulfeda*, an *Arabian* Geographer, who flourished about the Year of Christ 1300, and whose Writings were published at *Rome*) about the 800 Year of the Christian *Æra*, *Maimon* King of *Arabia*, or Calif of *Babylon*, being a great Student in Mathematics, commanded *Ptolemy's Great Construction* to be translated from the *Greek* into *Arabic*, which is, by the *Arabians*, called *Ptolemy's Almagest*. This *Maimon* having summoned together several learned Mathematicians commanded them to search into the Earth's Perimeter. For performing of which they made use of the Planes of *Zinjan* or *Mesopotamia*; and measuring from North to South under the same Meridian 'till they had decreased the Elevation of the Pole one Degr. they found the length of their Journey to be 56 Miles, or $56\frac{2}{3}$; from whence we find the Perimeter

Perimeter of the Earth to be 20.160 Miles, or 20.340, according to that Measure.

FROM that Time to this none were solicitous about solving the Problem. The *Arabs* commonly using the Dimensions they had received from their Mathematicians; and the *Italians*, when they began to study Astronomy, made use of *Ptolemy*'s Measure, *viz.* 180.000 Furlongs (which make 21.600 *Italian* Miles, or 5.400 *German*; so that 60 of the former, and 15 of the later was thought to make a Degree: but they ought to have reckoned 15⅝ of the latter, because 32 Furlongs nearly equal a *German* Mile; thus the Periphery would be 5625. *Germ.* Miles). But about 80 Years ago *Snellius*, a famous Mathematician, and Professor at *Leyden*, observing that the Perimeter of the Earth, commonly made use of by Mathematicians (or the length of a Degree, vulgarly supposed 15 *Dutch* Miles), was questionable, and founded upon no certain Demonstration; he thereupon applied himself with great Industry to it's Mensuration, and happily finished it; demonstrating the Magnitude of one Degree of the Earth's Periphery to be 28.500 Perches (each containing 12 *Rhinland* Feet) or 19 *Holland* Miles; and the whole Periphery to equal 6.840 Miles (reckoning 1.500 Perches, or 18.000 *Rhinland* Feet, to a Mile).

WE thought fit to premise this short History of the Earth's Mensuration, that the Reader may perceive by what Industry it hath been managed, and with what Difficulty effected. Now we shall treat of the different Methods of Mensuration, all founded upon the Discovery of the Earth's *spherical Figure*, which we have proved in the preceding Chapter. Therefore, considering it *globular*, if it be cut by a Plane passing thro' the Center, the Section will be a great Circle of the Earth: if not thro' the Center, then the Section will be one of the lesser Circles. Also the Periphery of a great Circle upon the Surface of the Earth,

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or which is all one, on different Days. This Star did not rise above the Horizon *b* H *s* at *Rhodes*, but only glanced upon it at S: tho' it was elevated above the Horizon of *Alexandria* F R T, the Arch *t s* $\frac{1}{48}$ Part of the Periphery or 7 *degr.* 30 *min.* He tells us the Distance betwixt *Alexandria* and *Rhodes* is 5.000 Furlongs. Therefore, as 7 *degr.* 30 *min.* is to 1 *degr.* (or as $\frac{1}{48}$ to $\frac{1}{360}$, *i. e.* as 360 to 48) so is 5.000 to 666⅔ Furlongs in 1 *degr.* or as 1 : 48 : : 5.000: 24.000 Furlongs, for the whole Periphery of the Earth, according to *Posidonius.*

The fourth Method, that of Snellius.

IN the Methods above delivered we have constantly supposed the two Places to lie under the same Meridian; but because Places may lie plainer, and more commodious for this Purpose under different Meridians, we shall propose an Example in this Case which is that of *Snellius.*

LET therefore ABCD (*Fig.* 6.) be the Meridian of *Alcmair*, and B, *Alcmair* itself; where the Elevation of the Pole *b a* is 52 *degr.* 40½ *min.* and the Polar Distance BA 37 *degr.* 19½ *min.* 30 *sec.*

LET the other Place P be *Bergen-op-zoom*, whose Meridian is A P C, and it's Distance from the Pole, or Complement of Latitude (*viz.* to 51 *degr.* 29 *min.*) is A P 38 *degr.* 31 *min.* therefore, having drawn P G perpendicular to A B G, the Difference of their Distances from the Pole is B G 1 *degr.* 11 *min.* 30 *sec.*

AFTER *Snellius* had taken these Observations, he accurately measured the Distance B P, between *Alcmair* and *Bergen*, and found it to be 34710 *Rhinland* Perches; and the Angle of Position P B G 11 *degr.* 26 *min.* 2 *sec.* therefore in the right-angled Triangle P B G, the Hypotenuse P B and

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the Angle PBG being given, the Side BG is found to be 34018 Perches (which *Snellius* makes only 33930, for he abated 88 Perches on Account of the Stations where the Elevation of the Pole was observed). But the Arch BG, as was said before, is $71\frac{1}{2}$ *min.* therefore as $71\frac{1}{2}$ is to 1 *degr.* or 60 *min.* so is 33930 (or 34018) to 28473 Perches; or the round Number 28500 for 1 *degr.* equal to 19 *Dutch* Miles. Or by spherical Trigonometry; having AB, AP, and the Angle ABP given, find the Arch BP 1 *degr.* 14 *min.* which equals 34710 Perches; therefore 1 *degr.* will be 28300 Perches, or $18\frac{7}{8}$ Miles. The Reason why this Account differs from that of *Snellius* is; 1. He did not observe the Elevation of the Pole from the very Tops of the Towers B and P themselves, from whence the Angle GBP was taken, but from some Eminence or rising Ground a little remote from them: yet without Doubt the Altitudes of the Pole were the same on the Tops of the Towers. 2. Another Reason is, he took BG, BP, PG for right Lines, which are indeed circular; tho', in so small an Arch, the Difference is of little or no Moment. Therefore, granting *Snellius*'s Measure of a Degree to be 28500 Perches, equal to $18\frac{147}{650}$ Miles, (and mine 28300 making $18\frac{7}{8}$) the Perimeter of the Earth will be, according to *Snellius*, 10.260.000 Perches, or 123.120.000 Feet, that is 6.840 *Holland* Miles (*a*).

The

(*a*) The Measure of the Earth which *Snellius* with great Industry discovered, hath been deservedly embraced by the Learned; as being much more accurate than any of the former. Nevertheless, in a Matter of such Moment, and which is involved with so many Difficulties, the curious have not thought it safe to confide in any one, tho' the most skillful Mathematician; which we see confirmed by *Cassini* the Son of the famous Astronomer of that Name. For he having calculated the Numbers arising from *Snellius*'s Observation, af-

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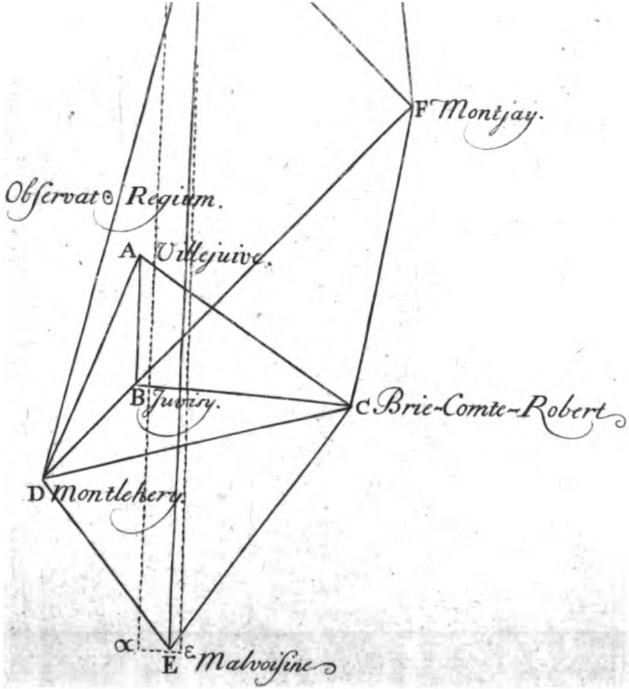

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The fifth, but first Terrestrial, Method.

HOW to perform the Work without Celestial Observations, or a Meridian Line, is explained in the

signed a much greater Measure to the Earth than *Snellius*; and also discovered some Errors in his Calculation, which spoiled the whole Process of his Work. See *Hist. Acad. Scien.* 1702. Add to this, that the Latitude and Angle of Position of Places can now be taken more accurately by Telescopes, which are begun, some Years ago, to be fitted to Astronomical and Surveying Instruments, instead of bare little Pins, which *Snellius* used. Tho' several others had set about this Work; yet some *French* Mathematicians, Fellows of the Royal Academy of Sciences, did most successfully perform it: whose Mensuration far exceeds all others, both in the Number and Accuracy of their Observations, and also in the Furniture of most exquisite Instruments. Wherefore we esteem it well worth the while, to give the whole Method of Operation in short.

The Points in the Figure which are marked with *Roman* Letters, shew the Places chosen for Observation; whose Bearing, or Situation, in respect of the Royal Observatory at *Paris*, is seen in a Geographical Map. (*See Fig.* 8.)

By the same Method of Mensuration which *Snellius* used, they proposed to find the Distance between the Parallels of the Places N and E, or the Line N α in Fathoms; so that this Distance being known, and the Latitude of each Place N and E, or the Difference of Latitude; that is an Arch of the Meridian intercepted between the two Parallels, being found, it will appear how many Fathoms make any determined Arch of a great Circle of the Earth, such as the Meridian is: from whence it will be easily found how many Fathoms equal a Degree, or the whole Periphery of the Earth. Afterwards it was thought fit to measure the Line N β, the Distance between the Parallels of the Places N and Q; so that the Latitude at Q being also observed, there might be had an Arch of the Meridian equal to the whole Distance β α. For by this Means, they could more accurately determine the Measure of the Earth's Periphery, when they had found it the same by two Operations. These Lines they measured by a continued *Series of Triangles* drawn from the Line A B; for it being directly plane and straight, they had the Advantage of measuring it with *Iron Rods* as accurately as could be, and found it to be 5663 Fathoms.

The Latitudes of the Places were taken by an Instrument, whose Radius was 10 *Paris* Feet; and the Angles of each Triangle by a Quadrant of a Circle whose Semidiameter was $3\frac{1}{6}$ Feet; both which Instruments were accurately divided by *Diagonal Lines*.

In the first Triangle A B C.
There are known by Observation

The Ang.	C A B	54°.	04′.	35″.
	A B C	95.	06.	55.
	A C B	30.	48.	30.

Found by measuring - - A B - 5663. 00. (*Fath. Fe.*)
Hence by Calculation is found the Side - - A C - - 11012. 05.

In the second Triangle ADC.
DAC 77°. 25′. 50″
ADC 55. 00. 00.
ACD 47. 34. 00.
Fath. Fe.
AC 11012. 5.
Hence DC 13121. 3.

In the third Triangle D E C.
DEC 74°. 09′ 30″.
DCE 40. 34 00.
CDE 65. 16. 30.
Fath. Fe.
DC 13121. 03.
Hence DE 8870. 03.

In the fourth Triangle DCF.
DCF 113. 47. 40.
DFC 33. 40. 00.
FDC 32. 32. 20.
Fath. Fe.
DC 13121. 03.
Hence DF 21658. 00.

In the fifth Triangle D F G.
DFG 92. 05. 20.
DGF 57. 34. 00.
GDF 30. 20. 40.
Fath. Fe.
DF 21658. 00.
Hence DG 25643. 00.
And FG 12963. 03.

In the sixth Triangle G D E.
GDE 28. 09. 30.
Fath. Fe.
DG 25643. 00.
DE 8874. 03.
Hence GE 31897. 00.

When they had found the Line GE, by another Series of Triangles, to be 31893 *Fath.* 3 *Feet*; they divided the Difference which made up the lesser Measure 31895 *Fath.*

In the seventh Triangle HFG.
HFG 36. 50. 00.
HGF 104. 48. 30.
Fath. Fe.
FG 12963. 03.
Hence HG 12523. 00.

In the eighth Triangle HGI.
HGI 31. 50. 36.
HIG 43. 29. 30.
Fath. Fe.
HG 12523. 00.
Hence GI 17562. 00.
And HI 9570. 00.

In the ninth Triangle HIK.
HIK 49. 20. 30.
HKI 53. 06. 40.
Fath. Fe.
HI 9570. 00.
Hence IK 11683. 00.

In the tenth Triangle I K L.
LIK 58. 31. 30.
IKL 58. 31. 00.
Fath.

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	Fath. Fe.
IK	11683. 00.
Hence KL	11188. 02.
And IL	11186. 04.

In the eleventh Triangle KLM.

LKM	28. 32. 30.
KML	63. 31. 00.
	Fath. Fe.
KL	11188. 02.
Hence LM	6036. 02.

If the Sum of the three Angles ILK, KLM, MLN. be taken from 360 Degrees, there will remain the Angle ILN 119 *degr.* 32 *min.* 40 *sec.*

In the 12th Triangle LMN.

LMN	60. 38. 00.
MNL	29. 28. 20.
	Fath. Fe.
LM	6036. 02.
Hence LN	10690. 00.

In the 13th Triangle ILN.

ILN	32. 40.
	Fath. Fe.
LN	10691. 00.
IL	11186. 04.
IN	18905. 00.

Here are found three Parts of the Space intercepted between the two Places E and N, *viz.* EG, GI, IN, not exactly in the Meridian Line it self N α; but so as the Meridional Distances may be found by the following Operations. Also after they had found the Length of GI and IN by another Series of Triangles, as they had done before in the Line GE, they proposed to measure a new straight Line RS (and found it to be 3902 *Fath.*) by which the Measures of the aforesaid Lines might be verified, and so be a Foundation to them in their proceeding to the Point Q.

Hence were found the Lines { ML 6037. IN 18907. IG 17564.

In the 14th Triangle LMO.

LMO	58. 21. 50.
MOL	68. 52. 30.
	Fath. Fe.
ML	6037. 00.
Hence LO	5510. 03.

In the 15th Triangle NOL.

NOL	115. 01. 30.
ONL	27. 50. 30.
	Fath. Fe.
LO	5510. 03.
Hence NO	7122. 02.

In the 16th Triangle NOP

NPO	72. 25. 40.
PNO	67. 21. 40.
	Fath. Fe.
NO	7122. 02.
NP	4822. 04.

In the 17th Triangle NPQ.

NPQ	83. 58. 40.
PNQ	70. 34. 30.
	Fath. Fe.
NP	4822. 04.
NQ	11161. 04.

Therefore they had got the Lines { QN 11161. 4. NI 18907. 0. IG 17564. 0. GE 31895. 0.

But before they could actually set upon measuring the Earth, all these were to be referred to the Meridian Line α β passing thro' the Point N, that these Lines following might be known, *viz.*

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N β	answering the Lines	Q N
N γ		N I
I θ or $\gamma\,\delta$		I G
G ε or $\delta\,\alpha$		G E

of which the Line $\beta\alpha$ is compounded, shewing the Distance between Q β and $\alpha\varepsilon$, Parallels of Latitude of the Places Q and E. For this being found, and an Arch of the Meridian intercepted between the same Parallels being known, they had in Effect obtained their Desire, *viz.* the Measure agreeing to a known Part of the Periphery of the Earth.

Let therefore βN γ δ α, Iθ, Gε be Parts of the Meridian Circle, passing thro' the Places N, I, G; also Q β, I γ, Gδ, and α E ε Parallels of Latitude passing perpendicularly thro' those Meridians in the Places Q I G E.

Then in the Triangle Q β N rightangled at β, the Inclination of the Line QN to the Meridian Line N β is observed, *viz.*

The Angle QNβ 18°. 55′.
Fath. Fe.
And the Line NQ is 11161. 4.
Hence NB 10559. 3.

In the Triangle N γ I rectangled at γ,
γ N I 2°. 9′ 10″.
Fath. Fe.
IN 18907. 0.
Hence Nγ 18893. 3.

In the Triangle G I θ, rectangled at θ, G I θ 1. 9. 0.
Fath. Fe.
I G 17564. 0.
Hence Iθ, or $\gamma\,\delta$ 17560. 3.

In the Triangle G E ε, rectangled at ε,
E G ε 00. 26. 00.
Fath. Fe.
GE 31895. 0.
Hence Gε, or $\delta\,\alpha$ 31894. 0.

Hence the Distance between the Parallels of the Places N and E, *viz.* the Sum of the three Lines, N γ, $\gamma\,\delta$, $\delta\,\alpha$, is 68348 Fathoms; to which if the Line N β be added, it will make up the Distance between the Parallels of the Places Q and E 78907 *Fath.* 3 *Feet.*

Then it remained to observe the Difference of Latitude of the Places E, N, and Q; or the Arches of the Meridian intercepted between their Parallels. To which end there were taken three Stations, a little distance from the Places themselves; for the sake of better Observation.

The first Station was distant from the Place E 18 *Fathoms* Southward; the second from the Place N 65 *Fathoms* Northward; the third from the Place Q 75 *Fathoms* Eastward.

The Arch of the Meridian intercepted between the first and second Station was found to be 1°. 11′. 57″. between the second and third was 122. 35.

But if 83 *Fath.* (the Sum of 18 and 65, by which the first and second Station were further than the Place N and E) be added to 68.348 (that is to the Line N α the Distance between the Parallels of the two Places N and E) the Sum will be 68.431

68.431 *Fath.* (the Distance between the Parallels of the first and second Station) which is equal to an Arch of 1° 11′ 57″. Therefore the Length of 1 Degr. is 57064 *Fath.* 3 *Feet.*

Also if 57 *Fath.* (the Difference between 75 and 18) be substracted from 78907 *Fath.* 3 *Feet* (the Distance between the Parallels of the Places Q and E) the Remainder will be 78.850 *Fath.* 3 *Feet.* (the Distance between the Parallels of the first and third Station) which agrees to the Arch of 1°. 22′. 55″. Hence 1 Degree is 57.057 Fathoms.

Therefore there was taken for 1 *degr.* 57.060 *Fath.* an intermediate Number betwixt these two.

Thus with great Labour they acquired the Measure of 1 Degr. of the Periphery of the Earth as accurately as possible. Nevertheless it is to be confessed, the Difficulty of making Observations (especially those about the Latitude of the Place) was so great, that it really baffled the profound Endeavours of the diligent Observers. And tho' the Instrument was exquisitly divided, and of 10 Foot Radius, yet they could not avoid an Error of 2 Seconds, which on the Earth make 22 Fathoms; by which the observed Latitude of each Place might be wrong.

Since this Error could not be avoided, it was thought necessary to measure a greater Space, so that it might be divided among more Degrees, by which means a lesser Portion of it would fall to any one.

This the famous *Cassini* effected a few Years ago, at the Command of the most Christian King, as he was marking a Meridian for the Observatory at *Paris*, thro' the South Provinces of *France*. He then measured with the same Care all that Space between *Paris* and the *Pyrenean* Mountains; to which if the former Distance between *Malvosine* and *Amiens* be added, they make 7½ Degr. Hence the Measure of the Earth is procured more accurately, and concluded on more safely, than from the former Observations only. And by this Mensuration he found 1 Degr. to make 57. 292 Fath. which by the former was computed to be 57.060 Fath.

Monsieur l'Abbé Bignon *tells us, that the same Meridian would have been observed round the whole World by Monsieur* de Chasel *(a Person of great Courage and Experience) with the same Exactness as it was begun; but that the War was at that Time every where unfortunately kindled, whereby we are deprived of a more accurate Measure.*

But to proceed. The same *Cassini*, by comparing the several Degrees in the aforesaid Space, thought himself to have found that there was no certain and determinate Measure to a Degree; but that one surpassed another continually towards the Equator by almost an 800th Part. So that to a Degree northward from the Observatory of *Paris* there were found 57 055 Degr. and to the next Degree Southward of it it 57.126½ which is more by 71½. *See. Hist. Acad. Scien.* 1701.

But by what we said above, about the Figure of the Earth, in our Notes upon the third Chapter, it appears there is some small Difference between one Degree and another; which can scarcely be perceived by meer Observation. Tho' this Increase is not towards the South, as *Cassini* thought, but to the North. Nevertheless, because *France* is almost an Intermediate between the Pole and the Equator; the Degrees there will be in a Medium betwixt the least at the Equator and the greatest at the Pole.

According to the aforesaid Dimensions,

One Degree of the Circumference of the Earth contains

Paris Feet	343752	*French* Leagues each 2000 Fath.	$28\frac{323}{500}$
London	366669	*English* Miles each 5280 Feet	$69\frac{783}{1760}$
Rhinland	356117	*Rhinland* Miles each 18000 Feet	$19\frac{14117}{18000}$

The Periphery of the Earth contains

Paris Feet - - - -	123750720	*French* Leagues - - -	$10312\frac{14}{25}$
London Feet - - - -	132000768	*English* Miles - - - -	$25000\frac{8}{55}$
Rhinland Feet - -	128202185	*Rhinland* Miles - - -	$7122\frac{1237}{3600}$

The Diameter of the Earth contains

Paris Feet - - - - -	39391077	*French* Leagues - -	$3282\frac{2359}{4000}$
London Feet - - - -	42017149	*English* Miles - - - -	$7957\frac{4189}{5280}$
Rhinland Feet - - -	40808032	*Rhinland* Miles - -	$2267\frac{2032}{18000}$

Min	French Feet	English Feet	Rhinl. Feet	Sec.	Fren Feet	Eng. Feet	Rhin Feet
1	5729	6111	5935	1	95	102	99
2	11458	12222	11871	2	191	204	198
3	17188	18333	17806	3	286	306	297
4	22917	24445	23741	4	382	407	396
5	28646	30556	29676	5	477	509	495
6	34375	36667	35612	6	573	611	594
7	40104	42778	41547	7	668	713	692
8	45834	48889	47482	8	764	815	791
9	51563	55000	53418	9	859	917	890
10	57292	61111	59353	10	955	1019	989
20	114584	122223	118706	20	1910	2037	1978
30	171876	183334	178059	30	2865	3056	2968
40	229168	244446	237411	40	3819	4074	3957
50	286460	305557	296764	50	4774	5093	4946
60	343752	366669	356117	60	5729	6111	5935

Jurin's Appendix.

the three following Methods *. Let P B (*Fig.* 9.) the Altitude of a Tower or Mountain, be found out by *Altimetry*; and imagine P S, the furtheſt Diſtance from which it may be ſeen, to be a right Line, as being ſo very ſmall a Part of the Earth's Periphery; and the Triangle B P S rectangled. In which having B P and P S given, the Angle P S B may be found; which is equal to the Angle P R S, whoſe Meaſure is the Arch S P (*b*). Therefore as this Arch is to 1 *degr.* ſo is the Diſtance P S meaſured by ſome known Meaſure to the Length of 1 *degr.* in that Meaſure. For Example, Let the Altitude B P be 480 Paces or $\frac{1}{8}$ part of a *German* Mile; and let the Diſtance of P from S, the Point which terminates the Sight, be 40000 Paces, or 10 *German* Miles. Then by the Problem *Cap.* 2. ſay, As P S 40000 Paces is to 480: ſo is the Radius 10000000 to 11904, the Trangent of the Angle B S P, or S R P, or of the Arch S P, which is 41. *min.* And as 41 *min.* is to 60: ſo is 40000 Paces to 59000; that is, about 15 Miles for 1 Degree.

OR the Semidiameter P R may be found without the Table of Sines, thus; As B P is to P S: ſo is P S to P R: Or as 480 is to 40000: ſo is 40000 to 3333333 Paces, for the Semidiameter P R (*c*).

The ſixth, but ſecond Terreſtrial, Method without knowing the Diſtances.

THE ſame Semidiameter P R (*Fig.* 9.) may be thus found. Suppoſe P B to be a high Mountain,

* The three following Terreſtrial Methods, are more to be admired for their Theory, than for any Truth in their Practice. For tho' they be all Geometrically true; yet Refraction and want of Accuracy, in taking the Height and Horizontal Diſtances of Mountains, hinder the Exactneſs which is required in a Matter of ſuch Nicety.

(*b*) *Euclid. Lib.* 6. *Prop.* 8.

(*c*) *Euclid. Coroll.* to *Prop.* 8. *Lib.* 6.

or

or a Tower. If a Tower, it's Altitude may be found by a Plumb-line to be, suppose, 100 Paces: If a Mountain, the Height P B may be known by *Altimetry* to be, suppose, 480 Paces. Then with a Quadrant at the Top B, find the Angle at the furthest Point of Sight P B S 88 *degr.* 37 *min.* wherefore B R S will be 1 *degr.* 23 *min.* Let the Sine of 88 *degr.* 37 *min.* be taken from the Canon of Sines, and substracted from the Radius 100000000, and then say; As the Remainder is to the Sine of 88 *degr.* 37 *min*: so is B P 100 Paces to the Semidiameter S R in Paces (*d*).

The seventh, but third Terrestrial, Method.

THIS Method (*Fig.* 9.) seems to be more accurate and fitter for Practice, where two Mountains or Eminences are used, whose Distance (without their Altitudes) is found by *Longimetry*. For Example, Let B P be a Mountain, Tower, or Castle; and let S T be another, whose Distance, suppose, 5 *German* Miles. *First*, by a Quadrant (or otherwise) find the Angle B T R 89 *degr.* 45 *min.* and on the other Mountain the Angle T B R 89 *degr.* 55 *min.* which will make the Angle P R S to be 20 *min.* because the three Angles T, B, and R, are equal to two right Angles, or 180 *degr.* Then say as 20 *min.* : 60 *min.* : : 5 *miles to* 15 Miles for 1 Degree (*e*).

THESE are the chief Methods of measuring the Earth; for by knowing the Measure of 1 *degr.* the whole Perimeter, Diameter, Superficies, and Solidity, may be found.

BUT the Perimeter of the Earth, according to *Snellius*, is 6840 *Dutch* Miles, or 10260000 *Rhinland* Perches, or 123120000 Feet. Therefore the

(*d*) See *Prop.* 14. of *Chap.* 2. above. (*e*) *Ibid.*

Semidiameter of the Earth is, by the *Prob.* of *Chap.* 2. found to be 1088$\frac{1}{4}$ Miles, or 1633190 Perches, or 19598300 Feet; and the Superficies 18811353$\frac{1}{5}$ square *Dutch* Miles *.

AND the Solidity of the whole is 40956831512 Cubic Miles.

BUT because accounting by *German* Miles is more common, 15 of which make a Degree, these may be used on this Condition, that 15 of such Miles may equal 19 *Holland* Miles, or that one Mile may contain 1900 *Rhinland* Perches, or 22800 *Rhinland* Feet.

OF such Miles the Circumference of the Earth is 5400, the Semidiameter 860, the Superficies 9278181 square Miles, and the Solidity 265693384 cubic Miles.

YET the *Italian* Miles are most commodious, 60 of which make a Degr. and a Mile a Minute. Tho' these *Italian* Miles are to be computed such as each of them may contain 475 *Rhinland* Perches. The Circuit of the Earth in this Measure is 21600 Miles, and it's Semidiameter 3440.

THESE Things being explained, let us next consider why the abovementioned Measures of several Authors differ; and what is wanting in each.

IN the first Method, these Things are dubious. 1. The Elevation of the Pole might, perhaps, have been taken wrong. 2. It may be doubted whether the Places observed were in the same Meridian or no. 3. Their Distance is not particularly known; nor the Measure which the *Arabians* then used. So that in this Mensuration these Things are required. 1. The Length of their Mile (accounted

* According to our *Norwood*, and the Famous *Cassini*, the Measures are thus; the Diameter 7,967,7 *English* Miles; the Surface, 199,444,201 Mileas and the solid Content, 264,856,000,000 Miles.

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counted 4000 Cubits according to *Alfraganus*) is not well known to us. 2. They do not ſhew us the Situation of the Places whoſe Latitude they took; neither can we be certain of their Diligence in taking them. 3. Nor do they tell us by what Method they meaſured their Diſtances.

IN *Eratoſthenes*'s Menſuration, theſe Things are to be obſerved. 1. He did not add 15 *min.* (for the Angle made by the Sun's apparent Ray *x z* and the true central Ray) (*Fig.* 7.) to the Arch found B Z 7 *degr.* 12 *min.* 2. He did not prove *Syene* and *Alexandria* to lie under the ſame Meridian. 3. The Termination of Shadows cannot be accurately obſerved; and alſo a Style at any other Place within 150 Furlongs of *Syene* would have been without a Shadow. 4. He took the Diſtance between *Syene* and *Alexandria* from common Computation which is ſeldom exact; neither do we certainly know the Length of his Furlong.

IN *Poſidonius*'s Method theſe Errors may be objected. 1. He ſuppoſed *Canopus* not to riſe above the Horizon of *Rhodes*; tho' it is known to be elevated two Degrees there: however, he could not be ſure it exactly touched it. 2. He determined the Diſtance between *Rhodes* and *Alexandria* by Gueſs, and computed Voyages. 3. The Length of his Furlong is not truly ſtated. 4. It may be doubted whether *Alexandria* and *Rhodes* lie under the ſame Meridian, &c.

IN the Terreſtrial Methods there are theſe Defects. 1. An Error is eaſily committed in taking the exact Altitude of any Mountain. 2. The extream Point of Viſion cannot be exactly determined, by reaſon of the Refraction and the Weakneſs of the Sight.

THUS far concerning the Dimenſions of the Earth's Perimeter, it's Semidiameter, Superficies, and Solidity; from whence we might compute it's

2 Solidity

Solidity or Weight: but because it's Parts are of different Gravities and Textures unknown to us, we cannot so well determine it's Weight but by Supposition.

IT must be remember'd that the Semidiameter of the Earth is the Model of all Celestial Dimensions, both in determining the Distances of the Planets from the Earth, and from one another, and in computing their Magnitude. Thus we say, the Sun is distant from the Earth 1200 Semidiameters, and the Moon 59, *&c.*

IN *Geography*, not only the greater Circles, as the Equator, *&c.* are to be considered, but also the lesser are of Use, that are parallel to the Equator, *viz.* how many Miles, or Perches, make a Degree in such or such a Parallel? Therefore we have taken the following Table out of *Snellius*, and have added to his Measure of a Degree in Perches, the same in *German*, *Dutch*, and *Italian* Miles.

A Table shewing the Extent of one Degree in the several Parallels.

The Latitude of the Place, or the Distance of each Parallel from the Equator.

	Perches in 1 Degr.	*Holland Miles*		*German Miles*		*Italian Miles*	
Deg.		*Miles*	*Perch.*	*Miles*	*Min.*	*Miles*	*Min.*
Equ.	28500	19		15	0	60	
1	28496	18	1496	14	59	59	59
2	28483	18	1483	14	59	59	58
3	28461	18	1461	14	58	59	54
4	28431	18	1431	14	57	59	51
5	28392	18	1392	14	56	59	45
6	28344	18	1344	14	55	59	41
7	28288	18	1288	14	53	59	34

Latitude	Perches in 1 Degr.	Holland Miles		German Miles		Italian Miles	
Deg.		Miles	Perch	Miles	Min.	Miles	Min.
8	2822	18	1223	14	51	59	25
9	28149	18	1149	14	48	59	16
10	28061	18	1067	14	46	59	6
11	27976	18	976	14	43	58	55
12	27877	18	877	14	40	58	42
13	27769	18	769	14	37	58	29
14	27653	18	653	14	33	58	14
15	27526	18	529	14	29	57	58
16	27396	18	396	14	25	57	42
17	27255	18	255	14	21	57	24
18	27105	18	105	14	16	57	4
19	26947	17	1447	14	11	56	44
20	26781	17	1281	14	6	56	24
21	26607	17	1107	14	0	56	0
22	26425	17	925	13	54	55	36
23	26234	17	734	13	48	55	12
24	26036	17	536	13	42	54	48
25	25830	17	330	13	36	54	24
26	25616	17	116	13	29	54	0
27	25394	16	1394	13	22	53	28
28	25164	16	1164	15	15	53	0
29	24927	16	927	13	7	52	28
30	24681	16	681	13	59	51	96
31	24429	16	429	12	51	51	24
32	24169	16	169	12	43	50	52
33	23902	15	1402	12	35	50	20
34	23628	15	1128	12	26	49	44
35	23346	15	846	12	17	49	8
36	23057	15	557	12	8	48	32
37	22761	15	261	11	59	47	56
38	22458	14	1458	11	49	47	16
39	22149	14	1149	11	39	46	39
40	21832	14	832	11	29	46	0
41	21509	14	509	11	19	45	16
42	21180	14	180	11	9	44	36
43	20843	13	1343	10	58	43	52
44	20501	13	1001	10	47	43	8
45	20152	13	652	10	36	42	24
46	19798	13	298	10	25	41	40
47	19437	13	0	10	14	41	0
48	19070	12	1070	10	2	40	8

Latitude	Perches in 1 Degr.	Holland Miles		German Miles		Italian Miles	
Deg.		Miles	Perch	Miles	Min	Miles	Min
49	18698	12	698	9	50	39	20
50	18319	12	319	9	38	38	32
51	17936	11	1436	9	26	37	44
52	17546	11	1046	9	14	37	0
53	17152	11	652	9	2	36	8
54	16752	11	252	8	49	35	26
55	16347	10	1347	8	36	34	24
56	15937	10	937	8	23	33	32
57	15522	10	522	8	10	32	40
58	15103	10	103	7	57	31	48
59	14679	9	1179	7	44	31	0
60	14250	9	750	7	30	30	0
61	13817	9	317	7	16	29	4
62	13380	8	1380	7	2	28	8
63	12939	8	939	6	48	27	12
64	12494	8	494	6	34	26	16
65	12045	8	45	6	20	25	20
66	11592	7	1092	6	6	24	24
67	11136	7	639	5	52	23	28
68	10676	7	176	5	38	22	32
69	10213	6	1213	5	23	21	32
70	9748	6	748	5	8	20	32
71	9279	6	279	4	53	19	32
72	8807	5	1307	4	38	18	32
73	8333	5	933	4	23	17	32
74	7846	5	346	4	8	16	32
75	7376	4	1376	3	53	15	32
76	6895	4	895	3	38	14	32
77	6411	4	411	3	23	13	32
78	5925	3	1425	3	8	12	32
79	5438	3	938	2	52	11	28
80	4949	3	449	2	36	10	24
81	4458	2	1458	2	20	9	20
82	3966	2	966	2	5	8	20
83	3473	2	473	1	50	7	20
84	2979	1	1479	1	34	6	12
85	2484	1	984	1	18	5	12
86	1988	1	488	1	3	4	12
87	1492	0	1492	0	47	3	12
88	995	0	991	0	31	2	4
89	497	0	498	0	16	1	4
90	0	0	0	0	0	0	0

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CHAP. V.

Of the Motion of the Earth.

THE *Pythagorean* Motion or Circumvolution of the Earth (not a Nutation or Quaking) is according to the *Copernicans* the Cause of most of the Changes in the Celestial Appearances, which would otherwise be constantly the same in every Place (*a*). Tho' indeed there is not any Property of

(*a*) This System was not invented by *Pythagoras*, as some imagine, for *Diogenes Laërtius* expresly saith, that *Pythagoras's* Opinion was, *That the World was round, containing the Earth in the middle of it*; and that *Philolaus*, the *Pythagorean*, was the first that said the Earth moved in a Circle: But some say *Hercetas* the *Syracusian*. *Derham's Astro-Theology*.

Pythagoras, who lived in Society with the *Egyptian Priests* seven Years, and was initiated into their Religion, carried home from thence, besides several Geometrical Inventions, the true System of the Universe, and was the first that taught in *Greece*, that the Earth and Planets turned round the Sun, which was immoveable in the Center; and that the Diurnal Motion of the Sun and fixed Stars, was not real but apparent, arising from the Motion of the Earth round it's Axis.

The next Person who made a considerable Figure this way, was *Ptolemy* with his Cycles, Epicycles, and Eccentrics, he quite burthened Nature, and his Hypothesis shews too much of Art; these are all now exploded, and his solid Spheres broke to pieces; he left behind him a Work entitled *Almagest*, or the great Construction, which was founded on the Observations of *Hipparchus*.

Copernicus had the Honour to restore the ancient *Pythagorean* System, notwithstanding the Prepossession the *Ptolemaic* had gained in the World.

To these succeeded the Noble Dane, *Tycho Brahe*, whose Hypothesis in a great Measure is compounded of the other two, and seems designed to account for of the Earth so much disputed against and cavilled at as this; so as even not long ago to have undergone the Censure of the *Romish* Church. However, because it seems very probable to many that there is such a Motion, we shall endeavour to explain it.

IT is known to all, even the Vulgar, that the Sun, Moon, and Stars, appear to move from East to West, and to return to almost the same Places again in the Heavens, in the Space of twenty four Hours. So that either they must really move, or we our selves be moved; and attribute our Motion to them. For it is a self-evident Principle, that if two Things change their Distance from one another, one of them, at least, must have moved.

THAT the Earth is fixed, or at Rest, and the Stars with the Heavens in Motion, was a common Opinion; and is so still among those that are accounted *Ptolemaic* Astronomers: But the *Pythagoreans* of old maintained, that the Stars constantly kept their Places; and that the Earth was revolved about it's Center. Of which Sect was the celebrated *Aristarchus* of *Samos*; who, for defending this Opinion, was by his Enemy and Adversary accused, before the Bench of the *Areopagites*, of having violated the Laws of Religion; but was fortunately absolved by them *. Afterwards, but very

for the difficulties of both of them, and so is liable to several Objections in them both. He was very skillful in observing, and in the Furniture of his Observatory exceeded even Princes and Kings.

John Kepler, the last I shall mention, by the help of *Tycho's* Labours, found out the Laws the Celestial Bodies observe in their Motion, and laid the Ground-work of the Modern Philosophy. Thus I have given a short Sketch of the Rise and Perfection of this Science.

* The Great *Galileo*, the Modern Assertor of the same Doctrine, met with the fate of the ancient *Samian* Philosopher; He

very few aſſented to this Opinion; ſo that it lay hid, or, as it were, buried in Oblivion for many Ages; inſomuch that we find not the leaſt mention of it in the Schools, till the famous Aſtronomer *Copernicus*, about 200 Years ago, brought it again into Eſtimation, and backed it with ſeveral Arguments, ſo that many excellent Aſtronomers after him embraced it; among whom flouriſhed not long ſince the great *Kepler*, Profeſſor of Mathematics to the Emperor; and *Galilæo* an *Italian*, Mathematician to the great Duke of *Tuſcany*; as alſo *Lanſberg* a *Dutchman*.

AND whereas we obſerve two *apparent* Motions in the Heavenly Bodies (one by which all the Stars both fixed and wandering ſeem to be carried about the Earth, and to riſe to the Meridian, and ſet under the Horizon *nearly* in the ſame or equal Times: The other, which is called their Annual Motion; by which the Planets with different Motions, and the fixed Stars with equal Velocity, are carried the contrary Way from Weſt to Eaſt) the *Ptolemaics* affirm both theſe Motions to be in the Stars themſelves, or in their Orbs; But the *Copernicans* attribute this firſt apparent Motion to that real one of the Earth, not in being transferred from one Place to another, but to it's Rotation about it's Axis from Weſt to Eaſt, while it continues ſtill in it's own Place (which cauſeth the apparent Motion of all the Stars the contrary way). And they alſo free the Sun and the fixed Stars from the aforeſaid annual Motion, by attri-

He was brought before the Inquiſition, and obliged ſolemnly to abjure his Aſtronomical Tenets, that the Sun ſtood immovable in the Midſt of the Univerſe, and that the Earth moved round it, as about it's proper Center. The poor Man was forced to ſay, that he did, with a ſincere Heart, and Faith unfeigned, abjure, curſe, and deteſt, the aforeſaid Errors and Hereſies.

buting

buting the apparent Motion of these to the real annual Motion of the Earth round the Sun; and to the Inclination of it's Axis: Notwithstanding they assign this said annual Motion to the rest of the Planets; only they deny the *Sun* to be a Planet, and advance him to the Center of the *System*, where *Ptolemy* had placed the Earth; and make the rest of the Planets, *Saturn*, *Jupiter*, *Mars*, the *Earth*, *Venus*, and *Mercury*, revolve round him.

THE Reasons for the *Copernican Hypothesis* are these.

1. THE Motion of the Earth round it's Axis, continuing in the same Place, will best account for the Appearance of such a vast Number of Stars which seem to perform their Revolutions round the Earth in 24 Hours; and therefore this Motion is most agreeable to Reason: As it happens with us when we sit in a Ship, sailing towards others at Rest in the Harbour; tho' they seem to approach and come nearer us, yet we do not assign that to any Motion in them. And as Nature never performs that by many means which may be done by a few; it is very likely the same Rule is observed here.

2. THE Motion of the Stars would thus be incredibly swift and beyond all Imagination; because their Distance, in Respect of us, is almost infinite, and the Orbit they have to run round so prodigiously great, that they must move at least 100000 Miles in a Minute: On the other hand, if this Motion be assigned to the Earth, we need not introduce a *progressive* Celerity; for tho' she remains still in the same part of Space, she solves the Phænomena by revolving about her Axis.

3. THIS Argument is the stronger if we compare the vast Bulk of the Celestial Bodies with the Bulk of the Earth. For as the Sun is at least 200

times bigger than the Earth, and ſome of the fixed Stars 1000 times; it is much more probable, that the Earth revolves round it's Axis with an eaſy natural Motion, than that ſuch vaſt Bodies ſhould move from one Place to another with incredible Swiftneſs.

4. THE moſt celebrated Aſtronomers are, with *Tycho*, forced, by the Phænomena, to deny that there are ſolid Orbs, ſuch as the Ancients made uſe of the better to explain their imaginary Motion of the Stars; hence their Arguments for this diurnal Rotation about the Earth, are leſs cogent. The Reaſon why they are forced to deny this, is, becauſe that one Planet is often ſeen within the Orb of another; which muſt cauſe a mutual Penetration.

5. NO Reaſon can be given why the Stars ſhould move round the Earth: But, on the other hand, it is moſt agreeable to Reaſon, that the Earth, and the reſt of the Planets, ſhould move about the Sun.

6. NEITHER the *Pole* nor the *Axis* about which the Stars are ſuppoſed to revolve, is real: On the contrary, there is a known *Pole* and *Axis* in the Earth.

7. FOR this Reaſon alſo Navigation is much eaſier from Weſt to Eaſt than the contrary Way. For they can ſail from *Europe* to *India* in about four Months; but can ſcarce return in ſix Months: becauſe in their going they move to the ſame Point with the Earth; but in their returning they ſteer contrary to the Earth's Motion.

8. BECAUSE the *Celeſtial Phænomena*, ſuch as the riſing and ſetting of the Stars, the Inequality of Days, *&c.* cannot be accounted for, by any other Motion than that of the *Earth*. And the Commodiouſneſs and Neceſſity of this Hypotheſis, is more particularly perceived in the wonderful Ap-

pearances

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pearances of the Planets; for explaining of which the *Ptolemaics* are forced to suppose several unnecessary interfering *Circles*, *Epicycles*, and *Eccentrics*, without any Reason: Whereas the *Copernicans* can naturally account for them all, (without any previous Suppositions,) by the annual Motion of the Earth, or it's Revolution round the Sun, *viz.* 1. Why the Planets seem sometimes retrograde; and why *Saturn* is oftener and continues longer so than *Jupiter*; and *Jupiter* oftener and longer so than *Mars*, &c. and also why they are carried sometimes with a swifter Motion, and at other times appear stationary. 2. Why *Mercury* and *Venus* can never be seen a whole Night together. 3. Why *Venus* is never carried further from the Sun than 48 degr. and *Mercury* never more than 28; and so can never be seen in Opposition to the Sun. 4. Why *Venus* may be seen in the Evening after the *Sun* is set; and the next day in the Morning before the Sun rises, &c.

I FORBEAR to mention any more Phænomena, (these being the principal from whence a solid Argument may be drawn for the Motion of the Earth) since they are all easily and naturally accounted for upon this *Hypothesis*; so that it would be strange if the Earth should not move, when such evident Appearances require such a Motion. And tho' these Arguments are not *demonstrative*, yet they render this Hypothesis preferable to the other, which supposeth the Motion of the Heavens. And we must admit of the one or the other.

BUT the Arguments which some alledge to the contrary are easily answered; such as, 1. The Earth is not fit for Motion, because of it's Gravity. 2. The Parts of the Earth naturally tend in a right Line to the Center; and therefore a circular Motion is against Nature. 3. If the Earth were

were moved, a Stone dropped from the Top of a Tower would not fall juſt at the Foot of it. 4. A Ball ſhot from a Cannon Eaſtward at a Mark, could not come home to it, if the Mark with the whole Earth did at the ſame Time move towards the Eaſt: or at leaſt would hit the Mark ſooner when ſhot towards the Weſt. Alſo a Bird flying towards the Eaſt would be retarded: but forwarded in flying the contrary Way. 5. Towers and Buildings could not ſtand upright, but would fall: and Men, by the quick Rotation, would become giddy. 6. Becauſe (ſay they) the Stars are obſerved to change their Places, but not the Earth. 7. Becauſe the Earth is in the Center of the World; but the Center of any Thing is not moved. 8. Becauſe the holy Scriptures confirm the Stability of the Earth.

TO all which the *Copernicans* anſwer thus. To the *firſt*, that the whole Earth, taken together, is not abſolutely heavy. For Gravity conſiſts in the Tendency of the homogeneous Parts to the whole; and tho' this kind of Gravity be found in the Sun and Moon, they are nevertheleſs not accounted weighty.

TO the *ſecond* they anſwer, that the circular Motion of the whole does in no wiſe hinder the relative Motion of the Parts, which are moved in in a direct Line towards the Center; as appears by the Parts of the Sun and Moon.

TO the *third* they anſwer three ways, 1. That heavy Bodies are not carried directly towards the Center of the Earth, but in the ſhorteſt Lines poſſible to it's Superficies; which are thoſe parallel to the Tower; as Iron does not tend to the Center of the Loadſtone, but to the Loadſtone it ſelf. 2. The whole Atmoſphere adheres to the Earth, and is moved along with it: therefore when Bodies are thus let fall, they partake of this circular Motion,

Motion, and are carried downwards as it were in a Vessel. 3. *Gassendus*, by repeated Experiments, found, that if a Body be projected from another Body in Motion, it will partake of the Motion of that other Body; as a Stone dropped from the Top of a Mast, while the Ship is in a very swift Motion, is not left by the Ship but falls at the Foot of the Mast. Also a Ball shot perpendicularly from the Foot of the Mast falls in the very same Place. Therefore the Objection is of no Force.

TO the *fourth* they answer as to the third.

THE *fifth* Objection hath no Place, because the Motion of the Earth is even and uniform, without dashing or striking against any other Body; and the Buildings being heavy Bodies, and homogeneous to the Earth, are moved as if they were in a Ship; which tho' it sails either swiftly or slowly, yet if the Motion be even and steady without Waves and on smooth Water, Bodies set upright will not be overturned, nor a Glass of Wine be spilt.

TO the *sixth* we answer, that we are not sensible of any Change of Place in the Stars, only of their Situation in Respect of our selves; which may appear and really be, whether we with the Earth, or the Stars themselves are moved; or even tho' both we and the Stars should be in Motion (*b*).

IN

(*b*) Most of these Objections are answered by the Laws of Mechanics, thus: Let W, E be the Line of Motion of a Ship from W to E, representing the Motion of the Earth from West to East. Let MT (in *Fig.* 9) be a Mast, from the Foot of which, M, suppose a Body to be thrown perpendicularly to the Top T, in the same Time that the Ship moves from M to D. From the Conjunction of these two Forces (M T the Projection, and M D the Ship's Motion) it is manifest, by the known Laws of Motion, that the Body will not be carried perpendicularly to the place T, but in the Diagonal Line M B, IN the *seventh* Objection both the Assertions are false; or at least doubtful.

TO

MB, so as to accompany the Mast in it's Motion from MT to BD. Then suppose the Body to fall from the top of the Mast B to the foot D, in the same Time the Ship moves from D to G; and it is plain, that, by the mutual acting of BD, the centripetal Force, and BF=DG, the Ship's Motion, the Body will fall in the diagonal Line BG, and also accompany the Mast in it's Motion from D to G; so that tho' it was really carried in the Lines MB, BG, yet it will seem to have moved, only upwards and downwards, parallel to the Line FG.

Also (in *Fig.* 10.) let MT be the same Mast, and suppose a Projectile to be cast eastward from the Stern S, to the top of the Mast T, in the Time the Ship moves also eastward from M to D; then will it's Motion upwards describe the Diagonal SB; where let it be obstructed so as to seem to fall perpendicularly to D, in the Time the Ship moves from D to G; then, as before, it will describe the Diagonal BG, tho' it seemed to move upwards only in the Line TS, and downwards in FG

So (in *Fig.* 11.) if a Body be projected westward from the Head of the Ship H to the top of the Mast T, in the Time it moves eastward, HG equal to the Distance MH, then will it's Motion upwards describe the perpendicular Line HB. And if in the same time it seems to descend from B to H that the Mast moves HG= G*b*=MH, it's Motion downwards will describe the Diagonal BG. So that, in this Case, it ascends by a perpendicular Line, and falls by an inclining Line; tho' it seemed to ascend by the inclined Line *b* F, and to fall by the perpendicular Line FG.

Hence it is plain that Bodies may appear to have a Motion, directly contrary to their real and absolute Motion: so that it is pleasant to conceive, how falsly we may judge of the Motion of Bodies by their unequal Distance from us; not considering that we may be insensibly moved from them.

Hence also is deduced that ingenious Experiment of *Galilæo*, mentioned in *Derham's Astro-Theology*, as follows.

'Shut yourself up (*says he*) 'with your Friend in the great 'Cabin of a Ship, together 'with a Parcel of Gnats and 'Flies, and other little winged 'Creatures. Procure also a 'great Tub of Water, and put 'Fishes therein. Hang also a 'Bottle of Water up to empty 'itself, drop by drop into another such Bottle placed underneath with a narrow Neck. 'Whilst the Ship lies still, diligently observe how these 'little winged Creature fly 'with the like swiftness to every

TO the *eighth* is answered, 1. The holy Scriptures, in physical matters, always speak according to Appearances, and the Capacity of the Vulgar; as where the *Moon* is said to be *a great Light created to give Light in the Night* (c): tho' the Moon

'ry Part of the Cabin; how 'the Fishes swim indifferently 'towards all Sides; and how 'the descending Drops all fall 'into the Bottle underneath. 'And if you throw any thing 'to your Friend you need use 'no more Force one way than 'another; provided the Di- 'stances be equal. And if you 'leap, you will reach as far 'one way as the other. Hav- 'ing observed these Particulars 'whilst the Ship lies still, make 'the Ship to sail with what 'Velocity you please; and so 'long as the Motion is uni- 'form, not fluctuating this 'Way and that Way, you shall 'not perceive there is any Al- 'teration in the aforesaid Ef- 'fects; neither can you from 'them conclude whether the 'Ship moveth or standeth still. 'But in leaping you shall reach 'as far on the Floor as you did 'before; nor by any Reason 'of the Ship's Motion shall you 'make a longer Leap towards 'the Poop than the Prow; 'notwithstanding that whilst 'you were up in the Air, the 'Floor under your Feet had 'run the contrary Way to 'your Leap. And if you cast 'any thing to your Compa- 'nion, you need use no more 'Strength to make it reach 'him, if he should be towards 'the Prow and you towards 'the Poop, than if you stood 'in a contrary Position. The 'Drops shall all fall into the 'Bottle that is lower; and not 'one towards the Poop, al- 'tho' the Ship shall have run 'many Feet, whilst the Drop 'was in the Air. The Fishes 'in the Water shall have no 'more Trouble in swimming 'towards the fore part of the 'Tub, than towards the hin- 'der Part; but shall make to 'the Bait with equal swiftness 'on any Side of the Tub. 'And lastly the Gnats and Flies 'shall continue their Flight in- 'differently towards all Parts, 'and never be driven together 'towards the Side of the Ca- 'bin next the Prow; as if 'wearied with following the 'swift Motion of the Ship. 'And if by burning a few 'Grains of Incense you make 'a little Smoak; you shall 'perceive it to ascend on high, 'and hang like a cloud, moving 'indifferently this Way or 'that, without any inclination 'to one Side more than ano- 'ther.' All which Observations depend upon the aforesaid Laws of Mechanics; and sufficiently answer the most considerable Objections, deduced from Philosophy, against the Motion of the Earth.

(c) *Gen.* i. 16.

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be not great in Respect of the *Earth* and fixed Stars, nor hath any Light in itself; neither doth it give Light to the Earth every Night. Thus the *Sun* is said *to go forth from the End of the Heavens, and to haste to it again* (*d*); whereas in Truth there is no such End to be found. So in the Book of *Job* (*e*), the Earth is said to be of a plane and square Figure, underpropped and supported with Pillars; which is not to be understood in a literal Sense, as even the most ignorant may perceive (*f*): More

(*d*) *Psal.* xix. 6. *Eccles.* i. 15.

(*e*) *Job* ix. 6. xxviii. 24.

(*f*) Besides, Things are often spoke of as they appear, not as they really are. For as St *Hierom* says (upon the thirteenth Chapter of St *Matthew*) *It is the Custom of the Scriptures, for the Historian to relate the Opinion Men had of many Matters, as at that Time those Matters were by all People taken to be.* And in another Place. *There are many Things in the Holy Scriptures, which are spoken according to the Opinion of the Time in which they were done; and not according to Reality.* And we should find very absurd Conclusions would follow the taking of these Texts in a literal Sense. For in *Joshua* x. 12, 13. the Sun is ordered to *stand still upon mount Gibeon, and* the *Moon in the valley of Ajalon*. But it would be very absurd to take this in a strict literal Sense, and imagine those two great Luminaries were confined to those two Places, otherwise than in Appearance to the victorious *Israelites*. And if so considerable a Part of the Transaction be spoken according to it's Appearance, why may not the whole? Why might not this Station as well be an Arrest of the Earth's Motion, as that of the Heavens? If the whole Miracle was not (as some not improbably think) effected by Means of some preternatural Refractions, or extraordinary Meteors, &c. And so for the Recess of the Sun, or it's Shadow in *Hezekiah*'s Case (2 *Kings* xx. 10. and *Isai.* xxxviii. 8.) which in appearance seemed to be the Sun, is, by divers learned Men, thought to have been the Effect of such like extraordinary Refractions or Meteors, as mentioned in the last Case: Or if it was a real Regress, why not of the Earth rather than the Sun and whole Heavens? See *Derham*'s *Astro-Theol.* Besides, Historiographers seldom confine themselves to a Geometrical or Astronomical nicety in their Descriptions of Things. As, in 1 *Kings* vii. 23. it is written, that *Solomon made a molten sea, ten cubits from one brim*

More Places might be quoted, but these are sufficient; for the holy *Scriptures* were not given us to philosophize by, but to increase our Piety. 2. Some Places of *Scripture* are also produced, which do not speak of the Mobility of the Earth, but of it's *Stability* and *Permanency*; as that in *Job* aforesaid (*g*).

THUS we have declared in brief what that *Motion* is, which the *Copernicans* assign to the *Earth*; the more full and accurate Explication of which belongs to *Astronomy*. And this Motion being supposed, all the Phænomena we observe in a Globe revolved about it's Axis, must be applied to the Earth, *viz.* That the Axis upon which it is turned, is one of the Diameters: That the Poles are two immoveable Points in the Extremities of the Axis: That the great Circle, or Perimeter, in which the Rotation is made, is the Equator with it's Parallels, *&c.*

LET us now consider the *Velocity of the Earth's Motion*; which, in that about it's Axis, is not over all the Earth equal, but different according to the Distance from the Equator; being there

brim to the other, round all about, and a line of thirty cubits did compass it round about. But as 7 : 22 :: 10 : 31½ Cubits is very near the true Length of the Line that ought to encompass a round Vessel of ten Cubits Diameter.

(*g*) Such as *Psal.* xciii. 1. cxix. 90. civ. 5. *Eccles.* i. 4. and 1 *Chron.* xvi. 30. which Texts are all understood by learned Commentators to mean the unalterable Condition, Security, Peace, and Tranquility, of the Earth.

The Ambit of the Earth, by the most accurate, is apprehended to be 25031,4 Miles, which, divided into 24 Hours, makes the Revolution to be at the Rate of about 1043 Miles in an Hour; a Rotation that would as easily throw off the Parts of the Earth, especially the Waters, as the whirling round of a Wheel, or a Globe, would the loose Dust and Water thereon; but by Reason the Gravitating Power exceeds the Centrifugal, as 2174 exceeds 7,54,064, that is, above 288 times; therefore all Parts lie quiet and secure in their respective Places. *Derham's Astro-Theol.* p. 149.

swiftest

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swiftest as passing thro' a greater Space, and so by Degrees slower towards the Poles, as passing thro' a less Space in the same Time. Therefore since every Part of the Earth is moved thro' the Space of it's Periphery (or 360 Degr.) in 24 Hours; the Space of one Hour's Motion is found by dividing 360 by 24, which gives in the Quotient 15 Degr. and so much doth any Place on the Earth move (whether in the Equator or without it) in an Hour. Also 15 Degr. in the Equator make 125 *German* Miles, therefore it revolves 15 such Miles (or one Degr.) in 4 *min.* and in one *min.* 3¾ Miles.

BUT Places without the Equator, lying towards either Pole, are in the same Time revolved the same Number of Degrees: but these Degrees are much less than those in the Equator; so that the Celerity of Motion, or Progression, is as the Sines of the Arches by which these Places are distant from the Pole. *Example.* The Distance from the Equator (or Elevation of the Pole) of *Amsterdam* is 52 *degr.* 23 *min.* therefore the Distance from the Pole (or Complement of Latitude) is 37 *degr.* 37 *min.* whose Sine is 61037. Suppose another Place, under the Equinoctial, distant from the Pole 90 Degr. whose Sine also is 100000, but the Place under the Equinoctial moves 15 Miles in 4 *min.* and 225 an Hour. Therefore by the Golden Rule, as 100000 : 61037 : : 15 : 9 Miles, or so is 225 to 137 Miles. So that *Amsterdam* is carried every Hour 137 Miles, and in 4 *min.* 9 Miles, by this Motion.

THIS is more easily found by the foregoing Table; for by dividing 360 by 24 we find each Place to move 15 Degr. of it's own Circle in an Hour, and therefore 1 Degr. in 4 *min.* &c. consulting the Table with the Latitude of the Place, we find how many Miles it moves in 4 *min.* For *Example*;

Example; The Latitude of *Stockholm* is about 60 Degr. opposite to which in the Table is 7½ Miles. Therefore *Stockholm* revolves so many Miles in 4 *min*. and such is the *first Motion* in divers Places.

THE *Second Motion of the Earth*, is it's Change of Place; whereby every Part of it moves the same Space with the same Velocity. This Motion is determined by the Distance of the Earth from the Sun, or the Semidiameter of the Orbit in which it performs it's annual Revolution, moving in a Day about a Degr. and in an Hour 2½ *min*.

AS to the third Motion of the Earth, because it is more difficult to conceive, we shall leave it to Astronomers, who have found it necessary to be supposed. *Origanus* moves a Doubt about the second Motion; and supposes the Earth to be only moved by the first, but the Sun and fixed Stars by the second: Tho' the above-cited Appearances, in the Motions of the Planets, sufficiently confirm this annual Motion (*b*).

(*b*) This imaginary third Motion of the Earth they were obliged to suppose, to account for the disputed Inequality of the Declination of the Ecliptic, which is now by most Astronomers thought to be always the same; *seeing there is nothing which should disturb the perpetual Parallelism of the Earth, on which this Equality depends, except it should be the insensible* Nutation *of the Axis, and the Regress of the Nodes; from which Thing nevertheless no Variation of Declination, properly so called, can arise. Whiston's Astron. Lect. pag.* 57. That there is such a *Nutation* whereby the Axis of the Earth doth twice incline towards the Ecliptic, and twice return to it's former Position, see in *Newton's Prin. Phil. Nat. Book* iii. *Prop.* 21.

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CHAP. VI.

Of the Situation, or Place, of the Earth, in Respect of the Planets and fixed Stars.

THE *Situation of the Earth*, in the Syſtem of the World, in reſpect to the reſt of the Planets, hath ſome Relation to the Account we gave of the Earth's Motion, in the preceeding Chapter. For it is the general Opinion of the *Ptolemaic* Aſtronomers and Philoſophers, that the Earth, being the Center of the World, is placed in the middle of the Stars and Planets (*a*): But the *Copernicans*, with the antient *Pythagoreans*, place the Sun in the Center of all the Stars, and make the Earth a Planet performing an annual Revolution about him, between *Mars* and *Venus*; as is beſt underſtood by a Diagram of the Syſtem. Nevertheleſs they both agree in this, that the Earth may be accounted the apparent Center of the diurnal Motion, by which the Stars ſeem to be carried about in twenty four Hours. For both Aſtronomy and Geography require this Suppoſition; ſo that whether we adhere to the *Ptolemaic* or *Copernican* Hypotheſis, we do not detract from the Certainty of general Aſtronomy or Geography. Becauſe the Difference of theſe Opinions conſiſts only in this; that the *Ptolemaics* will have this Motion to be

(*a*) Since the World, or Univerſe, is infinite, the central Place of it cannot be determined: What our Author means by the World here is only our Solar Syſtem, in which Senſe he muſt be taken in what follows.

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be in the Stars themselves, but the *Pythagoreans* in the Earth; the Stars in the mean time resting: neither of which need be determined in *Geography* or *common Astronomy*.

ACCORDING to the *Ptolemaics* the Situation of the Earth, in respect of the Planets and fixed Stars, is this; The *Earth in the Center*, then the *Moon*, *Mercury*, *Venus*, *The Sun*, *Mars*, *Jupiter*, *Saturn*, and the *Fixed Stars*.

ACCORDING to the *Copernicans*; The Sun is placed in the Center of the System, as the Heart and *Focus* of the World; and next him is the Orbit of *Mercury*, then that of *Venus*, the Earth, *with the Moon*, *Mars*, *Jupiter*, *Saturn*, and the *Fixed Stars*.

IF it be required how far distant we are from each of the Planets, we must know that the Distance is not always the same, but continually changing; and therefore Astronomers reckon three Degrees of Distance, *viz.* the *least*, *greatest*, and *mean* or *middle Distance*; which last of the Earth, from the rest of the Planets, is as follows, according to most Astronomers (*b*).

The Earth is distant from	*The Moon*	60	of it's Semi-diameters.
	Mercury	110	
	Venus	701	
	The Sun	1150	
	Mars about	5000	
	Jupiter about	11000	
	Saturn about	18000	

NEVERTHELESS the Distance of the Earth from *Mars*, *Jupiter*, *Saturn*, and the fixed

(*b*) See Note (*m*) at the end of this Chapter.

Stars, is not so perfectly determined, for want of Certainty in their Parallaxes. Also in the *Copernican* System the Distance varieth, not only from the Motion of the Planets; but also from the Motion of the Earth itself.

THE Reason for either Opinion, (*viz.* of the *Ptolemaic* and *Copernican*) about the Situation of the Earth, are much the same with those we discussed in the preceeding *Chapter* about the Earth's Motion. For this Dispute is of great Affinity with the former. Because, if the Sun hath an annual Motion, then the Earth and not the Sun possesses the middle Place: But if the Earth so move, the Sun and not the Earth will certainly be in the Center.

THE following Arguments favour the *Copernican Hypothesis.*

1. THE Sun is not only the glorious Fountain of Light, which like a clear shining Torch, illuminates the *Earth*, *Moon*, *Venus*, and, without doubt, the rest of the *Planets*; but is also the *Focus* of Heat, and the Source of vital Spirits; whereby the whole Universe is subsisted and nourished: and therefore very probably possesseth the Center about which they all revolve.

2. IT is more likely that the Earth, with the rest of the Planets, should revolve about the Sun, when they receive Light and Heat from him; than that the Sun should move about the Earth, when he receives nothing from it.

3. THERE are many Causes why the Sun should possess the middle Place, and the rest of the Planets revolve round him, (especially if we embrace the Hypothesis of *Kepler* concerning the Motion of the Planets) the chief of which is, that the Sun, being a vast Body, *is moved about it's Axis*, and by a strong [*Vectory*] Force exciteth the

Earth and the rest of the Planets to a *circular Motion* (*c*).

4. THIS Rotation of the Sun about it's Axis is proved from the Observations of the Spots upon it's Surface by *Galileo* (*d*), *Scheiner*, &c. and we may reasonably presume, it is owing to this common Cause that the rest of the Planets revolve about theirs; but we cannot perceive a likelihood of any Motion in this Luminary (*e*).

5. IF

(*c*) The sagacious *Kepler* was the Founder of the *Newtonian Philosophy*: it was he that first found out the true System of the World, and the Laws which the celestial Bodies observe in their Motions; it was he that determined the true Path of the Earth, and the rest of the Planets about the Sun, and discovered the harmonic Proportions and Concinnities of their Distances and Motions: and tho' he did not demonstrate (and shew a Reason for the necessity of) such Laws and Proportions; yet he gave a Hint, and laid a Foundation for that Prince of Geometers Sir *ISAAC NEWTON*, to demonstrate an absolute Necessity of these Laws; and that without a total Subversion of the Laws of Nature, no other Rule could take Place in the Revolutions of the heavenly Bodies.

(*d*) *He was the first that applied a Telescope to the Heavens, and by it's means discovered a great may new surprising* Phænomena; *as the Moons or Satellites of* Jupiter, *and their Motions; the various* Phases of Saturn; *the Increase and Decrease of the Light of* Venus; *the mountainous and uncertain Surface of the* Moon; *the* Spots *of the* Sun; *and the* Revolution *of the Sun about it's own Axis: all which were first discovered and observed by this great Philosopher.* Keill's Astron. Lect. Pref. Pag. 11.

(*e*) From the later Observations of Astronomers it is manifest to our Sight, that also every Heavenly Body we have any good Views of, is turned round some principal Point, and also it's own Axis, *viz.* hath the like Annual Revolutions, and Diurnal Motions as those are which we ascribe to the Earth; yea even the more massy Globes of *Saturn* and *Jupiter*, which seem not in their own Nature more fitted for such Rotations. Wherefore we may certainly conclude, that it is as possible, and as probable, that this our lesser Globe, should perform it's Revolutions according to the same Law which is observed in the rest of the Planets, whereby the beautiful Order and Harmony of Motions is every

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5. IF we suppose the *Earth* placed betwixt *Mars* and *Venus*, and also place the Sun in the Center of the System; the Motion of each of the Planets will be exactly in Proportion to their several Distances from that Center: But this will not hold in the *Ptolemaic* Hypothesis, as is manifest by comparing the Motion of the *Sun*, *Venus*, *Mercury*, &c. (*f*).

6. THE *Celestial Phænomena*, mentioned in the former *Chapter*, to prove the annual Motion of the Earth, do likewise as effectually prove that this is the right Place in which it ought to be moved, *viz.* The Retrograde Motion, and *seeming* Immobility of the Planets; the admirable apparent Motion [*and Phases*] of *Venus* and *Mercury*, &c (*g*). For since the annual Motion of the Earth is presupposed in this Place, or in some other very near it;

every where preserved thro' the Frame of Nature.

(*f*) Sir *Isaac Newton*'s Demonstration, *That the Squares of the Planets Revolutions are as the Cubes of their Distances*, every where takes Place, if the Sun be supposed the Center of the Planets about him; but does not hold at all in Relation to the Earth; for if the Moon revolve round the Earth in (27½ Days) a Periodical Month, as it certainly does, the Sun, as being at a greater Distance, will take no less than 54700 Years, according to the aforesaid Law, to make his Revolution about the Earth. But since this Law, is found to be observed not only in the *primary Planets* about the Sun, but also in the *Secondaries* about *Jupiter*, *Saturn*, and the *Earth*, it is an inconteſtable Argument that the Sun is as much the Center of the Earth and Planets about him, as the Earth is of the Moon.

(*g*) These Observations, which utterly overthrow the *Ptolemaic* Hypothesis, are owing to later Astronomers. For they, by their Glasses, have found out that the spherical Figure of *Venus* and *Mercury*, seen from the Earth, will be altered, and have the same variety of Phases as the Moon hath, *viz.* will appear opake, horned, bisected, gibbous, and full, at proper Distances from the Sun, as explained upon the *Copernican* Hypothesis; which certainly establishes and confirms that Order and Situation, namely that *Venus* and *Mercury* revolve about the Sun in Orbits that are included within the Earth's Orbit.

this Argument, in my Opinion, is the best to defend it by; since this situation of the Earth cannot be proved immediately from it's diurnal Motion: Because it might possess the Center of the Universe, and have a diurnal Motion, tho' it wanted the annual; as *Origanus* supposed.

7. BY this *Hypothesis* likewise, the Variation of the Distances of the Planets from the Earth is accounted for.

THE *Ptolemaics*, on the other hand, oppose the *Pythagorean* Opinion, and endeavour to prove that the *True Place of the Earth* is in the Center of the World, by the following Arguments. 1. That heavy Bodies are all naturally carried towards the Center; but that the Earth is more ponderous than the rest, therefore it ought to reside in the Center (*h*). 2. Heavy Bodies would recede from the Earth towards the Center of the World, if the Earth itself was not in the Center. 3. The Center is the basest Place, and the Earth the ignoblest Part of the Creation; therefore it ought to be placed in the Center. 4. If the Earth was placed out of the Center of the World, and was not the Center of the Stars and Planets Motion, then would the Stars and Constellations at some Seasons of the Year appear greater than at others (*i*). 5. The *Medium of the Heavens* could not always be perceptible, nor would *Taurus* rise when *Scorpio* sets. 6. Neither would there be Equinoxes. 7. Nor would the *Moon* set, nor be eclipsed when the Sun was rising. 8. Neither could an equal Number of

(*h*) This Assertion is false: See the Note at the end of this Chapter.

(*i*) Tho' this does not hold in the fixed Stars, because of their immense Distance; yet all the superior Planets seem far greater in the middle of their Regresses than in the middle of their Progresses, because the Earth, in their Regresses, comes nearer these Planets an entire Diameter of the *Orbis Magnus*.

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Miles on the Earth anſwer to each Degree in the Heavens.

THE *Copernicans* eaſily refute theſe Arguments of the *Ariſtotelians*. For the firſt and ſecond is rejected, becauſe the Motion of heavy Bodies is not towards the Center of the Univerſe, but towards the Earth, a homogeneous Body; as is proved from the Parts of the *Sun* and *Moon*, and of the Loadſtone. In the *third* both the Aſſumptions are falſe; For the Center is an Honourable Place; and the Earth is no ways diſhonourable. The reſt of the Arguments are eaſily diſproved by a Deſcription of the Syſtem; it being firſt preſuppoſed that tho' the Earth's Diſtance from the Sun be very great, yet if compared with the Diſtance of the fixed Stars, it is ſo ſmall, that it hath no Proportion to it; which ſeems to ſome a great *Poſtulatum* in the *Copernican Aſtronomy* (*k*).

(*k*) To find this Variation of the Diſtance of the fixed Stars (ariſing from the annual Motion of the Earth, and called their annual Parallax) hath been often attempted by the *Copernican* Aſtronomers; becauſe that the annual Motion of the Earth would thereby be not only made probable, but certainly demonſtrated. This, I ſay, was attempted without Succeſs, 'till Dr *Hook* and Mr *Flamſteed*, by new invented accurate Inſtruments, ſeemed to have found out this annual Parallax to be at leaſt as much again as the double of the Sun's diurnal Parallax, *viz.* 47 Seconds. But Mr *Molyneaux* and Mr *Bradley*, by their late accurate Obſervations, could not, with all their Skill, determine any ſenſible Parallax at all (only they diſcovered a ſeeming new Motion of the fixed Stars, which (allowing the progreſſive Motion of Light) does in ſome Meaſure demonſtrate the annual Motion of the Earth). There appearing therefore, after all, no ſenſible Parallax in the fixed Stars, the *Anti-Copernicans* have ſtill room, on that Account, to object againſt the Motion of the Earth. And the *Copernicans* are ſtill obliged to hold, that the *Orbis Magnus* is but as a Point in Compariſon of the Diſtance of the neareſt fixed Stars; which is certainly (as our Author obſerveth) a great Blot in the *Copernican* Aſtronomy, left to be wiped out by future Ages.

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IT belongs to this Place to explain this Theorem; that the Distances of the fixed Stars, and superior Planets, *Mars*, *Jupiter*, and *Saturn*, are so great from the Earth that it's Semidiameter hath no sensible Proportion thereto; tho' it is not so in the Distance of the *Moon*, *Mercury*, and *Venus*: And if there is any Proportion between the Earth's Semidiameter, and the Sun's Distance, it is so very small that we are still not able sensibly to discover it (*l*).

THIS Theorem is thus demonstrated. 1. The fixed Stars, and superior Planets appear to rise the very same Moment in our sensible Horizon, that they are found by Calculation to do, if we were at the Center of the Earth; therefore our Distances from the Center (or the Earth's Semidiameter) hath no Proportion to the Distance of the fixed Stars. 2. If we take the Meridian (or other) Altitude of a superior Planet, or any of the fixed Stars, with an Instrument, we find it the same as if we had observed it at the Center of the Earth: Therefore the Semidiameter of the Earth is nothing in respect of their Distance. 3. If there were any such Proportion, the Distance of two fixed Stars would appear less near the Horizon than at the Meridian, where they are nearer the Earth by almost it's Semidiameter.

THIS also is true in the Sun, whose apparent Diameter is not perceived greater in the Meridian than in the Horizon.

(*l*) The quantity of the Parallax of *Mars* is determined, by M. *Cassini*'s and *Flamsteed*'s Observations, to have been scarce 30 Sec. when in Opposition to the Sun, and also in his Perihelion; from whence having the true Proportions of the Distances of the Planets from the Sun, we have, in effect, acquired the Parallax of the Sun itself, and of the rest of the Planets, and also their Diameters and Distances from the Sun and the Earth; of which see the Note at the end of this Chapter.

BUT the apparent Diameter of the Moon is found to be somewhat enlarged in the Meridian; because she is there nearer us, than when she is in the Horizon, almost a whole Semidiameter of the Earth (*m*).

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(*m*) Here follow the *Distances*, *Periods*, *Diameters*, *Gravities*, and *Quantities of Matter*, in those of the Celestial Bodies which have afforded Means for determining the same, as Mr *Whiston* has calculated them from the latest Observations, by Sir *Isaac Newton*'s Rules.

1. *Distances.*

Mercury	is distant from the Sun, *English* Miles, each 5280 Feet	32.000.000
Venus		59.000.000
The Earth		81.000.000
Mars		123.000.000
Jupiter		424.000.000
Saturn		777.000.000

2. *Periods.*

		D.	H.	M.
Mercury	revolves about the Sun in the Space of	87.	23.	16.
Venus		224.	17.	49.
The Earth		365.	6.	9.
Mars		686.	23.	27.
Jupiter		4332.	12.	20.
Saturn		10759.	7.	36.

3. *Diameters.*

Mercury	contains in Diameter, *English* Miles	4240
Venus		7906
The Earth		7935
Mars		4444
Jupiter		81155
Saturn		67870
The Sun		763460
The Moon		2175

4. *Densities.*

The Moon	contains in Density, Parts,	700
The Earth		387
The Sun		100
Jupiter		76
Saturn		60

5. *Gravities.*

CHAP. VII.

Of the Substance and Constitution of the Earth.

IN the preceding *Chapters* we have considered Four general Properties of the Earth, without Regard to it's Substance or Constitution: it will therefore be here proper to consider what kind of Body the Earth is, that we may not be ignorant how it's Parts cleave or are cemented together: which tho' it seem more to belong to *Physics*; nevertheless because it renders the Knowledge of the Earth more perfect, we shall here briefly discuss it; leaving the accurate Theory thereof to *Natural Philosophers*.

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5. *Gravities.*

The Moon	contains in Gravity, or quantity of Matter, Parts,	$0\frac{1}{26}$
The Earth		1
The Sun		229600
Jupiter		208 72
Saturn		97·328

6. The Weight of Bodies on the Surface of the	Sun is	24 Parts
	Earth is	1
	Jupiter is	1.99
	Saturn is	1.7
	Moon is	0.515

7. The Time of the Rotation about it's Axis of the	Sun is	25 Days
	Earth is	1 Day
	Moon is	29 Days
	Jupiter is	10 Hours
	Mars is	$24\frac{1}{4}$Hours
	Venus is	23 Hours

PROPOSITION I.

To shew of what simple or similar Bodies the Earth may consist, or be compounded.

THERE are several Opinions of Philosophers concerning this matter. The Peripatetics reckon four Elements in the Earth and the whole Sublunary World, sufficiently known to every on, *viz.* *Fire*, *Air*, *Water*, and *Earth*. Many of the Ancients, as *Democritus*, *Leucippus*, &c. were of Opinion, that the whole World consisted of very small solid Particles, which only differed in Magnitude and Shape. Which Opinion is followed by several of the Moderns; and some time since, *des Cartes* endeavoured to account for all the Phænomena of Nature upon this Hypothesis.

THE Chymists imagine that there are three *Principles* of Nature, viz. *Salt*, *Sulphur*, and *Mercury*, to which some reasonably add *Caput Mortuum*. But there seems to me upon a thorough Consideration of the Matter (to drop all ambiguous terms and quibbles), to be five *simple Bodies* which are the first Elements or Principles of all things, viz. *Water*, *Oil* or *Sulphur*, *Salt*, *Earth*, and a *fixed* Spirit; which some call an *Acid*, and is perhaps like the Mercury of the Chymists (*a*). For it

(*a*) The illustrious Sir *Isaac Newton* thus explains the true Principles of Nature. "It seems 'probable to me (*says he*) that 'God in the Beginning formed Matter in solid, massy, 'hard, impenetrable, moveable Particles, of such Sizes 'and Figures, and with such 'other Properties, and in such 'Proportion to Space, as most 'conduced to the End for 'which he formed them; and 'that these primitive Particles 'being solid, are incomparably harder than any porous 'Bodies compounded of them; 'even so very hard as never 'to wear or break in Pieces: 'no ordinary Power being able " to

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it is plain that all Bodies, and Parts of the Earth, may be resolved into these five elementary Substances. Nevertheless I do not suppose them to differ so much in their particular Essences, as in the Variety of their several Shapes and Magnitudes.

OF these Bodies, mixed after different manners, is the whole Earth composed; from which proceeds such a surprising Variety in the Nature of Bodies; tho' they are apparently similar (*b*). But since the more accurate Explication of these things belongs to Physics, we shall say no more to them here; but handle them at large in another Place.

PROPOSITION II.

The Earth is divided into dry and moist Parts, or into Land and Water; to which some add the Atmosphere.

THIS is the common Division of *Geography*. But then Water is taken, in a large Sense, for all sorts of *Liquids* and *Fluids*; and Land for the whole dry and consistent Parts of the Globe: whilst

'to divide what God himself 'made one in the first Creation. While the Particles 'continue entire, they may 'compose Bodies of one and 'the same Nature and Texture 'in all Ages: But should they 'wear away, or break in Pieces, the Nature of Things 'depending on them would be 'changed. Water and Earth 'composed of old worn Particles, and Fragments of Particles, would not be of the same 'Nature and Texture now, 'with Water and Earth composed of entire Particles in 'the Beginning. And therefore, that Nature may be 'lasting, the Changes of corporeal things are to be placed 'only in the various Separations, and new Associations 'and Motions of these permanent Particles; compound Bodies being apt to break, not 'in the midst of solid Particles, 'but where those Particles are 'laid together, and only touch 'in a few Points.' *Newton's Optics, Pag.* 375.

(*b*) See the Notes below on *Prop.* 6 and 7 of this *Chap.*

both

both comprehend various Bodies of Different Natures. To the Earth belong, 1. Sand, Gravel, Clay, and Mineral Earth; also Chalk, Minium, Oker, *Terra Sigillata*, Earth of *Samos*, *Bole-Armeniac*, and several other Kinds of Earth. 2. Stones of various sorts. 3. Metals; as Gold, Silver, Copper, Tin, Lead, Mercury or Quick-silver, &c. 4. Sulphur, Salt, Nitre, Allum, Bitumen, Vitriol, Antimony, &c. 5. Herbs, Animals, &c.

TO the Water belong, 1. The Ocean and Seas. 2. Rivers and fresh Waters. 3. Lakes and Marshes. 4. Mineral Waters, as *Hot Baths*, *Spaw Waters*, &c.

THE Atmosphere is a subtile Body which surrounds the whole Globe of the Earth, and includes the Air, Clouds, and Rain, &c. So that the Earth is best divided into these three Parts.

PROPOSITION III.

To explain how the Earth and Water cleave one to another; and constitute the Terraqueous Globe.

THE Earth, that is the dry Part of the Globe, is not terminated by an even and smooth Surface; but is here and there hollowed into Cavities, and in other Places elevated into Protuberances. In the Cavities found all over the Earth is contained the Ocean or Sea; so that this Part of the superficies of the Earth is covered with Water, and the other Part is raised and appeareth above the Waters. These Cavities are not depressed into an equal hollowness, but are in some Places rugged and rocky; and in others sunk down into Gulphs and Whirl-Pools. Also those Places of the Earth which are raised above the Waters, have in the middle of them, as it were, certain Navels or Eminences; and some Parts are either raised or depressed more than others. Hence the Water surrounding the whole

whole Globe is hindred from covering the higher Parts which appear above the Surface of the Ocean; and are called *Islands*: whereof some are great and others are small.

BESIDES that continued *Cavity* or *Chanel* in the Surface of the Earth, there are also within it's Bowels innumerable Openings, Recesses, Fissures, Chasms, Mazes, Swallows, Water Passages, and vast Receptacles; some of which are filled with salt Water, *viz.* such as are joined by subterraneous Passages to the Main Ocean; others with fresh Water, Rivers and Brooks; in some also are sulphureous Vapours, and smoaking Substances. So that *Seneca* seems to be in the right when he says, *That he trusts too much to his Sight, who does not believe that there is a large Quantity of Sea in the hidden Recesses of the Earth.* Nor do I perceive why there should not be much Sea Water received by these subterraneous Swallows; and formed into Bays by Banks or Bounds. And from the following Observations we cannot doubt, that there are a great many Cavities in the Bowels of the Earth. For several subterraneous Rivers are found in Places where the Earth is dug to a considerable Depth; as is common in Mines. 2. The Depth of the Sea is in some Places unfathomable. 3. There are in several Places, Caverns discovered near the Surface of the Earth. Thus in the West part of the Island of *Hispaniola*, there is a Mountain of a vast Height all hollowed within, into several Dens and Openings, in which Rivers rush precipitantly with such a violent Torrent and Noise of Waters, that they may be heard at five Miles distance. 4. Several Whirl-Pools are found in the Sea, and called in the Dutch Language *Maelstroom*. 5. Earthquakes also shew that there are such subterraneous Caverns. 6. Several Rivers hide themselves under the Earth, as the *Niger*, *Tigris*, *&c.* 7. Brackish

Fountains

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Fountains are obſerved in ſeveral Places, moſt of which certainly flow from the Sea. 8. In many Places the Ground trembles when People walk upon it, as at the Abby of S. *Omer* in *Flanders*; and in the Province of *Brabant* upon *Peel Mariſh*.

COROLLARY

Hence it is evident, that the Opinion of thoſe old Philoſophers, who maintained that the Earth at firſt floated upon the Waters, is falſe; for by this Means there would be no Chanels in the Sea, but it would be every where of an immenſe Depth. Some indeed of the Antients (eſpecially *Democritus*) are ſaid to have been of the following Opinion, *viz.* that the Waters were formerly mixed with the Earth; and that the whole Maſs being perfectly ſpherical, was ſoft and of an indifferent Conſiſtence betwixt wet and dry: But afterwards when the Particles of Water were gathered into one Body, according to the natural Property obſerved in Water, the earthly Particles, being ſeparated from the watery, came together and were curdled into Earth and wrought into Chanels by the Water in ſeveral Places. The ſame Hypotheſis is embraced by many modern Chriſtian Philoſophers, who think theſe Words of *Moſes* (or rather of GOD delivered to us by *Moſes*) *Let the Waters be gathered together into one Place, and let the dry Land appear*, ought to be thus underſtood. But the Fathers of the Primitive Church thought otherwiſe about this; for they judged that the Waters were ſeparated from the earthy Particles [*before the Creation*] and covered the Face of the whole Earth; and ſo occupied their natural Place; and then miraculouſly receded, and uncovered the Earth by the Power of theſe words of *Jehovah*; and that to this day they are hindred and reſtrained, by the eſpecial Providence

Providence of God, from flowing back and covering the Face of the whole Earth as before; so that the present Constitution of the Earth and Sea is by them accounted a perfect Miracle. But that there is no great Occasion to think it so much a Miracle we shall prove in Chap. xiii. where we shall shew, that the Inundation of the Waters, or Ocean, upon the adjacent Land, is hindred by the Altitude and Consistence of the Earth, which if removed by some certain Causes, whereof there are many, the Ocean will soon overflow the dry Land and cover it: whence there is manifestly, no need of a Miracle in the matter. Neither does the beforementioned Opinion of the Antients want it's Defects; for if the Earth and Water had been once mixed into one Mass; why did not the earthly Particles rather subside, and the Waters, being of less Gravity, cover the whole Earth? This they are forced to ascribe to a fortuitous Motion and Conjunction of the watery and earthly Particles. These things are said, by the way, to gratifie some that earnestly enquire into such matters; tho' they do not so properly belong to Geography; which hath no Regard to the Opinions of the Ancients, nor need fly to Miracles in explaining the Properties of the Earth (*c*).

PROPOSITION IV.

The Superficies of the Earth is continued, but not that of the Waters.

THE Superficies of that Part of the Earth which is raised above the Waters, is continued to the Superficies of the Chanel of the Sea, and that again to other elevated Parts of the Earth. Also the

(*c*) See Dr *Woodward's Essay towards a Nat. Hist. of the Earth*, &c.

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the Ocean, Bays and Rivers have one continued Superficies; but all Waters have not: for there are some Lakes whose Superficies are not joined with that of the Ocean, as the Lake *Parime*, and the *Caspian* Sea, &c.

PROPOSITION V.

The Constitution of the Earth, far within the Surface (which is our Habitation) towards the Center, is uncertain.

SOME think that Water taketh up the lowest Place about the Center; but it is more likely that dry Earth should occupy that Place (*d*). *Gilbert* was

(*d*) The learned and sagacious Dr *Halley*, to account for the Changes of the Needle's Variation, hath shewed a Possibility that the exterior Parts of the terraqueous Globe are formed inwardly like the concave Surface of a petrified Shell; and the internal as a *Nucleus*, or inner Globe, included within ours, with a fluid Medium between, which moves along with it, as having the same common Center, without sensibly approaching one Side or another, like the Globe of *Saturn* environed with his Ring. 'And 'tho' (*says he*) these included 'Globes can be of very little 'Service to the Inhabitants 'of this outward World, nor 'can the Sun be of Service to 'them: yet since we see all 'Parts of the Creation abound 'with animate Beings, why 'should we think it strange 'that the prodigious Mass of 'Matter, whereof this Globe 'doth consist, should be capable 'of some other Improvements, 'than barely to serve to support it's Surface? Why may 'we not rather suppose, that 'the exceeding small quantity 'of Matter in respect of the 'fluid Æther, is so disposed 'by the Almighty Wisdom, as 'to yield as great a Surface 'for the Use of living Creatures, as can consist with the 'Conveniency and Security of 'the whole.

'And tho' without Light 'there can be no living, yet 'there are many Ways of producing Light which we are 'wholly ignorant of: The Medium itself may be always luminous after the Manner of 'our *Ignes Fatui*: The concave Arches may in several 'Places shine with such a Substance was of Opinion that the Body of the Earth within is nothing but a very hard Loadstone; and that these exteriour Parts towards the Surface, which are penetrated into by digging, and on which Herbs grow and we live, are but as it were the Bark and Crust of the Earth, and the Seat of perpetual Generation and Corruption. The Opinion of *des Cartes* is not much different from this; for he believed there were three *Strata* in the Body of the Earth of divers Consistences. The first and innermost possessing the Center, the second of a dense and opaque Nature, consisting of the minutest Particles; the third (being replete with Men and Animals) he supposes to be compounded of Particles not sticking so close together.

NEVERTHELESS, for want of Observation, we cannot affirm any Thing for Certainty in this Matter; and tho' it be true that in several subterraneous Places, there is a glowing Heat, and that Smoke and sulphureous Fumes are exhaled from several hot Baths: and also tho' *Thurnheuser* affirms, that he found by Experience that the nearer they digged to the Center of the Earth, there was the less Water in Mines; yet we are still in a Doubt, and cannot positively depend upon his particular Observation.

'stance as invests the Surface 'of the Sun; nor can we, without a Boldness unbecoming a 'Philosopher, adventure to assert the Impossibility of peculiar Luminaries below, of 'which we have no sort of 'Idea.

'Thus have I shewn a Possibility of a much more ample 'Creation than has hitherto 'been; and a Notion not so 'much as started in the World 'before.'

Thus far Dr *Halley*. How he accounts for the Variation of the Needle from this Hypothesis; See the Notes upon *Chap.* 38. *Prop.* 4. of the Comparative Part, or *Philos. Transact.* N° 148. Pag. 208. and N° 195. Pag. 564.

PRO-

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PROPOSITION VI.

The Consistence or Coherence of the Particles of the Earth is from Salt.

THE artificial Separation of the Particles of Bodies demonstrate, that in the Composition of the whole there is a certain kind of Salt which is more abundant in harder Bodies, as in Metals, Stones, *&c.* (a few oily Substances only excepted) (*e*). And that all solid Bodies are concreted by Salt, is manifest from the artificial *Petrefaction* of those that are soft, to any Degree of Hardness by it.

(*e*) Tho' most sorts of Bodies are replete with saline and vitriolic Particles, such as may in some Means contribute to their Coagulation and Consolidation; yet the primary and naturally indivisible Corpuscles, of which the Particles of all Bodies are composed, are not connected by salt or hooked Atoms, as some imagine; nor glewed together by Rest, which is an occult Quality or nothing, nor stick together by conspiring Motions, but rather cohere and are united by mutual Attraction. So that *the smallest Particles of Matter may cohere by the strongest Attractions, and compose bigger Particles of weaker Virtue; and many of these may cohere, and compose bigger Particles whose Virtue is still weaker.* See *Newton's Optics, Pag.* 370.

Hence Particles of Bodies which touch one another in large Superficies's, by a strong mutual Attraction of their Parts, compose a Body very *hard*; and if these Particles are not so strongly attracted or entangled with each other, the Body will be *brittle*; if they touch one another in less Superficies, the Body is not so hard, but yet may be more *solid*; if they only approach each other, without slipping one under another, the Body is *Elastic*, and springs to it's former Figure; if they slip under each other the Body is *soft*, and easily yields to the Stroke of the Hammer; if they scarce touch one another the Body is *crumbling*, or such whose Parts may be easily separated; if they are small, round, slippery, and easily agitated by Heat, the Body is *fluid*; if these Particles are of an unequal Superficies, and hooked or entangled one with another, then is the Body *flexile* or *pliant*, &c. See Dr *Clarke's Notes upon Rohault's Physics.*

So

So that if Salt be ſeparated from Bodies, their Particles will no longer be cemented; but they will become Powder, which cannot be brought to a Coherence without the Admixtion of ſaline Particles.

PROPOSITION VII.

Various kinds of Bodies are ſeveral Ways mixed together in the Globe of the Earth.

IN Mines there are found Particles of Gold, Silver, Lead, &c. not gathered into a Maſs and ſeparate from others; but ſometimes mixed among themſelves, and ſometimes with uſeleſs Earth, in ſuch very ſmall Particles that the beſt Judges in Metals cannot at firſt Sight diſcover what ſort of Mineral is contained in ſome *Metalline Earths* (*f*). Alſo in the Fields, Sand is ſometimes

(*f*) The indefatigable Dr *Woodward*, in his *Eſſay towards a Natural Hiſtory of the Earth*, reaſonably ſuppoſes all theſe Commixtures of the Particles of Bodies in the *Strata* of the Earth, to proceed from thoſe ſtrange Alterations that were every where made in the Terreſtrial Globe at the Deluge, when the whole Globe was diſſolved, and the Particles of Stone, Marble, and all other ſolid Foſſils diſſevered, taken up into the Water, and there ſuſtained together with Sea Shells, and other animal and vegetable Bodies: that at length all theſe ſubſided from the Water, according to the Nature of their Gravity; the heavieſt Bodies firſt, then thoſe that were lighter; but all that had the ſame Degree of Gravity ſettled down at the ſame Time; ſo that thoſe Shells, or other Bodies, that were of the ſame ſpecific Gravity with Clay, Chalk, Sand, &c. ſunk down together with them, and ſo were incloſed in the *Strata* of Chalk, Clay, Sand, or Stone, which their Particles formed; that at the general Subſidence, Metals and Minerals, as well thoſe which were amaſſed into Lumps as thoſe which continued aſunder, and in ſingle Corpuſcles, ſunk down to the Bottom along with Sand, Coal, Marble, &c. and ſo were lodged with the *Strata* which the Sand, &c. conſtituted. That all the metallic and mineral Matter which is ſometimes mixed with Clay or Lime, and ſometimes with Salt, *&c.* Not long ſince at *Amſterdam*, when the Earth was digged up to the Depth of two hundred thirty two Feet to make a Well, theſe kinds of Earth were gradually diſcovered. Firſt ſeven Foot of Garden Mould, then nine Foot of black combuſtible Earth, which is called Peat, (not like that they properly call *Dutch* Turf) then nine Foot of ſoft Clay, then eight Foot of Sand and four of common Earth, then ten Foot of Clay, and again four of common Earth, next that ten Foot of ſuch Sand as the Foundations of the Houſes in *Amſterdam* are laid in, then two Foot of Clay, next four Foot of white Gravel, then five Foot of dry Earth, and one Foot of Mud, again fourteen Foot of Sand, then three Foot of ſandy Clay or Mire, afterwards five Foot of Sand mixed with Clay, and next four Foot of Sand mixed with little Sea-Shells, then there was a *Stratum* of Clay one hundred and two Foot deep, and laſtly thirty one Foot of Gravel, where the Shaft was finiſhed.

is now found in the Fiſſures, or perpendicular Intervals of the *Strata*, was originally lodged in ſingle Particles among the Sand, *&c.* having been detached and drawn thence by little and little by the Water, which continually pervades the *Strata*; and that Trees, which are found in great Plenty in Moſſes, Fens, or Bogs, were depoſited thereby the Deluge; ſo that the preſent Earth was formed out of this promiſcuous mixed Maſs of Sand, Earth, Shells, and Metals, and of broken and diſlocated *Strata*, ſome elevated and others depreſſed, by which Means all the Inequalities of the Globe, Fiſſures, Grotto's, Mountains, Vallies, Iſlands, the Chanel of the Sea, and all others, were formed, and that the whole Terraqueous Globe (with all it's Materials) was, at the Time of the Deluge, put nearly into the Condition that we at this Day behold it. See *Woodward's Eſſay*, or *Philoſophical Tranſactions* No 217. *p.* 115.

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PROPOSITION VIII.

The Cavities of the Earth, and the external and internal Disposition, or Situation of it's Parts, are not perpetually the same, but different at different Times.

THE Sea not only makes many Devastations and Changes in the Parts of the Earth, by some of it's Passages being stopped, and others more opened; but also that spirituous and sulphureous Substance which here and there lies hid in the interior Parts, when it begins to heat and evaporate, impetuously shakes the exterior Parts of the Earth, raising them up, as is usual in Earthquakes. And it is probable the like Eructations may often happen in the more interior Parts of the Earth; which for the most part we have no Notion of.

WE shall treat of the mutual Changes of Land and Water in Chapter 18. hereafter.

The Terraqueous Globe is divided into

Earth whose Surface is	covered with Water, or raised above the Waters; and into *Water*.

THE Superficies of that Part of the Earth which appeareth above the Waters, is, by the Interflux of the Sea thus divided.

I. INTO large Continents, or great Islands, which we suppose to be four.

North by the *Hyperborean Frozen* and *Tartaric Ocean*.

1. The

1. The *Old World* which containeth -	*Europe* *Asia* and *Africa*	and is bounded on the	East by the *Pacific* and *Indian Ocean*. South by the *Southern Ocean*. West by the *Atlantic*, or *Western Ocean*.
2. The *New World* which containeth --	North and South *America*	is bounded on the	North by *Davis's* Streights. East by the *Atlantic Ocean*. South by the Streights of *Magellan*. West by the *Pacific Ocean*.

3. THE *Arctic Continent*, or *Groenland* is surrounded on every Side with Seas and Streights.

4. THE *Antarctic Continent*, or *Terra Australis Incognita*.

II. INTO *Peninsula's*, or *Chersonesusses*, which are Parts of these Continents.

Of which some are of a round Figure, whose Longitude and Latitude are almost equal, as ——	*Africa*. [North and South *America*] *Peloponnesus*, or the *Morea* in *Greece*, *Taurica Chersonesus* or *Crim-Tartary*. *Cambaya* or *Guzarat*.

Others

Others oblong of which there are many, as — —
- *Chersonesa d'or*, or *Malacca* in *India.*
- *Cimbrica*, or *Jutland*, contiguous to *Holstein.*
- *Corea* contiguous to *Tartary.*
- * *California*, *Yuçatan*, the *Chersonesus* of *Romania.*
- *Ionia* [as *Smyrna*] *Cnidus* and *Myndus.*

Others which are almost like Peninsula's, which are ——— ———
- *Italy*, *Greece*, and proper *Achaia.*
- *Spain*, *Asia minor*, and *Arabia.*
- *Norway*, with *Sweden*, and *Lapland.*
- *Patagon* near the Streights of *Magellan* and *New Guinea.*
- *Indostan*, *Cochinchina*, *New Britain*, *Monopatapa*, &c.

III. INTO Islands of which there are three Classes, *viz.*

1. [*Eleven*] very large ones
- *Britain*
- * *Japan*
- *Iceland*
- James Island]
- *Sumatra*
- Luconia]
- *Madagascar*
- *Borneo*
- * *Nova Zembla*
- Newfoundland]
- *California.*

2. [*Eleven*] of a middle Size ———
- *Sicily*
- *Ireland*
- *Hispaniola*
- *Cuba*
- *Java*
- *Celebes*
- *Candia*
- *Sardinia*
- *Friesland*
- *Ceylon*
- *Mindanao.*

3. [*Nine*] lesser ones
- *Gilolo*, *Amboina*, *Timor*, among the *Indians* Islands
- *Corsica*, *Majorca*, *Cyprus*, *Negropont*, in the *Mediterranean*
- *Zealand* in *Denmark*, and *Jamaica* in the *Gulf of Mexico.*

* *See the Notes upon these Words in the next Chapter.*

Very many small ones, of which we reckon ——

1. The most remarkable Solitary ones, are *Rhodes*, *Malta*, *Lemnos*, *St Helena*, *St Thomas*, *Madera*, &c.
2. The noted Clusters of Islands which lie near one another in great Numbers are

The *Canary* Islands
The *Azores*
Cape Verd Islands
The *Antillis*
The *Maldivia* Island
The *Comoro* Islands
The *Molucca* and *Bandana* Islands.
The *Philippine* Islands
The *Ladrone* Islands
Those in the *Ægean* Sea
The *Britannic* Islands
The Islands of *Solomon*.

IV. *Isthmus*'s or narrow Necks of Land.

That of *Suez*, between *Africa* and *Asia*.
That of *Corinth*, joining the *Morea* to *Achaia*.
That of *Panama*, in *America*, longer than any of the rest.
That between *Jutland* and *Holstein*.
That joining *Malacca* to *India*.

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SECT. III.

In which the Constitution of the Earth, or the dry Part of the Terraqueous Globe, is explained, in four Chapters.

CHAP. VIII.

Of the natural Division of the Earth into Parts by the circumfluent Ocean.

WHAT we shall exhibit in this Chapter, concerning the Division of the Earth, and that in Chap. xv. about the Distribution of the Sea, will be of great use to young Students, for understanding, and remembring the Bounds and Situation of the several Countries on the Earth's Superficies: wherefore these two Chapters ought to be read throughout with great Attention, and compared with Maps, or the artificial terrestrial Globe. We said before, in the preceding Chapter, that the Terraqueous Globe, as to it's constituent Parts, may be best divided into a Body of a firm Consistence as Earth, and a fluid matter as Water; to which may be added the Atmosphere as a circumambient Fluid or Covering.

IN the first Place, we shall treat of the Earth, or that Part of the Globe which hath Consistence.

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PROPOSITION I.

Part of the Earth is covered with Water, and Part of it is raised above the Superficies of the Water, and surrounded thereby.

THE Truth of this Propoſition is manifeſt from Experience. Nevertheleſs there are ſome Places which are now and then covered with Water, and at other Times dry and conſpicuous, as the Iſlands near *Norway*, *Scotland*, and other Countries, to which may be added *Sand-beds* or *Shelves*, and Sea-ſhores; but becauſe theſe are ſo ſmall in compariſon of the reſt, we ſhall take no notice of them at preſent. Nor ſhall we trouble our ſelves here with diſputing whether the greater Part of the Superficies of the Globe be taken up by Land or Water, but leave it to be diſcuſſed in Chap. xviii. and conſider here only the apparent Parts of the Earth which we call *Iſlands*.

PROPOSITION II.

The Parts of the Earth, which are raiſed above the Waters, are not always joined together by one continued Superficies, but often ſeparated one from another, and formed into Iſlands by the Interflux of the Sea.

THESE may be diſtributed into five Claſſes, viz. *Plats* of Land or *Iſlands*, that are great, and *Continents* that are greateſt; ſome ſmall, and others that are ſmalleſt; and laſtly ſome of a middle Size.

WE ſhall treat of the Origin, and Cauſe of theſe Iſlands in the proper Place, Chap. xviii.

THO'

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THO' all the separate and apparent Parts of the Earth ought to be called *Islands*, because an Island is nothing but a Part of the dry Land every where environed with Water; yet, in the common Way of speaking, this Word is seldom used to express these large Tracts of Land whose Boundaries by the main Ocean, (by reason of their vast Extent,) are not so perceptible. Such as those are frequently called the *Terra firma*, or *great Continents*, which peculiar name they ought to be distinguished by on account of their Magnitude, in respect of the rest of the Islands, which are very small in comparison of them. Therefore we shall, in what follows, call them the *Terra firma* or *great Continents*. But the word *Continent* is frequently used to express several Parts of the *Terra firma* as well as the whole. And sometimes it is taken strictly for a Part of the Earth, on no side contiguous to the Sea: Or in a large Sense for a Country bounded by the Sea on one side, and on the other joined to a large Tract of the *Terra firma*. It is also often taken in general for a Part of the Earth joined to another, whether by a large or a narrow Tract of Land. In these Senses the Word *Continent* differs from that in which it is frequently used to express large Islands.

PROPOSITION III.

These large Tracts of Land, Continents or Terra firma, *(which you will please to call them) are accounted four in Number.*

1. THE old World. 2. The new World, or *America*. 3. The *Northern Continent*, or *Terra Arctica*. 4. The *Southern Continent*, or *Terra Australis*.

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1. *THE Old World* (being the most famous of the four, which we inhabit, and which was only known to the Ancients) is divided, by the Sea into two Parts, which are only joined one to another by a small neck of Land, whereof one is *Africa*; while *Europe* and *Asia* jointly make the other. It is thus environed by the Ocean.

ON the North by the *Icy* or *North Sea*, the *White Sea*, and the *Tartaric Ocean*.

ON the East by the *Great South Sea* and *Pacific Ocean*.

ON the South by the *Indian Sea*, the *Southern* and *Æthiopic Ocean*.

ON the West by the *Atlantic Sea*.

THE aforesaid Division of this Continent is made by the *Mediterranean*, and *Arabian Gulph* or *Red Sea*. The Distance of these two Bays, or the Breadth of the intervening Tract of Land being about 40 *German* Miles; so that *Africa* would have been an entire *Terra firma*, and numbred among the Continents, but for this small *Isthmus*.

THE Old World is not far distant from *America* in the East about the [*supposed*] Streights of *Anian* [or *Uries*,] if there be such; but the least [*known*] Distance of *Europe* from *America* is between *Norway* and *Newfoundland*.

THE Distance between the Old World, and the Arctic Continent is shortest about the [*Icy Sea*]; also the Old World is not far distant from the South Continent about *New Guinea*.

2. *THE New World*, or *America*, is thus encompassed by the Ocean.

ON the North we are in Doubt whether there be Sea or Land beyond the *Streights* of *Davis*.

ON the East it is bounded by the *Atlantic Ocean*.

ON the South by the *Magellanic Streights*.

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ON the West by the *Pacific Ocean.*

THE New World is alfo nearly divided into two Iflands at *Panama* and *Nombre de Dios*, where the *Atlantic* and *Pacific Ocean* are hindred from meeting by a very fmall Ridge of Land.

AMERICA is not far diftant from the Old World about the Streights of *Anian* [*or the Sea of Japan*]; and not far again from the Arctic Continent at *Davis's Streights*, and feparated from the South Continent only by the *Streights* [*of la Maire*] and the *Magellanic Sea.*

THE Arctic and Antarctic Continents are every where environed with Sea, the former [*as is fuppofed*] with the *North* Sea at the *Streights of Davis*, [*Uries or*] *Anian*, [*and the Icy Sea*]; the later with the *South Sea*, *Pacific* and *Indian Ocean*, and the Streights [*of la Maire*].

3. *THE Arctic Continent* is not far diftant from the Old World [*at the Icy Sea*], nor from *America* at *Davis's Streights*; but it is feparated from the South Continent by a vaft Interval.

4. *THE Antarctic Continent* is not far removed from the old World at the Peninfula of *New Guinea*, and feparated from *America* by the Streights of *Magellan* [*and la Maire*].

BUT we have not been able to find for certain whether the *Old World*, *America*, and the *Northern Continent*, be each of them encompaffed with Sea, and feparated one from another; tho' it be very probable that they are, by reafon of the feveral Bays and Entrances of Streights that run in from the Ocean to the Landward. Only the *Southern Continent* hath been actually failed round, and therefore is certainly known to be environed on all fides with Sea, and therefore feparated from the reft. But this has not yet been done by the

other

other Parts; for men have not failed about the Old World much further then *Streights of Waigats*, tho' the whole Western, Southern, and Oriental Shores have been visited, and there is but a small Part of the North [*East*] Coast that remains to be discovered (*a*). *America* also hath been sailed round

(*a*) All the Attempts made by the *Europeans* to discover a *North-East-Passage* to the Oriental Countries have been hitherto unsuccessful. The Reason was formerly thought in a great measure owing to the Discoverers not steering their Course near enough the *North Pole*; being either misled by an Opinion, that that Part of the Sea which lies betwixt *Nova Zembla* and the Continent of *Tartary* had been passable; or that they might have coasted it along the North of *Nova Zembla* and *Tartary*, till they had entered the Streights of *Jesso*, which could never be effected by Reason that most of these northern Coasts are frozen up many Leagues from the Shore, especially in the Winter, tho' in the open Sea it is not so, even under the Pole itself; unless, for Example, upon the Approach of the Summer when the Frost breaketh, and the Ice, which was congealed near 40 or 50 Leagues from the Shore, goes off from the Land and floats up and down in the Sea; whereby several have been forced to quit their Design and stand back for their own Country. *See Philos. Trans.* N°. 118. *Pag.* 417. Big with this last notion our Country-man Capt. *John Wood*, the latest Adventurer who attempted the North-East Passage, in the year 1676, steered directly N E from the *North Cape of Norway*, in order to fall in between *Greenland* and *Nova Zembla*; but he could find no Sea or Inlet between those Countries; on the contrary, he observed the *Ice* to adhere immovably to the Coast of *Nova Zembla*, and that all the *English* and *Dutch* Pilots had been mistaken in their Conjectures of an open Sea thereabouts, for he could pass no further this Way than to the 76 Degr. of Latitude, on account of the Ice, which must have then taken up some Centuries to thaw. He concludes therefore that *Greenland* and *Nova Zembla* must be the same Continent, by Reason there was no Current found there, but only a small Tide which rises about eight Foot, and ebbs back again. And if it should be admitted, *to the contrary*, that the Continent of *Asia* and *America* are separated by the Ocean, yet we may now rest satisfied that the Difficulties to be met with in a North-East Passage are not to be surmounted, and possibly will never be attempted again. *Salmon's Present State of all Nations.* Vol. 6. Pag. 380.

[I forbear

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round except a Part of the Northern Shores, on account of the Uncertainty of the Streights and other Difficulties. This therefore is the Situation of the four Continents.

PROPOSITION IV.

To enumerate the great Islands dispersed over the Surface of the Terraqueous Globe: viz.

1. *BRITAIN*, comprehending *England* and *Scotland*, is supposed to be the greatest of those commonly called Islands (those in the preceding Proposition excepted). It lies betwixt *Europe* and *America*, near *France* and *Flanders*. It is surrounded by the *Atlantic Ocean*, and it's Form is oblong.

2. *JAPAN*, in Maps and Globes is represented of a less Magnitude than it ought to be; for they that have been there affirm it to be larger, or at least no less, than *Britain* (*b*). It lies eastward of *Asia* not far from *China*. It is surrounded by the *Pacific Ocean*, and is of a curve Figure.

3. *LUCONIA*, which is also called, from it's Metropolis, *Manilha*, is the Principal of the *Philippines*,

[I forbear to enlarge upon an Account given us lately, as advices from *Muscovy*, of an Expedition entered upon, under the Command of one Capt. *Berring*, to find out this *North-East-Passage*, whose Voyage is now said to be Printing at *Moscow*; in which he affirms, that there is a free and open Sea to about the North-East Point of *Tartary*, and believes it to be likewise open to the Sea of *China*, or, as some Geographers call it, the Sea of *Japan*.]

(*b*) Whether *Japan* be an Island, or annexed to the Land of *Jesso*, the Inhabitants of both Countries doubt; because vast and inaccessable Mountains interpose which hinder the Communication. Neither doth it as yet clearly appear, whether this Land of *Jesso* is a Part of *Tartary*, or whether it is by an Arm of the Sea divided from it. The *Chinese* affirm that *Tartary* runs 300 *China* Leagues beyond their famous Wall; so that if we follow them the Country of *Jesso*, and also *Japan*, may seem not to be Islands but annexed to *Tartary*. *Philos. Trans.* N° 118.

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pines, which are the furtheſt, of the Oriental Iſlands, on the Borders of *Aſia*. Some will have it to be larger than *Britain*; but they who have been there ſay it is ſomething leſs. It is encompaſſed by the [*great South Sea*,] and is of a curved oblong Figure, with many Inlets and Windings.

4. *MADAGASCAR*, or the Iſland of St *Laurence*, lies on the eaſtern Shore of *Africa*, not far from the Streights of [*Babelmandel or*] the *Red Sea*. It is environed by the *Indian Ocean* (all the Sea between *Africa* and *India* being now called by that Name). It's Form is oblong.

5. *SUMATRA*, thought by ſome Geographers to be the *Taprobana* of the Ancients, lies near the Borders of *Aſia* among the [*Sunda Iſlands*] not far from the Peninſula of *Malacca* (*c*). It ſtretches to a great Length, and is ſurrounded by the *Indian Ocean*.

6. *BORNEO* is ſituated in the *Indian Sea* not far from *Sumatra*: it's Form is almoſt round. There is a great Difference among Authors about it's Extent; ſome make it's Circumference to be about 2100 Miles, and will have it to be the greateſt among the *Indian* Iſlands: others but about 300.

7. *ICELAND*, Part of which is ſituated in the Temperate, and Part in the Frigid Zone, betwixt *Groenland*, and *Norway*, is encompaſſed by the *Northern Ocean*, and it's Form is oblong.

8. *NEWFOUNDLAND* is an Iſland adjacent to *Canada*, in *North America*. It is ſomething larger than it is ſhewed in our common Maps. It is environed by the *Northern Ocean*, and receiveth the Sea in at a great many Creeks.

(*c*) Not *Sumatra* but *Ceylon* is thought, by all modern Geographers, to be the *Taprobane* of the Ancients. And it is ſtill called by the *Indians Tenaraſin*, i. e. *A Land of Delights*, as it was repreſented by the Ancients.

9. [*JAMES's*

9. [*JAMES's or Cumberland's Island*] lies in the *Northern Ocean* near the *Arctic Continent*, between *Davis*'s and *Hudson*'s Streights. I have not found it in any Map before that of *Vischerus*, printed in 1594. It is a large *Island* of an oval Figure.

10. *NOVA Zembla* is situated between the *Arctic Continent* and the Land of the *Samoieds* and [*Ostiacs*]. It is bounded on the North by the *Icy* and [*Muscovian*] Sea, and separated from *Europe* at the Land of the *Samoieds* by the Streights of *Waygats* (*d*). It's Form is oval.

11. *CALIFORNIA* may be added to these if it be an Island, and not a Part of *America* (*e*). The *Dutch* found in a *Spanish* Ship a large *Geographical Map*, in which *California* was represented as an *Island* not contiguous to *America*, but surrounded with the Sea.

(*d*) Mr *Witsen* tells us, in *Philos. Trans.* N° 101. Pag. 3. "That he had received out of "*Muscovy*, a new Map of *Nova* "*Zembla* and *Waygats*, as it "had been discovered by the "express Order of the Czar; "by which it appears, that "*Nova Zembla* is not an Island, "as hitherto believed, and that "the *Mare Glaciale* is not a "Sea but a Bay". Tho' Mr *Witsen* himself seems to be of a contrary Opinion afterwards, in another *Transaction* N° 193. Pag. 494. where he says. "I "formerly thought *Nova* "*Zembla* a Continent; but I "have since been better in-"formed. Therefore since no "Ships have sailed beyond it, "it may be both joined to the "Continent, and extended to "the Pole, for ought we can discover".

(*e*) *Gemelli* tells us, that *a Provincial at* Manilha, *in the year* 1697. "Thought *Cali-*"*fornia* a Part of the Conti-"nent; because some Fathers "of the Society having gone "to the Mouth of the Streights "which it 60 Leagues over, "and run many Leagues up it, "found at last that there was "but very little Water in the "Chanel, and could go no "further; by which he guess-"sed, that long Bay had no "Communication with the "Northern Sea to make *Ca-*"*lifornia* an Island". *Collect. Voyages and Travels. Vol.* 4. *Pag.* 420. Father *Eusebius Francis Kino* is also of the same Opinion, as is understood from his Map communicated to the *Royal Society*, Anno 1708. Nevertheless it is generally represented in our Maps as an Island.

PROPO-

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PROPOSITION V.

To enumerate the Islands of a middle Size scattered over the Surface of the Globe: viz.

1. *JAVA*, one of the *Sunda Islands* betwixt *Asia* and *New Holland*, is replenished with every Thing fit for human Life, and is a perfect earthly Paradise. It is surrounded by the *India Ocean*; and it's Form is oblong.

2. *CUBA*, one of the *Antilles*, betwixt *Florida* and *New Spain*, is encompassed by the *Atlantic Ocean* at the Entrance into the *Gulph of Mexico*. It's Form is oblong.

3. *HISPANIOLA* lies to the South of *Cuba*, *and is almost as large*. It is surrounded by the *North*, or *Atlantic*, *Sea*, where it flows into the Gulph of *Mexico*. It is of an oval Figure, with several Notches in it.

4. *IRELAND* lieth near *Britain*, towards *America*. It is environed by the *North Sea*; and it's Form is oval.

5. *CANDIA* in the *Mediterranean*, near *Greece*, is of an oblong Figure.

6. *SICILY* lies in the *Mediterranean*, near *Italy*. It's Form is [*somewhat Triangular*.]

7. *CEYLON*, near the furthest Promontory of *Cormandel* in *India*; is surrounded by the *Indian Ocean*, and is of a round Figure. *Barrius* will have this to be the *Taprobana* of the Ancients.

8. *MINDANAO*, one of the *Philippine Islands* in the *Pacific Ocean*, is of an oval Figure.

9. *SARDINIA* lies in the *Mediterranean*. It's Form is oblong.

10. *CELEBES*, an Island not far from *Borneo*, is encompassed by the *Indian Ocean*; and is of an oblong Figure.

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11. *FRIESLAND*, not far from *Iceland*, may alſo be referred to this Claſs.

PROPOSITION VI.

To enumerate the ſmall Iſlands in the Globe's Superficies: viz.

1. *GILOLO*, one of the [*Molucca Iſlands*] is ſurrounded with the [*great South-Sea*] and ſhaped like a Horſe-Shoe.

2. *AMBOINA*, not far from *Gilolo* in the ſame Ocean; is of an oblong Figure.

3. *TIMOR*, an Iſland adjoining to [*Arnhems Land* in] the Continent; it is one of the [*Sunda Iſlands*] and it's Form is round.

4. *JAMAICA*, one of the [*Antilles*] in the Gulph of *Mexico*, is of an oblong Figure.

5. *ZELAND*, an Iſland in *Denmark* between *Jutland* and *Gotland*. It is ſurrounded by the *North-Sea*, as it flows into the *Baltic*, and is of a round Figure.

6. *NEGROPONT*, near *Greece* in the [*Archipelago*], is of an oblong Figure.

7. *MAJORCA*, in the *Mediterranean*, near *Spain*, [*is of a quadrangular Figure*].

8. *CORSICA*, [*near Sardinia*] in the *Mediterranean*, [*is of an oval Figure*].

9. *CYPRUS*, not far from the *leſſer Aſia* in the *Mediterranean*, is alſo of an oval Figure.

10. *ISABELLA*, one of *Solomon*'s Iſlands, in the *Pacific Ocean*.

THERE are ſeveral other Iſlands that might be referred to this Claſs, but we ſhall conſider them among the following.

PROPOSITION VII.

There are almost an innumerable Multitude of very little Islands dispersed over the Surface of the Globe; among which these following deserve a particular Consideration. 1. *The celebrated Solitary ones.* 2. *Those that are collected into Clusters, and for their Affinity to one another, included under one Name.*

THE most noted *Solitary Islands* are, Those in the *Mediterranean*; viz. *Rhodes*, *Malta*, *Yvica*, *Minorca*, *Scio*, *Cephalonia*, &c.

THOSE in the *Atlantic Ocean* between *Africa* and *Brasil*, *St Helena*, well known to Mariners, *Ascension Isle*, *St Thomas's Isle*, lying in the Equator.

MADERA which lies off the Streights of *Gibraltar*, towards *America*.

ZOCOTORA lying before the [*Streights of Babelmandel*].

GOTLAND lying in the *Baltic*.

PARADON, supposed by the *Portuguese* Sailors (as *Linschoten* relates) to lie about a hundred Miles West of the *Canaries*, hath this peculiar Property, that it is sometimes perceptable, but for the most part invisible; so that several Geographers dispute it's Existence. They tell us it's Fields are green and fertile, and that the Inhabitants are Christians, but they know not from what Nation they are descended, or what Language they use. The *Spaniards* once made a Voyage from the *Canaries* to seek it, but could never find it: Therefore some have thought it to be an Illusion, or Apparition; others will have it to be seen only some certain Days of the Year, and at other Times to be covered with a Cloud. The whole Story seems to me fabulous and foolish.

FLOAT-

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FLOATING Islands ought also to be reckoned among these, for which see Chapter xviii.

PROPOSITION VIII.

To enumerate the Clusters of Islands in the several Parts of the Globe.

WE generally call these *Clusters of Islands*, having no better Name to express them by, such as:

1. THE *Canaries*, formerly called the *Fortunate Islands*, which lie in the *Atlantic Ocean*, near the Western Shore of *Africa*, over against Mount *Atlas*. They are [*Seven*] in Number, not reckoning the *Salvages*.

2. THE *Azores*, or *Flandrian Islands*, betwixt *Europe* and *America*, in the Western Ocean; they are accounted *Nine* in Number.

3. THE Islands of *Cape Verd*, or the *Hesperides* of the Ancients, lie in the *Atlantic Ocean*, near the Western Shore of *Africa*, over against *Cape Verd*. These are *Ten* in Number.

4. THE *Maldivia Islands* lie in the *Indian Ocean*, not far from the Coast of *Malabar* in *India*, *and extend North-West from the second Degree of South Latitude, to the seventh Degree of North Latitude. Their Number is very uncertain, some reckoning them one Thousand, and others twelve Thousand. Narrow Chanels, which seem to be worn by the Currents, separate them one from another, of which some are not a Stone's-cast over.*

5. [*THE Antilles comprehending*] 1. The *Lucaios* or *Bahama Islands*, situated between *Cape Florida* and *Cuba*, are remarkable in being one of them (*viz. St Salvador*) the first Land seen by *Columbus*, the first of the *Europeans* that discovered *America*. The Chief of them is *Lucayo*, from whence the rest are named [*being of the larger sort, about seven*

in Number]. 2. [The *Virgin Caribee*, or *Leeward Islands*] between *Hispaniola* and the *Old World*. 3. [*The Stotovento and Bermundas Islands*] to which are referred all those in the Gulph of *Mexico*.

6. THE [*Comoro and Admiralty Islands*] lie between *Madagascar* and *Africa*.

7. THE *Molucco* [*and Sunda*] *Islands* are many in Number, of which five are particularly called [*Spice Islands*]. They are surrounded by the *Indian Sea*.

8. THE. [*old and new*] *Philippine Islands* near the remote Parts of *Asia*, are almost innumerable.

9. THE *Banda Islands*, and others betwixt *Java* and [*Timor*].

10. THE *Ægean Islands*, or those in the *Archipelago*.

11. THE *Japan Islands*.

12. [*PRINCE William*'s *Islands*] or those of *Solomon* in the *Pacific Ocean*.

13. THE *Ladrone Islands*, in the same Ocean.

14. THE *British Islands*, or those about *England* and *Scotland*.

15. THE. Islands of *Terra del Fuego*, between the Streights of *Magellan* and those of *la Maire*.

TO these may be referred such Islands as are found in large Rivers, as those in the *Nile* in *Africa*, the *Wolga*, *St Laurence* in *Canada*, and in other Rivers: Also those observed in *Lakes* or Morasses, such as are in the Morass of *Lambre* in *Africa*, and in the Lakes of South *America*.

WE do not here reckon those Islands, that in great Numbers are stretched along the Shores of some Counties, as *Norway*, *China*, *Brasil*, *Davis*'s *Streights*, &c.

PRO-

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PROPOSITION IX.

Besides these Islands there are other Parts of the Earth, whose Surfaces are different in Shape or Figure; such as **Peninsulas's** ***and*** **Isthmusses.**

A *Peninsula*, called by the *Greeks Chersonesus*, is a Part of the Earth joined to another by a narrow Neck of Land, and on every Side else encompassed with the Sea. That narrow Tract or strait Passage, whereby one Country hath communication with another by Land, is called an *Isthmus*. We must also here observe those Parts of the Earth that are stretched out into the Sea, but are joined by a larger Tract to the main Land, for such extended Parts form a Species of *Peninsula's*, and may in some sense be so called.

SUCH are *Italy*, *Spain*, part of *England*, *Greece* and *proper Achaia*, *Asia minor*, *Norway* with *Sweden* and *Lapland*, *Indostan*, *New Guinea* in the *South Continent*, [*New Holland*] *New Britain*, and [*New Scotland*] in *America*, *Cambodia*, *Patagon*, the extream Parts of *Africa*, &c.

PROPOSITION X.

To enumerate the Peninsula's.

THESE *Peninsula's* are oblong, *viz.*

1. *CHERSONESA d'or*, or *Malacca*, contiguous to *India*.

2. *CIMBRICA*, or *Jutland*, contiguous to *Holstein*.

3. *CALIFORNIA*, on the Western Shore of *North America, is thought, by some, to be a Peninsula; but commonly represented in our Maps as an Island.*

 4. *YUCATAN*

4. *YUCATAN*, in the Bay of *Mexico*, contiguous to *New Spain*.

5. THE Cherſoneſus of *Romania*, near the *Helleſpont*.

6. *COREA*, was formerly thought to be an Iſland, and not a Peninſula. In ſome Maps I have ſeen it joined to *Tartary*, and in others ſurrounded with the Sea. Nevertheleſs, the lateſt Obſervations make it a Peninſula; *but even now it is not ſettled among Geographers*.

7. TO theſe may be added the three ſmall ones of *Ionia* in *leſſer Aſia* [*or Smyrna*], *Melaſſo*, and *Halicarnaſſus*.

THESE Six Peninſula's are roundiſh, *viz.*

1. *AFRICA*, a great Part of the old World, ſurrounded by the *Mediterranean*, *Atlantic*, *Æthiopic*, *Indian*, and *Red Sea*. It is joined to *Aſia* by a narrow Neck of Land near *Ægypt*.

2, 3. *NORTH* and *South America* viz. *Mexico* and *Peru*. They are joined together by the Streights of *Panama*.

4. *PELOPONNESUS*, now called the *Morea*, a Part of *Greece*.

5. *TAURICA* Cherſoneſus, now called [*Crim Tartary*] in the *Black Sea*, near the *Streights of Caffa*.

6. *CAMBAYA*, *or Guzarat*, in *India*.

PROPOSITION XI.

There are as many Iſthmus's *as* Peninſula's. *Thoſe of moſt note are,*

1. THAT of *Suez*, which joins *Africa* to *Aſia*.

2. THAT of *Corinth*, which joins the [*Morea to Achaia.*]

3. THAT of *Panama*, which joins *North America* to *South America*.

4. THAT joining *Malacca* to *India*. And,

5. THAT joining [*Crim to Precop Tartary.*]

CHAP.

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CHAP. IX.

Of Mountains in general.

MANY Things occur worthy of particular Notice, in explaining the Nature of Mountains, and therefore they are copiously handled by Geographical Writers, *especially the Computation of their Altitudes*, because they seem to many to make against the Earth's Rotundity.

PROPOSITION I.

A Mountain is an elevated Part of the dry Land, overtopping the adjacent Country; and a Hill *or* Cliff *is a small kind of Mountain. A* Promontory, *is a Mountain stretching itself into the Sea, and* Rocks *are Stones raised above the Sea or Land, in the Form of Mountains.*

We must know that all the Parts of the Earth which appear plain, are not exactly of the same Altitude, but commonly elevated towards the Inland Parts, and depressed towards the Sea Shores, as is manifest from the Origin and Course of Rivers; for that Part towards which they flow, is always more depressed than that where they Spring; and Fountains seldom are increased into Rivers, unless they take their Origin from Mediterranean or inland Countries: which shews, that those Countries are more elevated than the Maritime Parts. So *Bohemia* is known to be higher than *Holstein*, becauſe the River *Elbe* riſes in the former, and falls into the later. Alſo from the *Danube*, the *Weſer*, the *Rhine*, and the *Moſelle*, we perceive the greater Altitude of thoſe inland Countries, from whence they flow. For this reaſon, *Switzerland* and the Country of the *Griſons*, are accounted the higheſt Lands in *Europe*; becauſe the *Rhine*, the *Danube*, and the *Rhone*, derive their ſource from them. Moreover, the inland Countries are elevated above the maritime Parts, according to the different Declivity and Rapidity of the Rivers.

HERE follow ſome Problems, by which we may form a Judgment upon the controverſial Writings handed down to us, about the different Altitudes of Mountains.

PROPOSITION II.

To take the Height of a Mountain by Altimetry.

THIS is performed the ſame Way as we take the Height of a Tower, provided the very Top of the Mountain be perceptible by any Mark.

LET AB (*Fig.* 12.) be the Altitude of a Mountain, A the Foot of it, B the Mark ſeen at the Top. Take the Line FC at a convenient Diſtance, ſo that neither of the Angles AFC or ACF may be very acute, but nearly equal. Let the Angles BFC and BCF be obſerved; and the Sum of their Degrees being taken from 180 the Remainder will give the Angle CBF (*a*). Then let CF the Diſtance of the two Stations be accurately meaſured; which done, ſay, as the Sine of the Angle FBC, to the Sine of the Angle CFB: (or of FCB: if you would find FB) ſo

(*a*) *By Article* 14. *of Chap.* ii. *above.*

is

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is F C to B C the Distance of the Top of the Mountain from C. Then [*with a Telescope fixed to a Quadrant or otherwise*] take the Angle B C A, and you will have also the Angle A B C, because the Triangle CAB is rectangular *.

THEREFORE in the Triangle ABC, As the Radius 10000000, is to the Sine of the Angle BCA: so is the Distance BC, to the perpendicular Altitude of the Mountain AB.

FOR Example. Let us suppose that *Xenagoras*, the Son of *Eumelus*, used some such Method as this to find the Height of the Mountain *Olympus*, which he is said to have measured exactly. Wherefore if he found the Angle BFC 84 *degr.* 18 *min.* and the Angle B C F 85 *degr.* 34 *min.* then was CBF 10 *degr.* 8 *min.* And suppose, by measuring, or some other Method, he found FC 1200 *Grecian* Feet, or 2 Furlongs. Therefore as the Sine of the Angle CBF 10 *degr.* 8 *min.* 17594 is to the Sine of the Angle BCF 85 *degr.* 34 *min.* 99701: so is CF 1200 Feet to BF 6800 Feet, the Distance from the Top. Likewise the Angle BFA being found, *by some Instrument then in Use* to be 63 *degr.* 30 *min.* by saying, in the Triangle FAB, As Rad. 100000 to the Sine of the Angle BFA 89500: so is F B 6800 to A B 6096 Feet, the Altitude of Mount *Olympus*. But 600 Feet make a *Grecian* Furlong; therefore dividing 6096 by 600, the Quotient, 10 Furlongs 96 Feet, is the Height of Mount *Olympus* in *Grecian* Measure, as *Xenagoras* found it. *Note*, Each of these Furlongs is about $\frac{1}{16}$ of a *German* Mile.

ARISTOTLE and several others affirm, that this Mountain, *Olympus*, is so high, that there is no Rain, nor the least Motion of Air upon the Top of it; which he, and the Ancients understood

* *By Article* 14 *of Chap.* ii. *above.*

from

from their finding the Draughts of Letters made in Ashes, which had been regularly scattered, to remain entire and fresh as they were at first, without being either confused or defaced in many Years; therefore they supposed it to be raised above the second Region of the Air.

THERE is also another Method of taking the Altitude of Mountains, by two Stations in the same Plane, with the perpendicular Height of the Mountain; but this is subject to Error because of the small Difference of the Angles (*b*).

ALSO

(*b*) There is a very pleasant and expeditious Method of taking the Height of Mountains by the *Barometer*, thus: It is to be observed how many Inches or Parts of Inches the Quicksilver is depressed at the Top of the Mountain, we have a mind to measure, below the Altitude it hath acquired, at the same Time, at the Bottom, or Superficies of the Sea; from whence the true Height of the Mountain is found by an established Proportion. This Proportion may be known by the Table we have added below to Chap. xix. Prop. 7. Also, by this Table, the Height of the Quicksilver at the Surface of the Sea may be found, by observing it's Height at any Place, whose Altitude above the Sea is known. But this is to be observed, that the Altitudes found this way will be more accurate, the nearer the Height of the Quicksilver is to 28 *French* Inches or to $29\frac{1}{7}\frac{1}{7}$ *English*.

Jurin's Appendix.

This way of *taking the Height of Mountains*, is very expeditious and pleasant, as Dr *Jurin* saith, and with due care may be very useful to several purposes; particularly in measuring the *Height of Islands* above the Sea, by two Observers, with well adjusted *Barometers*; and at the same Instant of time, observing the *Barometrical Heights*, by the Sea-side, and on the highest Part of the *Island*. So also it may serve to give an Estimate of the Height of a *Fountain*, or *River*, that we would have conveyed to some Miles Distance. But in all those Experiments, it is necessary that the *Barometer* (as I said) should be well adjusted, and (if two Observers) that the Observations should be made at the same time, to prevent errors that may arise from errors in the *Barometer*, or from the Alteration of the Weight of the *Atmosphere*; which sometimes changes in the very time of Observation, if we are not speedy therein.

For the *Discovery* of a *Mountain*'s, or any other, *Height*, Dr *Halley* (from *Barometrical* Observa-

ALSO having the Height of a Tower given, and it's Distance from the Mountain, we may more accurately find the Height of the Mountain itself; thus, suppose F to be a Tower 300 Foot high, and from it's Top, or some convenient Place, let BFP be observed to be 83 *degr.* 30 *min.* then will BP be found to be 5796 Feet, to which the Height of the Tower is to be added: P A.

PROPOSITION III.

The perspicuous Altitude of a Mountain being given, to find what Distance we are from it; by a Quadrant [Theodolite] *or any other Surveying Instrument, for taking Heights or Angles.*

LET the Height of the Mountain A B be known beforehand, by the Observations of others, to be 10 *Grecian* Furlongs 96 Feet, or 6096 Feet. And let the Place of Observation be at F; (*Fig.* 13.) the Distance FA is supposed to be required. Let the Angle BFA by a Quadrant or [*Theodolite*] be found 63 *degr.* 30 *min.* Then in the right-angled Triangle B A F, where three Things are given, it will be as the Radius 100000 is to the Tangent of the Angle ABF 26 *degr.* 30 *min.* 49858: so is AB 6096 to AF 3040 Feet, or 5 Furlongs

Observations on *Snowdon-Hill*) concludes, that the Quicksilver descends a Tenth of an Inch, every 30 Yards of Ascent. And Dr *Derham* (by good Observations on the *Monument* in *London*) reckons 82 Feet for every tenth of an Inch. Vid. *Lowthorp's Abridg.* Vol. 2. p. 13, *&c.* But by very nice Observations he afterwards made with excellent Instruments at divers Altitudes in *St Paul's Dome*, and when the *Barometer* was at a different Height, he found, at near 90 Feet, the Quicksilver sunk $\frac{1}{10}$, and at somewhat less than double, and treble that Height, $\frac{2}{10}$ and $\frac{3}{10}$, according to Dr *Halley's* Table, *ibid.* p. 16, and Mr *Cassini's* referred to in this *Note* (*b.*)

40 Feet

40 Feet, the Distance required between the Place of Observation and the Mountain.

THERE are some Instruments by which you may perform this, without making use of the *Canon of Sines*, &c. as is apparent from their Description, but the Result is this way less accurate, for Want of Exactness in the Lines of Proportion.

Note. In both these Problems we have taken the Distance F A for a right Line, because of the small Difference between it and a Curve; but shall consider it as Part of the Periphery of the Earth in the following Methods.

PROPOSITION IV.

Having the Distance between a Mountain and the Place where it's Top may be first seen, given: to find Geographically the Height of the Mountain.

LET us take, for Example, the prodigious high Mountain in the Island of *Teneriff*, one of the *Canaries*, commonly called the *Pike of Teneriff*. Let AFC. (*Fig.* 14.) whose Center is R, be the Periphery of the Earth, or the Meridian of the Mountain, and let AB be the Mountain itself. Draw from B the right Line BF a Tangent to the Periphery, and F will be the first or last Point from which the Top of the Mountain can be seen. (Then Draw R F.) Mariners affirm, that they first discover the Top of this Mountain when they are 4 Degr. of the Meridian distant from it (and they need not be at a loss for finding the Distance from any Mountain in Degrees when they are sailing under the same Meridian it is in). Therefore, supposing their Relation to be true, and the first visual Ray B F to come in a direct Line from the Top B, let us endeavour to find out the Altitude

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tude of the Mountain. In the Triangle BRF there are three Things known. 1. RF the Semidiameter of the Earth. 2. The Right-angle BFR. And 3. Becauſe the Arch FA is 4 Degr. the Angle BRF is alſo 4 Degr. Therefore ſay, As the Radius (100000000) is to the Secant of the Angle BRF 4 *Degr.* (10024419) ſo is RF (3440 *Italian* Miles or 860 *German* Miſes) to RB (3448 *Italian* Miles or 860 *German* Miles); ſubſtract RA (3440 or 860) and there will remain BA (8 *Italian* Miles, or 2 *German* Miles, for the Height of the Mountain [*which is extraordinary, and even above the Computations of the Antients*]. Therefore we muſt know that there are two Things aſſumed as Truths which are actually falſe. 1. It is ſuppoſed that the Ray of Light which firſt ſtrikes the Eye, comes from B in a right Line, when it is known on the contrary to be curved, or refracted, by Reaſon of the Denſity of the Atmoſphere. For a Right Line cannot be drawn from the Top B to F (FA being 4 Degr.) without paſſing thro' a Part of the Earth, and therefore the Top B cannot be ſeen in a right Line from the Place F, but by the bowed Ray BTF, being the firſt of the refracted Rays that can touch F. From whence we may reaſonably infer, that this Refraction cauſes the Mountain to be diſcovered ſooner by 1 Degr. (or 15 *German* Miles) than if there had been no Refraction at all; ſo that ſuppoſing AF but 3 Degr. the Height of the Mountain will be found but 40 Furlongs, or 5 *Italian* Miles. 2. It is to be conſidered, that Sailors allow themſelves a Liberty of ſpeaking largely, eſpecially about their Diſtances; if therefore, in Conſideration of this, we deduct half a Degr. more, and ſuppoſe the Top firſt ſeen at 2½ Degr. or 38 *German* Miles equal to FA; then will the Altitude of the Mountain AB be found.

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found by the former Calculation to be a Mile, or thereabouts.

IF a Mountain be first seen at 2 Degr. distance, (setting aside the Refraction) it will be found 2 *Italian* Miles high; but if at 1 Degr. or 15 *German* Miles, it will be half an *Italian* Mile, or 5 Furlongs high.

To this Purpose is calculated the following Table.

If the Altitude of a Mountain be	$\frac{1}{8}$ *Ger.* Mil.	$\frac{1}{7}$	$\frac{1}{6}$	$\frac{1}{5}$	$\frac{1}{4}$	$\frac{1}{3}$	$\frac{1}{2}$	1
Then it will be seen at the Distance of	$14\frac{3}{4}$	$15\frac{1}{2}$	17	$18\frac{1}{2}$	21	24	29	$41\frac{1}{2}$

BUT these are all to be understood without Refraction, whereby the apparent Height and Distance is generally increased, as may be seen by the Figure; where the refracted Ray T F being produced to N, gives the apparent Altitude N A.

PROPOSITION V.

Having the Altitude of a Mountain given, to find Geographically it's Distance from the Place, whence it may be first seen.

THIS is but the converse of the last Proposition, and may be had from the foregoing Table: but Calculation will give a more accurate Solution.

LET therefore A B be the Height of a Mountain given, and suppose it to be first seen at F, to find the Distance A F. (*Fig.* 14.) In the right angled Triangle B F R, the Angle F is a right Angle, and the two Sides F R, R B are given, the former being the Semidiameter of the Earth, and the later the same added to A B, which suppose half a *German* Mile; so that R F or R A being

860

860 Miles, BR will be 860½. Therefore say, as RB 860½ is to FR 860: so is the Radius 10000000 to the Sine of the Angle RBF 9994186. 88 *degr.* 2 *min.* 40 *sec.* Wherefore BRF or the Arch AF will be 1. *degr.* 57 *min.* 20. *sec.* which being turned into *German* Miles make 29½, the Distance from whence a Mountain whose Altitude is half a Mile, may be first seen without any Refraction, upon which Account we may add 8 Miles, so that it may be actually seen 37½ Miles off. But the Refraction varies according to the different Altitude of the Sun, or the different Density of the Air, when the Sun, is below the Horizon; as we shall shew more at large, when we come to treat of the Atmosphere; and in the third Part of this Book, where we shall Discourse of the visible Horizon.

PROPOSITION VI.

The Length of the Shadow of a Mountain, and the Altitude of the Sun at the same Time, being given, to find the Altitude of the Mountain.

WE propose this Problem more for the Antiquity and Elegancy of it, than for any Accuracy we believe to be in the Method. *Plutarch* and *Pliny* have writ, that Mount *Athos*, on the *Macedonian* Shore, is so high as that it overshadoweth the Isle of *Lemnos*, [*now called Stalimene*] as far as the Market-place of the City of *Myrrhina* [*or Lemnos*], when the Sun is in the Summer Solstice; where the ancient Inhabitants for the Curiosity of the Appearance erected a Brazen Calf, at the termination of the Shadow, as is testified by the old *Greek* Monostich, *which may be thus Englished.*

Mount Atho's *Shadow covers half*
The Bulk of Lemno's *molten Calf.* (*c*)

PLINY writes, that the Distance between *Athos* and the Isle of *Lemnos*, was accounted 87000 Paces, or 87 *Italian* Miles, but neither he nor any other Author have determined the Altitude of the Sun, at the Time of this Shadow; tho' it is probable, it was projected upon the Town of *Myrrhina* when Mount *Athos*, a little before Sun-set, began to intercept their View of the Sun-Beams; the Sun being then in the same vertical Circle, which passeth over *Athos* and *Myrrhina* (because *Athos* is situated westward of *Myrrhina*). We may suppose the Sun to have been almost in the very Horizon of *Myrrhina* F O, and so the Ray O F, passing the Top of the Mountain, to have projected the Shadow AF. (*Fig.* 15). Here O F is a Tangent to the Periphery, and from having the Angle F B R given, and also FR, (or FA in the Triangle, BAF taken as a right Line) B A will be found to be 8 Furlongs, or 1 *Italian* Mile for the Height of the Mountain. But because in this Position of the Sun, the Shadow would be infinitely continued, and therefore it's Extent could not be observed; and as the Interposition of the Houses in the Town, would also intercept the neighbouring Rays, to those that bounded the Shadow; therefore, we must allow the Sun to have been elevated at least 2 Degr. above the Horizon of *Myrrhina*;

(*c*) Ἄθως καλύψει πλευρὰ Λημνίας βοός.

Mr *Salmon* looks upon this to be a very ridiculous Assertion, and tells us that there never was a Shadow discernable at 10 Miles Distance from the Hill that made it. But in Opposition to this, Mr *Edens* says, that he actually saw the Shadow of the *Pike of Teneriff* upon the Sea reaching over the Island *Gomera*, and the Shadow of the upper Part, *viz.* of the *Sugarloaf* to be imprinted like another *Pike* in the Sky it self. *See Salmon's Present State of all Nat. Vol.* 5. *Pag.* 396. *and Philos. Trans.* N° 345. *Pag.* 317.

For

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For Example, to S; so that S F O may be 2 Degr. and S F a Ray of the Sun passing the Vertex of the Mountain T, and terminating the Shadow in F.

THEREFORE in the oblique angled Triangle R F T, the Angle T F R 92 Degr. and F R T 1 *degr.* 6 *min.* (*i. e.* the Distance F A 87 *Italian* Miles, turned into Degr.) hence F T R 86 *degr.* 54 *min.* and also the Semidiameter F R, 860 *German* Miles, being all given; the Side T R may be found by this Proportion. As the Sine of the Angle F T R 86 *degr.* 54 *min.* is to the Sine of the Angle T F R 92 *degr.* so is F R 860, to RT 861 *German* Miles. So that AT, the Altitude of Mount *Athos*, is 1 *German* Mile, or 32 Furlongs, which is too much; for the *Grecians* account it not above 11 Furlongs

IF we assume the Altitude of the Sun to be but one Degr. the Altitude of the Mountain will be found but 20 Furlongs.

BUT *Pliny*, I suppose, has given us too large a Distance betwixt *Athos* and *Myrrhina*, which may perhaps be a Reason, that too great a Height arises from this Calculation: and in most of our modern Maps of *Greece*, the Distance F A seems to be but about 55 *Italian* Miles; wherefore the Angle FRT will be but about 55 *min.* So that supposing the Sun's Altitude to be 1 *degr.* 30 *min.* the Angle TFR will be 91 *degr.* 30 *min.* and F T R 87 *degr.* 35 *min.* Therefore in the Triangle FRT, as the Sine of the Angle FRT 87 *degr.* 35 *min.* is to the Sine of the Angle TFR 91 *degr.* 30 *min.* so is FR 860 to RT.

OR in the Triangle TFA right angled at A, TFA will be 1 *degr.* 30 *min.* and FA, supposed a right Line, 55 Miles, from whence the Height TA will be found by this Proportion. As the Radius is to the Tangent of the Angle TFA, 1 *degr.* 30 *min.* so is FA 55 Miles to AT, the Altitude of the Mountain.

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TO this Place belongs the Solution of this Problem, *viz.* Having the difference of Time between the Sun's rising (or setting) on the Top of a Mountain, and it's first Appearance to (or Occultation from) an Observer at the Bottom, to find, if required, the Height of the Mountain; and conversly, having the Height of the Mountain, to find this difference of Time. *Aristotle* and *Pliny*, have, by this Method of Calculation, supposed some Mountains to be of incredible Altitudes, as appears from their Writings. However, since the Solution of these Problems depends upon another, which we have referred to the second Part of this Work, we shall refer them to Chapter xxx.

PROPOSITION VII.

The highest Mountains have no sensible Proportion to the Semidiameter of the Earth; or so little, that their Altitude no more affects it's Rotundity, than a speck or particle of Dust upon the Surface of the artificial Globe does it's Rotundity.

WE have shewed, that the Mountain in the Island of *Teneriff*, called *the Pike*, is at most no higher than a *German* Mile, or a *German* Mile and a half; and we are assured, that there are but few Mountains in the World higher than that: Therefore since the Earth's Semidiameter is 860 such Miles, the Altitude of this high Mountain is to the Earth's Semidiameter as 1 to 860. But few Mountains are of this Height, most of them not exceeding a quarter of a Mile; wherefore they no more obstruct the Earth's spherical Figure, than the small inequality observed in Globes turned artificially, does their Rotundity; and Nature hath not

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yet been able to produce a Body of an exact Geometrical Roundness (*d*).

PROPOSITION VIII.

To explain the Origin of Mountains.

THIS is a great Question with some Philosophers, but others think it superfluous, and not fit to be enquired into; because they suppose Mountains to have had a Being ever since the Creation. Nevertheless History acquaints us, that not a few Mountains have been undermined by interior Ruins, and sunk down into subterraneous Chasms and Receptacles, or wasted by some other Means; so that since we can perceive a natural Decay and Corruption of them, we may judge they do not proceed from a supernatural Origin. Moreover, that several Mountains were raised successively, and at several Times, is apparent from the Quantities of Sea-shells that are found in some of them, as in those of *Gelderland*, &c. Such Mountains as these seem to be generated by a rapid Wind, carrying Sand and Gravel by Degrees into the form of the Mountain, which is afterwards soaked and made solid by the Rain. This is to be understood in little Mountains, as to the very large ones it is probable, they

(*d*) Tho' the Body of the Moon be three times as little as the Earth, and the Protuberances or Mountains upon her Surface, three Times as high as the highest upon the Earth's Surface; yet when she is at the full, and observed with the naked Eye, we cannot perceive that these vast Mountains in the least obstruct, or deface her apparent Rotundity. On the contrary, when she is viewed thro' a good Telescope, we can see the outward Edge of her Disk notched and made rugged, by the Tops of the Mountains rising far above the other Parts of the Surface; which need not seem strange, when the best polished Globe that ever was made, being viewed thro' a good Microscope, is found not to be free from such Rugosities.

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are of the same Age and Origin with the Earth itself. They that argue more Theologically, suppose the Globe of the Earth to have been at first created perfectly round, and with a soft Surface, without any eminent Parts or Mountains, without any Fissures or Grottos; and afterwards, when GOD commanded *the Waters to be gathered together in one Place*, then there were Chanels made to receive the Waters, and the Earth that was removed out of these Chanels, was converted into Mountains. But we leave it to them to prove, whether the Mountains be so many, and so large, as to fill all the Chanels of the Sea (*e*).

PROPOSITION IX.

To explain the Causes, why Rain, Mists, and Snows, are frequent upon the Tops of the Mountains; when in the neighbouring Vallies, the Air is serene and calm without any such Meteors.

WE are informed by those, that have travelled over the Mountains of *Asia*, *Peru*, and other Countries,

(*e*) 'Dr *Woodward*, in his 'Essay towards a Natural History of the Earth, proposes 'to prove, that the Strata at 'first, whether of Stone, of 'Chalk, of Coal, of Earth, or 'whatever other Matter they 'consisted of, (lying each upon other) were all originally 'parallel: that they were plain, 'even, and regular; and the 'Surface of the Earth likewise even and spherical: that 'they were continuous, and 'not interrupted or broken: 'and that the whole Mass of 'the Water lay then above 'them all, and constituted a 'fluid Sphere environing the 'whole Globe. That after 'some Time the Strata were 'broken on all sides of the 'Globe: that they were dislocated and their Situation 'varied, being elevated in 'some Places, and depressed 'in others. That the Inequalities and Irregularities of the 'Terrestrial Globe, were caused by this Means: date their 'Original from this Disruption, and are entirely owing 'unto it. That the more 'eminent Parts of the Earth, Mountains

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tries, that while they were on their Tops, they were frequently attacked with Showers of Rain, Snow, and thick Fogs; but descending thence into the neighbouring Vallies, they observed no such Meteors, but enjoyed a serene and pleasant Air. We also observe the same in the Mountains of our own Country.

SOME say, the Cause of this Phænomenon is owing to an occult Power that Mountains have of attracting Air, Clouds, and other Meteors; but since they cannot explain this Power, they say nothing to the Purpose (*f*). The following Explication seems to me the most rational, *viz.* That Vapours and Exhalations being condensed into small Drops, in the middle Region of the Air, (into which the Tops of several Mountains rise) begin to descend and fall upon the Tops of the subjacent Mountains which are nearer them than the Vallies, and coming there first to Ground, they leave their Places in the Air, which are presently taken up by the small Drops that are next them; these being pressed and forced downwards by others, either to avoid a *Vacuum*, or because it is the Na-

'Mountains and Rocks, are 'only the Elevations of the 'Strata; these wherever they 'were solid, rearing against 'and supporting each other in 'the Posture wherein they 'were put, by the bursting 'or breaking up of the 'Sphere of the Earth.' *Woodward's* Essay. *Pag.* 90, 91, 92.

(*f*) The Air in Vallies is much heavier than the Vapours, and therefore fitted to support them better than that light Air which is upon the Tops of high Mountains. Therefore when the Vapours are put into a violent Agitation, and, in some measure, condensed by Winds, or other external Causes, they gather themseves into Clouds and Mists, and by their own specific Gravity, fall downwards, till they meet with such Air as is heavy and able to support them, with which they mix and swim about, and are every way dispersed in it, whereby the Sky is made serene and clear: but if they meet not with such Air, or light upon the Top of a Mountain before they come at such Air, then they are formed into Drops, and fall down to the Ground.

ture of Water to flow to the loweſt Place, or to that Place where the Flux was firſt begun.

PROPOSITION X.

There happen to Mountains, Ruins, Ruptures, Tranſpoſitions, &c.

IT is but ſeldom ſuch Accidents happen, yet ſome Inſtances are found in Hiſtory, eſpecially of Ruptures, whereof we ſhall give ſome Examples in the following Chapter.

PROPOSITION XI.

Whether the Superficies of a Mountain be more capacious than the Plane whereon it ſtands?

THAT it is larger is proved from Geometry: But whether it can ſupport a greater Number of living Creatures, or produce a larger Quantity of Corn is another Queſtion; to which I anſwer in the Affirmative. For tho' every thing placed upon the Surface of the Mountain, is ſuppoſed to ſtand perpendicular to the ſubjacent Plane, yet there is a greater Quantity of Earth, and a larger Superficies.

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CHAP. X.

Of the Difference of Mountains and their Extent, and particularly of Burning Mountains.

PROPOSITION I.

Some Mountains are of small Extent, and others run out to a great Distance.

THE latter Sort, called *Ridges*, or *Chains of Mountains*, are found almost in every Country throughout the World; and such might be accounted one continued Mountain, if it were not for small Breaches or Passages that sometimes intervene. They are indifferently extended several Ways; some from North to South, others from East to West, and some to other Points collateral to the four Cardinal ones.

THE most celebrated Ridges of Mountains are,

1. THE *Alps*, which separate *Italy* from the neighbouring Provinces, extending themselves over vast Tracts of Land, and stretching out their Arms, or Branches, into distant Countries, *viz.* thro' *France* to *Spain*, where they are called the *Pyreneans*; and thro' *Rhætia* [i. e. *the Country of the Grisons*] where they are called the *Rhetian* Mountains; also thro' *Hungary*, where they are named the *Hungarian* Mountains; and above *Dalmatia*, where they receive the Name of the *Dalmatian* Mountains; from whence they are stretch-

ed thro' *Macedonia* into [*Romania*], and even to the Coast of the *Black-Sea*. But because there is in *Dalmatia* a considerable Space between the *Alps* and the *Dalmatian* Mountains, the former is reckoned by some to end here. Nevertheless they send out one continued Ridge, which passeth, with a winding Course, in the Form of a Half-Moon, thro' the whole Length of *Italy*, and divides it into two Parts even to the Streights of [*Messina*]; tho' it does not run every where directly forward in one Tract, but here and there sends out collateral Branches that run sideways from it. Several of these Mountains are distinguished by particular Names, by Reason of their Altitude, or for some other Cause, as *Monte Masso*, *Gaurus*, *Monte di Capua*, the burning Mount *Vesuvius*, &c.

2. THE Ridge of Mountains in *Peru* [*called the Andes*] is the longest in the World. They run in a continued Tract about 800 *German* Miles, (whereof 15 make a Degree) thro' all *South America*, from the Equator to the Streights of *Magellan*, and separate the Kingdom of *Peru*, from other Provinces. And so high are the Tops of these Mountains, that they are reported to tire the Birds in their Flight over them; there being but one only Passage over them as yet discovered, and that very difficult. Many of them are covered with perpetual Snow, as well in Summer as in Winter. The Tops of others are hid in the Clouds, and some are raised above the middle Region of the Air. Several of the *Spaniards*, with their Horses, have suddenly expired upon the Tops of these Mountains, in their Passage from *Nicaragua* to *Peru*, and growing stiff with the Cold, they, in a Moment, became immoveable as Statues. The Cause of which seems to be no other than the Want of such Air as was fit for

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for Respiration. There are also found among this Ridge of Mountains several that are *sulphureous* and *smoaking*.

3. THERE are many other Ridges of Mountains between *Peru* and *Brasil*, which are stretched out thro' unknown Countries as far as the Streights of *Magellan*, where their Tops are covered with continual Snow, tho' they lie in the Latitude of 52 Degrees.

4. TO these may be added the Ridges of Mountains in *Canada*, and *New England*, whose Tops are also perpetually covered with Snow, tho' they are not so famous as the rest.

5. *MOUNT Taurus*, in *Asia*, was antiently thought to make a Part of the largest and noblest Ridge of Mountains in the World. It begins to shew itself in the *Lesser Asia* near [*the Gulph of Statalia*], and runs from West to East, under several Names, thro' divers large Kingdoms, and Countries, even to *India*; whereby all *Asia* is divided into two Parts, of which that on the North Side is called *Asia intra Taurum*, and that on the South, *Asia extra Taurum*. This Ridge is as it were fenced on either Side with several others that accompany it, among which the most celebrated are the *Greater* and *Lesser Antitaurus*, which separate the *Greater Armenia* from the *Lesser*; also where *Taurus* itself passes between *Armenia* and *Mesopotamia*, it sends forth many Branches towards the North and South.

6. THE Mountain *Imaüs* is extended North and South, and also East and West, in the Form of a Cross. The North Portion of it, is now called *Alkai:* It is stretched out southward as far as the Borders of *India*, to the very Head of the River *Ganges*, and is computed in Length about 400 *German* Miles. It divides [*Asiatic Tartary*] into two Parts

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Parts, formerly called *Scythia intra & extra Imaüm.*

7. THE Mountains of *Caucasus* are about 50 Miles in Breadth, and extend themselves lengthway from the Confines of the *Caspian-Sea* towards the *Euxine-Sea.* They are a sure Sea-Mark to those that sail in the *Caspian-Sea*, to steer their Course by. An Arm of them reaches to Mount *Ararat* in *Armenia*, upon which it is said, in Sacred Scripture, the *Ark* of *Noah* rested; and the *Turks* and *Persians* will have it to be preserved there to this very Day. *Ararat* is also not far from Mount *Taurus*, where all these Mountains are contiguous. We shall treat of the Height of Mount *Caucasus* in Chapter xxx.

8. THE long Range of Hills in *China*, which comprehends the *Damasian* Mountains of the Antients towards the West, and the *Ottorocoran* towards the North. This Range is composed of a vast Number of Mountains, not altogether continued, but here and there affording a Passage between them. The Mountains of *Cambodia* seem also to be a Part of this Range.

9. THE Mountains of *Arabia* are drawn out in three Ranks, whereof the holy Mount *Sinai* is a Part.

10. *MOUNT Atlas*, in *Africa*, is made famous by the innumerable Fictions of the *Greek* Poets. It's Rise is near the western Shore of *Africa*, from whence it stretches itself to the eastward as far as the Confines of *Egypt.* Most of the Rivers in this Continent take their Rise from it; and tho' it lie in the *Torrid Zone* it is cold and covered with Snow in several Places.

11. THE *Mountains of the Moon*, near *Monomotapa* in *Africa*, sendeth out several Branches, which surround almost all *Monomotapa*, and are distinguished by divers Names, as *Zeth*, [*Gibel*, *Caph*,] &c.

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&c. There are almost innumerable other Branches in *Africa*, separated one from another only by narrow Passages, insomuch that they all seem to be Parts of the same Range of Mountains.

12. THE *Riphean* Mountains, in *Europe*, run from the *White-Sea*, or *Muscovian-Bay*, to the Mouth of the River *Oby*; from whence they are called sometimes by that Name. The *Muscovites* call them *Weliki Kamenypoys*, i. e. *the great stony Girdle*; because they suppose them to encompass the whole Earth. Near these there is another Ridge of Mountains, which the *Russians* call *Joegoria*; they reach from the South Borders of *Tartary* to the *Northern Ocean*. Several Rivers take their Rise from them, *viz. Witsagda*, *Neem*, *Wissera*, and *Petsiora*. These are none of them well represented in Maps, and very often totally omitted. Also between *Russia* and *Siberia* there are, besides these, a triple Range of Mountains running from North to South. The first of these the *Russians* call *Cosvinscoy Camen*, which is two Days in passing over. The next to this (some Vallies intervening) is called *Chirginscoy Camen*, which is also two Days Journey over. The third, being higher than the rest, is named *Podvinscoy Camen*, and in several Places is all the Year round covered with Snow and Fogs, so that a Passage is, with great Difficulty, obtained in four Days. The Town of *Vergateria*, in *Siberia*, is near this Range.

13. [*THE Dofrine Hills*,] which separate *Sweden* from *Norway*, arise near the South Promontory of *Norway*, and proceed in several Ranges to the farthest Part of *Lapland*, being also distinguished by several Names, as *Fillefiel*, *Dofrefiel*, &c.

14. THE *Hercynian* Mountains in *Germany* [now *Fiechtelberg* Mountains] surround *Bohemia*; and

and various Ways extend themselves into divers Countries where they have different Names. In the Dukedom of *Brunswic* they retain something of their antient Name, being called *Der Hark*; Mount *Bructerus* is a Part of this Ridge.

PROPOSITION II.

In most Islands, and Parts of the Continent that run out into the Sea, the Ridges of Mountains are so situated as to take their Course thro' the middle of them, and divide them into two Parts.

IN *Scotland* the *Grampian* Mountain (or *Gransbain* as the Inhabitants call it) runs from West to East tho' the middle of this Peninsula; and divides it into two Parts, which very much differ both in the Nature of the Soil, and the Inhabitants. So in the Islands of *Sumatra*, *Borneo*, *Luconia*, *Celebes*, *Cuba*, *Hispaniola*, &c. Chains of Mountains are found which arise gradually to a great Height, from the Sea-Shore to the Inland Parts.

THUS the Mountain *Gate*, in *India*, begins at the Extremity of Mount *Caucasus*, and reaches to Cape *Comorin*; whereby the Peninsula of *India* is divided, from North to South, into two Parts, whereof that Part which lies on this Side *Gate*, towards the West, is called *Malabar*; and the other beyond the Mountain towards the East is called *Cormandel*. Part of the same Ridge of Mountains is also stretched out into that Part of *India* which is now called *Bengal*, and from thence thro' *Pegu*, *Siam*, to the extream Parts of *Malacca*.

THERE is the like Ridge of Mountains in the Peninsula of *Cambaya*, and in the Island, or Peninsula, of *California*; also in the procurrent Parts of *Africa*, there is a Ridge which reaches from

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from the Morass of *Zaire* to the *Cape of Good-Hope.* In *Italy* there are the *Apennine* Mountains; and the like in *Corea*, &c.

AS to the Origin of these Ridges, whether they are of the same Date with the Earth, or were afterwards generated from natural Causes, is uncertain (*a*).

PRO-

(*a*) 'The learned Dr *Woodward*, in his Essay abovementioned Page 280, proves, 'that there were Rivers as well 'as Sea in the Antediluvian 'Earth, from the great quantities of River-Shells that were 'then brought forth, and left inclosed among others in the '*Strata* of Stone, &c. And 'if there were Rivers, there 'must needs also have been 'Mountains; for they will not 'flow unless upon a Declivity, 'and their Sources be raised above the Earth's ordinary Surface, so that they may run 'upon a Descent. *Moses* also, 'treating upon the Deluge, 'saith in *Gen.* vii. 19. &c. '*And the waters prevailed exceedingly upon the earth; and 'all the high hills that were 'under the whole heaven were 'covered. Fifteen cubits upward, did the waters prevail; 'and the mountains were covered. And all flesh died:— 'all in whose nostrils was the 'breath of life.* Here he 'plainly makes these Antediluvian Mountains the Standards 'and Measures of the Rise of 'the Water; which they could 'never have been, had they not 'been standing when it did so 'rise and overpower the Earth. 'His Intention, in the whole, 'is to acquaint us, that all 'Land Creatures whatever, 'Both Men, Quadrupeds, 'Birds, and Insects, perished, 'and were destroyed by the 'Water; *Noah*, only excepted, '*and they that were with 'him in the ark.* And at the 'same Time to let us see the 'Truth and Probability of the 'Thing: to convince us there 'was no Way for any one to 'escape, and particularly that 'none could save themselves 'by climbing up to the Tops of 'the Mountains that then were, 'he assures us that they, even 'the highest of them, were all 'covered and buried under 'Water. Now to say that 'there was then no Mountains 'and that this is meant of 'Mountains that were not formed 'till afterwards, makes it 'not intelligible, and indeed 'hardly common Sense.' Thus far Dr *Woodward*. But at the universal Deluge, the Mountains in general were defaced, levelled, and dissolved, as it were, and promiscuously mixed with the Waters, which ransacked and tore up their very Foundations, so as to make one common confused Mass. Therefore these Mountains of our present

PROPOSITION III.

To enumerate the Mountains famous for their Height.

1. *THE Pike of Teneriff*, which the Inhabitants call *Pico de Terraira*, is accounted the highest Mountain in the World; and it's Top is plainly perceived at Sea 60 Miles before we come up to it, as was said in the preceding Chapter. There is no ascending it but in the Months of *July* and *August*, for at other Times it is covered with Snow, tho' there is never any seen in the rest of the Island, or in the neighbouring *Canaries*. It's Top doth plainly appear to be above the Clouds, which are often seen to surround the middle Part; but because it is usually covered with Snow, it is certainly, not elevated above the middle Region of the Air. It requires three Days to ascend this Mountain, whose *Vertex* is not sharp-pointed but plain; from whence, on a clear Day, one may see distinctly the rest of the *Canaries*, tho' some of them are fifty Miles remote from it. In the two Months abovemention'd great Quantities of sulphureous Stones are dug out of the Side of this Mountain, and carried into *Spain*. *Scaliger* writes, that this Mountain continually vomited out burning

sent Earth, are not the same with the Antediluvian Mountains, but were formed at the Deluge, out of the confused Heaps of several sorts of Matter, which (when the Cause of the general Devastation ceased) began to curdle as it were, and settle in innumerable Forms and Shapes; some extending themselves into long Ridges, others into round and rugged Shapes; just as the subsiding Waters happened to dash out, or pile up, their Particles, by washing and hollowing their Sides, or carrying the loose and unsettled Earth, towards the Drains and Sluices which were naturally formed to carry the Water downward to the Ocean. How the Antediluvian Mountains were formed see Chapter vii. Note (*f*) above.

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ing Coals formerly (*b*). I am ignorant from what Author he had it, and never found any such Thing in those I have read.

2. IN one of the *Azores*, or western Islands, near the Island *Fayal*, there is found a Mountain called the *Pike of St George*, from whence the Island itself is called *Pico*. It is said to be as high as the *Pike of Teneriff*, or something higher.

3. THE Ridge of the *Cordileras*, or *Andes*, in *South-America*, which separates *Peru* from other Countries, is one of the vastest and highest Mountains in the World. It is extended from the Streights of *Magellan* to *Panama*.

4. *ÆTNA*, a Mountain in *Sicily*; when it casteth forth Fire the Sparks are seen from the Island of *Malta*, from whence it is supposed to be at least a [*German*] Mile high; but that this is a Deception of Sight we have shewed in the preceding Chapter.

5. *HECLA* a Mountain in *Iceland*.

6. *PICO de Adam* in the Island of *Ceylon*.

7. MOUNT *Bructerus* and *Abnoba* in *Germany*.

8. MOUNT *Figenojamma* in *Japan* is thought to reach above the Clouds.

9. MOUNT *Caucasus* was thought to be of an incredible Height by the Antients.

(*b*) It is very likely this Mountain might burn formerly, for there is a *Crater*, or Tunnel, on the Top, that produceth a sort of sulphureous Earth, which, being rolled up long-ways, and put to a Candle, will burn like Brimstone; and several Places upon the Ledges of the *Pike* are even now burning or smoaking; and in some Places, if you turn up the Stones, you will find very fine Brimstone, or Sulphur, sticking to them. Also at the Bottom there are Stones which shine, and look like Dross that comes out of a Smith's Forge; which, without Doubt, was occasioned by the extream Heat of the Place they came from. This is testified by Mr *Edens* who made a Journey thither in the Year 1715, which see in *Philos. Trans.* No. 345. Page 317.

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10. *PELION* [*now Petras*] a Mountain in *Macedonia*. *Pliny* says, that the Mathematician *Dicearchus Siculus* measured this Mountain by the Command, and at the Expence, of some Princes, and found it to be 1250 Paces, that is 10 Furlongs, or ¼ of a *German* Mile: and *Geminus* tells us, that the same *Dicearchus* found the Mountain *Cyllene* to be of the same Altitude.

11. MOUNT *Athos* was thought by *Mela* to be so high as to rise above the highest Clouds, and therefore never to be rained upon. This Opinion had it's Rise from the Ashes which were left upon the Altars, erected at the Top of it, being not washed away, but found upon a Heap as they had been left. It runs out with a long Ridge into the Sea. *Xerxes*, when he made his Expedition to *Greece*, cut thro' this Mountain in that Place where it is joined to the Continent, and let the Sea in at the Breach, whereby it was made navigable.

12. MOUNT *Olympus* in *lesser Asia*, of which we have treated in the preceding Chapter.

13. *CASIUS* [*now Lison*] a Mountain in *Asia*, which is said by *Pliny* to the four Miles high.

14. MOUNT *Hæmus* [*now Balkan*] is said by *Martianus Capella* to be six Miles high.

15. THE Rock of *Sisimethra*, *Strabo* tells us, was found to be fifteen Furlongs high; and the Rock *Sodiane* twice the Height.

16. MOUNT *Atlas* in *Africa*, which we spoke of before. The Poets feigned it so high, that it supported the Heavens upon it's Shoulders; but Experience hath taught us that it's Height is not so very considerable.

PRO-

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PROPOSITION IV.

To enumerate the remaining Differences of Mountains.

IN the former Propositions we have explained three Differences, *viz.*

1. SOME are extended in a long Tract, others are bounded with narrow Limits.

2. SOME run thro' the middle of Countries, others are extended here and there in them.

3. SOME are of a remarkable Altitude, others of a middle, and some very low. To these we may add,

4. SOME are sandy, others rocky, some chalky, and others of Clay, &c.

5. SOME produce Fountains and Heads of Rivers, others are without them.

6. SOME are adorned with Woods, others are bare and destitute of Trees.

7. SOME are burning and smoking, others without Fire or Smoke.

8. SOME Mountains yield Metals, as Gold, Silver, Iron, &c. others produce no sort of Metal.

9. SOME are continually covered with Snow, others have none in Summer.

PROPOSITION V.

To enumerate the burning Mountains, and such as cast out Fire.

SUCH Mountains are called *Vulcanos*, a Name first used by the *Portugueze* Sailors, and now they are commonly so called.

1. THE most famous of these is Mount *Ætna*, (*now Gibel*) in *Sicily*, whose Eruptions of Flame

 and

and Smoke are discovered at a great Distance, by those that sail on the *Mediterranean*, even as far as the Harbour of *Malta*, which is 40 *German* Miles from the Shore of *Sicily*. Tho' Fire and Smoke are continually vomited up by it, yet at some particular Times, it rages with greater Violence. In the Year 1536 it shook all *Sicily*, from the first to the twelfth of *May*: after that, there was heard a most horrible bellowing and cracking, as if great Guns had been fired: then were a great many Houses overthrown throughout the whole Island. When this Storm had continued about eleven Days, the Ground opened in several Places, and dreadful Gapings appeared here and there, from which issued forth Fire and Flame with great Violence, which in four Days consumed and burnt up all that were within five Leagues of *Ætna*. A little after, the Funnel, which is on the Top of the Mountain, disgorged a great Quantity of hot Embers and Ashes, for three whole Days together, which were not only dispersed throughout the whole Island, but also carried beyond Sea to *Italy*; and several Ships that were sailing to *Venice*, at 200 Leagues distance suffered Damage (*c*). *Farellus* hath given us an Historical Account of the Eruptions of this Mountain, and says, that the Bottom of it is 100 Leagues in Circuit.

2. *HECLA*, a Mountain in *Iceland*, rages sometimes with as great Violence as *Ætna*, and casts out great Stones. The imprisoned Fire often, by wanting Vent, causes horrible Sounds, like Lamentations and Howlings, which make some credulous People think it the Place of Hell, where the Souls of the wicked are tormented.

(*c*) Mr *Oldenberge* hath also given us an Historical Account, of the Eruptions of Mount *Ætna*, which see in *Philos. Trans.* N°. 48. *Pag.* 967.

3. *VESUVIUS*

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3. *VESUVIUS* (*now Monte de Soma*) in *Campania*, not far from the Town of *Naples*, tho' it be planted with most fruitful Vines, and at other Times yieldeth the best *Muscadel* Wine; yet it is very often annoyed with violent Eruptions (*d*). *Dion*

(*d*) *That the Reader may have a better Idea of these burning Mountains, and their dreadful Eruptions, I shall transcribe* (*from* Philos. Trans. No. 354. Pag. 708.) *an Extract of a Letter of Mr* Edward Berkeley *from* Naples, *giving an Account of the Eruptions of Fire and Smoke, from Mount* Vesuvius. *Communicated to the* Royal Society *by Dr* John Arbuthnot, *M. D.* and *R. S. S. as follows:*

'*April* 17. 1717. With much 'Difficulty I reached the Top of '*Vesuvius*, in which I saw a vast 'Aperture full of Smoke, which 'hindred the seeing it's Depth 'and Figure. I heard within 'that horrid Gulph certain odd 'Sounds, which seemed to proceed from the Belly of the 'Mountain; a sort of Murmuring, Sighing, Throbbing, 'Churning, dashing (as it were) 'of Waves, and between whiles 'a Noise like that of Thunder 'or Cannon, which was constantly attended with clattering, like that of Tiles falling 'from the Tops of Houses on 'the Streets. Sometimes as the 'Wind changed, the Smoke 'grew thinner, discovering a 'very ruddy Flame, and the 'Jaws of the Pan, or *Crater*, 'streaked with red, and several 'shades of Yellow. After an 'Hour's stay, the Smoke being 'moved by the Wind, gave 'us short and partial Prospects of the great Hollow in 'the flat Bottom, of which I 'could discern two Furnaces, almost contiguous; that on the 'left, seeming about 3 Yards 'in Diameter, glowed with red 'Flame, and threw up red hot 'Stones, with a hideous Noise, 'which as they fell back caused 'the forementioned clattering. '*May* 8. In the Morning I ascended to the Top of *Vesuvius* a second Time, and found 'a different Face of Things. 'The Smoke ascending upright, gave a full Prospect of 'the *Crater*, which as I cou'd 'judge, is about a Mile in 'Circumference, and a hundred Yards deep. A conical 'Mount had been formed since 'my last Visit in the middle 'of the Bottom. This Mount 'I could see was made of the 'Stones thrown up and fallen 'back again into the *Crater*. 'In this new Hill remained 'the two Mouths or Furnaces 'already mentioned: that on 'our left Hand was in the *Vertex* of the Hill, which it had 'formed round it, and raged 'more violently than before, 'throwing up every three or 'four Minutes, with a dreadful bellowing, a vast Number of red hot Stones, some-

Dion Cassius relates, that in the Reign of *Vespasian*, there was such a dreadful Eruption of impetuous Flames, that great quantities of Ashes and sulphureous Smoke were carried not only to *Rome* by the Wind, but also, beyond the *Mediterranean*, into *Africa*,

'times, in Appearance, above '1000, and at least 300, Foot 'higher than my Head as I 'stood upon the Brink. But 'there being little or no Wind, 'they fell back perpendicularly 'into the *Crater*, increasing 'the conical Heap. The other 'Mouth was lower in the Side 'of the same new formed Hill, 'I could discern it to be filled 'with red hot liquid Matter, 'like that in the Furnace of a 'Glass-house, which raged 'and wrought, as the Waves 'of the Sea, causing a short a'brupt Noise, like what may 'be imagined to proceed from 'a Sea of Quickfilver, dashing 'among uneven Rocks. This 'stuff would sometimes spew 'over, and run down the con'vex Side of the conical Hill, 'and appearing at first red hot, 'it changed Colour, and hard'ned as it cooled, shewing the 'first Rudiments of an Erup'tion, or, if I may so say, an 'Eruption in Miniature. Had 'the Wind driven in our Face, 'we had been in no small 'Danger of stifling by the sul'phureous Smoke, or being 'knocked, on the Head, by 'lumps of molten Minerals, 'which we saw had sometimes 'fallen on the Brink of the '*Crater*, upon those shot from 'the Gulph at the Bottom. 'But as the Wind was favour'able, I had an Opportunity 'to survey this odd Scene for 'above an Hour and a half to'gether; during which it was 'very observable, that all the 'Vollies of Smoke, Flame, and 'burning Stones came only out 'of the Hole to our left, while 'the liquid stuff in the other 'Mouth wrought and over'flowed, as hath been already 'described. *June* 5. After a 'horrid Noise, the Mountain 'was seen at *Naples* to spew a 'little out of the *Crater*. The 'same continued the 6th. The '7th. nothing was observed 'till within two Hours of 'Night, when it began a hi'deous bellowing, which con'tinued all that Night, and 'the next Day till Noon, caus'ing the Windows, and, as 'some affirm, the very Houses 'in *Naples* to shake. From 'that time it spewed vast 'Quantities of molten Stuff to 'the South, which streamed 'down the Side of the Moun'tain, like a Pot boiling over. 'This Evening I returned from 'a Voyage thro' *Apulia*, and 'was surprized, passing by the 'North Side of the Mountain, 'to see a great Quantity of 'ruddy Smoke lie along a huge 'Tract of Sky over the River 'of molten Stuff, which was itself

Africa, and even into *Egypt*. Moreover, Birds were suffocated in the Air, and fell down dead upon the Ground, and Fishes perished in the neighbouring Waters, which were made hot and infected by it. There happened another Eruption in

'itself out of Sight. The 9th, '*Vesuvius* raged less violently; 'that Night we saw from *Naples*, a Column of Fire shoot 'between whiles out of it's 'Summit. The 10th, when 'we thought all would have 'been over, the Mountain 'grew very outragious again, 'roaring and groaning most 'dreadfully. You cannot form 'a juster Idea of this Noise, in 'the violent Fits of it, than 'by imagining a mix'd Sound 'made up of the raging of a 'Tempest, the murmur of a 'troubled Sea, and the roaring 'of Thunder and Artillery, 'confused all together. It was 'very terrible, as we heard it 'in the further End of *Naples*, 'at the Distance of above 12 'Miles. This moved my Curiosity to approach the Mountain. Three or four of us 'got into a Boat, and were set 'ashore at *Torre del Greco*, a 'Town situate at the Foot of '*Vesuvius* to the South West, 'whence we rode four or five 'Miles before we came to the 'burning River, which was about Midnight. The roaring 'of the *Vulcano* grew exceeding loud and horrible as we 'approached. I observed a 'mixture of Colours in the 'Cloud over the *Crater*, green, 'yellow, red, and blue; there 'was likewise a ruddy dismal 'Light in the Air over that 'Tract of Land, where the 'burning River flowed; Ashes 'continually showered on us 'all the Way from the Sea-'Coast. All which Circum-'stances, set off and augmen-'ted by the horror and silence 'of the Night, made a Scene 'the most uncommon and a-'stonishing I ever saw; which 'grew still more extraordinary 'as we came nearer the Stream. 'Imagine a vast Torrent of li-'quid Fire rolling from the 'Top down the Side of the 'Mountain, and with irresisti-'ble Fury bearing down and 'consuming Vines, Olives, 'Fig-trees, Houses, in a word, 'every Thing that stood in it's 'Way. The largest Stream 'seemed half a Mile broad at 'least, and five Miles long. I 'walked so far before my Com-'panions up the Mountain, a-'long the Side of the River of 'Fire, that I was obliged to 'retire in haste, the sulphure-'ous Steam having surprized 'me, and almost taken away 'my Breath. During our Re-'turn, which was about three 'o'Clock in the Morning, we 'constantly heard the murmur 'and groaning of the Moun-'tain, which between whiles 'would burst out into louder 'Peals, throwing up huge 'spouts of Fire, and burning 'Stones, in *Martial*'s Time, which he elegantly describes in one of his *Epigrams*, and laments the sad Change of the Mountain, which he saw first in it's Verdure, and immediately after black with Ashes and Embers. When the Burning ceased, the Rain and Dew watered the Surface of the Mountain, and made these sulphureous Ashes and Embers fruitful, so that they produced a large Increase of excellent Wine; but when the Mountain began to burn again, and to disgorge Fire and Smoke afresh (which sometimes happened within a few Years) then were the neighbouring Fields burnt up, and the High-ways made dangerous to Travellers.

4. A Mountain in *Java*, not far from the Town of *Panacura*, in the Year 1586, was shattered to Pieces by a violent Eruption of glowing Sulphur, (tho' it had never burnt before) whereby (as it was reported) 10000 People perished in the underland Fields: it threw up large Stones, and cast them as far as *Pancras*, and continued for three Days to throw out so much black Smoke, mixed with Flame

' Stones, which falling down ' again, resembled the Stars in ' our Rockets. Sometimes I ' observed two, at others three, ' distinct Columns of Flame, ' and sometimes one vast one, ' that seemed to fill the whole ' *Crater*. These burning Co- ' lumns, and the fiery Stones, ' seemed to be shot 1000 Foot ' perpendicular above the Sum- ' mit of the *Vulcano*. The 11th ' at Night, I observed it from ' a Terrass at *Naples*, to throw ' up incessantly a vast Body of ' Fire and great Stones, to a ' surprising Height. The 12th ' in the Morning, it darkened ' the Sun with Ashes and ' Smoke, causing a sort of E- ' clipse. Horrid Bellowings, ' this and the foregoing Day, ' were heard at *Naples*, whi- ' ther Part of the Ashes also ' reached. On the 13th, the ' Wind changing, we saw a Pil- ' lar of black Smoke shoot up- ' right to a prodigious Height. ' The 15th in the Morning, the ' Court and Walls of our House ' in *Naples* were covered with ' Ashes. In the Evening, ' Flame appeared on the Moun- ' tain thro' the Cloud. The 17th, ' the Smoke appeared much di- ' minished, fat and greasy. The ' 18th, the whole Appearance ' ended, the Mountain remain- ' ing perfectly quiet without a- ' ny visible Smoke or Flame.'

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Flame and hot Embers, that it darkened the Face of the Sun, and made the Day appear as dark as the Night.

5. MOUNT *Gonnapi*, in one of the *Banda* Islands, when it had burnt for 17 Years together, in *April* 1586, broke out with a terrible bellowing Noise, and disgorged such large Quantities of great Stones, and thick sulphureous burning Matter all over the Sea and Land, that it threatned Destruction to all that were near it. Hot Ashes and Embers were vomited out with such a Force, and in such great Quantities, that they covered the great Guns of the *Dutch*, which were planted upon the Walls of their Citadel, and rendered them unserviceable. Red hot Stones above a Span long, were cast into the Sea, and such a Number of little ones, that small Ships had scarcely a free Passage out of the Harbour. The Water near the Shore was heaved up, and seemed to boil for several Hours, as if it had been set over a Fire; and several dead Fishes were found floating upon the Surface.

6. MOUNT *Balaluanum* in *Sumatra*, vomiteth Flame and Smoke as *Ætna* doth.

7. THE Ground in several Places in the *Molucca* Islands belches out Fire with a raging Noise; but none are so terrible as the Spiracle in the Island *Ternata*. The Mountain, which is steep and difficult to ascend, is covered towards the Bottom with thick Woods, but the Top which is elevated to the Clouds, is made bare and rugged by the Fire. The Funnel is a vast Hollow, which goes shelving down, and by Degrees becomes less and less, like the inside of an Amphitheatre; from whence, in Spring and Harvest Time, or about the Equinoxes, when some particular Winds blow, especially from the North, there are cast forth, with a rumbling Noise, Flames mixed with black

 Smoke,

Smoke, and hot Embers; whereby all the Places far and near are ſtrewed with Aſhes. The Inhabitants viſit it at ſome certain Times of the Year, to gather Sulphur, tho' in ſome Places the Hill cannot be aſcended, but by Ropes faſtned to Iron Hooks.

8. There is an Iſland about 60 Leagues from the *Moluccas*, (being one of thoſe that belong to the *Moors*) which is often all together ſhaken with Earthquakes and Eructations of Fire and Aſhes in abundance; ſo that whole Rocks and Mountains are often made red hot by the Heat of the ſubterraneous Fire, and burning Stones are blown up into the Air, as large as the Trunks of Trees. When there is a briſker Wind than ordinary, ſuch Clouds of Aſhes are blown all over the Country, that People labouring in the Fields are forced to haſten Home, half covered with them; and Boars, and other living Creatures, are found buried in them, after the Storm is over. Fiſhes near the Sea Shore are poiſoned with the Aſhes, and ſo are the Inhabitants if they taſte any of the Water wherewith they are mixed. This diſaſterous black and poiſonous Fire breaketh out, from the Top of a Mountain, with a diſmal rumbling Noiſe like Thunder-claps, or the report of great Guns, and bringeth up with it abundance of Aſhes, and burnt *Pumice Stones*.

9. THERE is a Mountain in *Japan*, which continually vomiteth forth Flames; where it is reported the Devil ſhews himſelf, ſurrounded with a bright Cloud, to ſome particular Perſons after they have, for Performance of their Vows, kept themſelves lean for a long Time.

10. THERE are ſeveral other Vulcanos in the *Japan* Iſlands; about ſeventy Miles from *Firando* there is one, and in a ſmall Iſland between *Tanaxima* and the *Seven Siſters* (Iſlands ſo named) there

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there is another, which now and then is obſerved to burn, and at other Times to ſmoke.

11. NEAR the *Cape Spiritu Sancto* in *Tandaya*, one of the *Philippines*, there are found ſome ſmall Vulcanos; and one in *Marinda*, which is a Part of the ſaid Iſlands.

12. IN *Nicaragua* a Province of *America*, thirty Leagues from the Town of *Leon*, there is a Mountain, of a vaſt Height, which diſgorgeth ſuch quantities of Flame, that they may be perceived at ten Miles diſtance.

13. IN the *Peruvian* Range of Mountains (called the *Cordilleras*) there are in ſeveral Places burning Rocks and Mountains, ſome vomiting Fire and Flame, and others ſmoaking; eſpecially thoſe in *Carrapa* a Province of *Popaiana*, which are perceived in clear Weather to emit a deal of Smoke.

14. NEAR *Arequipa*, a Town in *Peru*, about ninety Leagues from *Lima*, there is a Mountain which continually vomits ſulphureous Fire, which, the Inhabitants are afraid, will ſome Time or other burſt and overthrow the Town adjacent to it.

15. IN *Peru*, near the Vale called *Mulahallo*, about fifty Leagues from *Quito*, there is a Vulcano, or ſulphureous Mountain, which, ſome Time ſince, burſt and threw out great Stones, with a dreadful Noiſe, which frighted People even at a great Diſtance.

16. IN one of the Iſlands called *Papoys*, which *La Maire* diſcovered (tho' perhaps it be not an Iſland, but is joined to the eaſtern Shore of *New Guinea*) there is a Mountain which, at that Time, burnt and ſmoked.

17. THERE are ſeveral Mountains (as the *Muſcovites* tell us) in the Country of the *Ton-Guiſins*,

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sins, upon the East of the River *Jenisia*, some Weeks Journey from the River *Oby*, which produce Vulcanos and smoking Mountains.

18. THERE are also some of this sort near the River *Pesida* beyond the Country of the *Ton-Guisins*.

19. THERE is a Mountain in *Fez*, called *Beni-Gua-zeval*, which hath a Cave in the Side of it, that vomiteth out Fire.

20. IN *Croatia*, not far from the Sea-Shore near the Town of *Apollonia*, there is a rocky Mountain, from whose Top there often breaks out Fire and Smoke; and, in the adjacent Places, several of the Springs are hot.

THERE are also some Mountains which have left off burning; such as that in the Island *Queimoda* upon the Shore of *Brasil*, not far from the Mouth of the *Silver River*, or *Rio de la Plata*, which burnt formerly, but now ceases. Likewise the Mountains in *Congo* or *Angola*; also those in the *Azores* (especially in *Tercera* and *St Michael*) which used formerly to burn in several Places, but at present only emit, now and then, Smoke and Vapours; whence they are annoyed with more frequent Earthquakes. The Islands of *St Helena* and *Ascension* produce Earth which seems to be composed of Dross, Ashes, and burnt Cinders; so that in Time past it is probable the Mountains in these Islands burned; and further, because in these, as well as in the *Azores*, there are found sulphureous Earths and Slags, like the Recrements of *Smithy Coal*, which are every Way fit to take Fire, and make Smoke; it will be no wonder if new Vulcanos should, some Time hence, be kindled and break forth in these Islands; for the Cause of these burning Mountains is a sulphureous and bitumi-

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bituminous Matter, which is contained and kindled in them (*e*).

(*e*) Earthquakes and Vulcanos are both produced from the same Cause; which may be thus explained. Those Countries which yield great store of Sulphur and Nitre, or where Sulphur is sublimed from the *Pyrites*, are by far the most injured and incommoded by Earthquakes; for where there are such Mines they must send up Exhalations, which meeting with subterraneous Caverns, they must stick to the Arches of them, as Soot does to the Sides of our Chimnies, where they mix themselves with the Nitre or Saltpeter, which comes out of these Arches, in like manner as we see it come out of the Inside of the Arch of a Bridge, and so makes a kind of Crust, which will very easily take Fire. There are several ways by which this Crust may take Fire, *viz.* 1. By the inflammable Breath of the *Pyrites*, which is a kind of Sulphur that naturally takes Fire of itself. 2. By a Fermentation of Vapours to a degree of Heat, equal to that of Fire and Flame. 3. To the falling of some great Stone, which is undermined by Water, and striking against another, produces some Sparks which set Fire to the combustible Matter that is near; which, being a kind of natural Gun-Powder, at the Appulse of the Fire, goes off (if I may so say) with a sudden Blast or violent Explosion, rumbling in the Bowels of the Earth, and lifting up the Ground above it, so as sometimes to make miserable Havock and Destruction, 'till it gets Vent or a Discharge. Burning Mountains and Vulcanos are only so many Spiracles serving for the Discharge of this subterranean Fire, when it is thus preternaturally assembled. And where there happens to be such a Structure and Conformation of the interior Parts of the Earth, that the Fire may pass freely and without Impediment from the Caverns therein, it assembles unto these Spiracles, and then readily and easily gets out, from Time to Time, without shaking or disturbing the Earth. But where such Communication is wanting, or the Passages not sufficiently large and open, so that it cannot come at the said Spiracles without first forcing and removing all Obstacles, it heaves up and shocks the Earth, till it hath made it's Way to the Mouth of the Vulcano; where it rusheth forth, sometimes in mighty Flames, with great Velocity, and a terrible bellowing Noise. See *Woodward's Essay Page* 157, 158. *Rohault's Physics Part* 3. *Chap.* 9. *Sect.* 23, 24. *Philos. Trans.* № 157. *Pag.* 512.

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PROPOSITION VI.

Some Ranges of Mountains afford no Apertures, as others afford many; and some are discontinued but in one or two Places.

THESE Streights, or Paſſages, were formerly called *Thermopylæ*, of which the moſt famous are, 1. The *Thermopylæ* of Mount *Oeta* [or *Banina*] in *Theſſalia*, [now called *Bocca de Lupo*] which gave Name to the reſt. 2. The *Caſpian* Streights, thro' which there is a Paſſage between the *Caſpian* Mountains. 3. The Paſſage thro' the Ridge of the *Cordilleras* in *Peru*. 4. The Paſſage thro' the Mountains on the Weſt-ſide of the *Arabian* Gulph, by which Merchandize is carried from *Abyſſinia* into *Arabia*. 5. The two Paſſages thro' Mount *Caucaſus*, *&c.*

PROPOSITION VII.

When a Mountain runs out into the Sea, or ſeems [to Mariners] to overtop the reſt of the Country, it is called a Promontory, Cape, *or* Head-land. *The moſt famous are,*

1. THE *Cape of Good Hope* at the extream Point of *Africa*, which muſt be doubled by thoſe that ſail into *India*.

2. CAPE *Victory* at the further end of the Streights of *Magellan*.

3. CAPE *Verd*, the moſt weſtern Point of *Africa*, where the Coaſt begins to wind towards the Eaſt.

4. CAPE *Vincent* in *Spain*.

5. THE Promontory of *Atlas* was, ſome Ages ago, called a *Head-land* by Mariners, becauſe they ſuppoſed it unpaſſable, or that if any ſailed

failed beyond it they could not return safe; wherefore it was the utmost Bound of their Navigation on the *African* Coast. Other Promontories may be seen in Maps.

PROPOSITION VIII.

To Mountains are opposed Chasms, deep Pits, and Caves, which are found in some Places of the Earth.

THERE is a stinking sulphureous Cave in *Ireland*, which was formerly very famous, now called St *Patrick's Purgatory*; and in *Italy* there is that called *Grotta del Cane* (*f*). *Leo Africanus* mentions one which emits Fire on a Mountain in *Fez*, called *Beni-gua-zeval.*

IN *Bardesay*, an Island adjacent to the Principality of *Wales* in *Britain*, there is a Rock near the Sea in which there is a Cave, unto which if you apply your Ear, you will hear the Strokes of a Hammer, the blowing of Bellows, and the filing of Iron, as if it were in a Smith's Shop.

NOT far from the Town of *Besse* in *Aquitain*, there is a Cave, called by the Natives *Du Souley*, in which there is heard a Noise like Thunder in the Summer Season.

IN several Places there are found among Mountains, Vallies of such a prodigious Depth, that they strike the Beholders with Horror, and cause a Giddiness in the Head.

(*f*) See *Sturmius Philos. Exercit.* 11. *de Terræ Mot. Chap* 3. where some of the most eminent Specus's are enumerated, and some of their Uses, *viz.* that they serve for Spiracles and Funnels to the Countries where they are to vent and discharge the Damps and Vapours which would otherwise, being imprisoned, occasion frequent Succussions, and dreadful Convulsions of the Earth. *See the Note above.* And for more to this purpose, see the *Philosophical Transactions*, and *French Memoirs*: *passim.*

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CHAP. XI.

Of Mines, Woods, and Desarts.

MINES, *Woods*, and *Desarts*, make several Tracts of the Earth remarkable, of which, tho' but little can be said, yet it will not be unnecessary for the more perfect Knowledge of the Parts of the Earth's Superficies, to consider these Places, and to trace out their Situations, which we shall briefly do in this Chapter.

PROPOSITION I.

Mines are Places in the Earth, out of which Metals, Minerals, and other Kinds of Earth are dug.

SO many different Kinds of Fossils as there are, so many various Names have their *Mines*, viz. *Gold-Mines*, *Silver-Mines*, *Copper-Mines*, *Iron-Mines*, *Coal-Mines*, *Salt-Mines*, and such as produce Gems, *&c.*

THE most celebrated *Gold* and *Silver-Mines*, are.

1. THOSE of *Peru*, and *Castella del Oro*, which are the richest in the World, yielding Gold and Silver in abundance, and not being destitute of other Metals; insomuch that the Natives of *Peru*, and the *Spaniards* used to boast, that this Kingdom was founded upon Gold and Silver. *Girava*, a *Spanish* Writer

Writer affirms, that there were formerly Mines about the Town of *Quito*, which produced more Gold than Earth. And when the *Spaniards* made their first Expedition into this Golden Country, they found several Houses, especially in the Regal City *Cusco*, which were all covered over within and without with Plates of massy Gold. And the Officers of the *Peruvian* Forces, not only wore Silver Armour, but all their Arms were made of pure Gold. The most rich and advantageous Mine of Silver is in the Mountains of *Potosi*, where 20000 Workmen are daily employed to dig it, and carry it up at least 400 Steps. These Mines produce that vast Quantity of Gold and Silver, which the King of *Spain* receives out of *America* every Year, to the Mortification of other Kings and Potentates; and which, he therefore keeps fortified with strong Forts and Garrisons.

2. THERE are excellent rich Mines of Silver in the *Japan* Islands, whence they are called by the *Spaniards*, the Silver Islands. There are also some Mines of Gold found there; but these are not so rich as formerly.

3. THERE were more plentiful Gold-Mines formerly in *Arabia*, than at present.

4. IN the Mountains of *Persia*, and in *China*, there are some Silver-Mines.

5. IN *Guinea* there are several Mountains, that produce Gold, but they are remote from the Shore, and the Gold-Dust that is brought from thence, is not dug out of the Ground, but gathered up and down by the Natives. Their in-land Kings are however said to possess each his Mine, the Product of which he sells to the Neighbouring Merchants, and they again to others, till it reaches the Sea-Shore, where it is exchanged with the *Europeans*.

6. IN

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6. IN *Monomotapa*, there are found rich Mines of Gold and Silver, and alſo in *Angola*, both which are thought to be Parts of one continued Vein.

7. *GERMANY* excels the reſt of the Kingdoms of *Europe* for plenty of Mines, of which ſome produce ſmall Quantities of *Gold*, others abundance of *Silver*, and a great many of them *Copper*, *Iron*, *Lead*, *Vitriol*, *Antimony*, &c. about which conſult the Deſcriptions of *Germany*.

8. *SWEDEN* is enriched with the beſt *Copper-Mine* of any hitherto diſcovered; it is in a vaſt high Mountain, which they call *Kopperberg*, out of which as much Copper is dug as makes up a third Part of the King's Revenue. Here are alſo *Iron-Mines*, and ſome *Silver-Mines*, but they ſcarcely defray the Expence of digging them.

9. THERE are Mines of precious Stones found in the Iſland of *Ceylon*, and alſo in *Congo* (where there is a Silver-Mine, and ſo much Marble, that the Earth under Ground is thought to be all Marble) and in *Peru*, about *Portovejo* in *Smaragdina*) and in *Guiana*, near the Coaſt of which there is a ſmall Iſland, called *St Maria*, which yields abundance of Gold, even 100 Pound Weight every Year, if we may believe the *Dutch*. In the Kingdom of *Golunda*, there is a Mine which yieldeth precious Stones, particularly Diamonds in abundance, but it is not now dug.

10. IN *Chili*, there are Mines yielding *Gold*, *Silver*, and *Gems*, but the warlike Inhabitants, ſetting more by Iron Weapons than Gold or Silver, have partly killed, and partly driven away the *Spaniards*, and demoliſhed the Mines that were but newly begun.

11. THE Iſland *Madagaſcar* abounds in *Iron* and *Tin*, with a moderate Quantity of Silver, a little *Gold*, but no *Lead*. Wherefore the Natives value Lead Spoons above Silver ones.

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12. IN the Island of *Sumatra*, it is reported, that there are rich Mines of Gold, Silver, Brass, and Iron; and that the King in one Year (*viz.* 1620) received into his Treasure 1000 Pound Weight of Gold.

13. IN the *Philippine* Islands, and in *Java*, *Hispaniola*, *Cuba*, and others; there are found Mines of Gold, Silver, Copper, and Iron: and in the Mountains of *Siam* there is got Gold, Silver, and Tin.

14. THERE are Mines of Salt in *Poland* at *Pocbnia*, four Miles from *Cracow*; (where huge Lumps of transparent white Salt are cut out of the Ground) in *Transilvania*, in the County of *Tyrol* in *Spain*, in *Lesser Asia*, and in Places near the *Caspian Sea*, not far from the River *Wolga*, over-against the Island *Kistowat*, where the *Russians* dig their Salt and boil it to a more pure Substance, and after transport it to all Parts of *Russia*. In *Cuba*, there is a whole Mountain of Salt. All the Mountains in the Island of *Ormus*, at the Mouth of the *Persian* Gulph, are of Salt, which may be gathered in any Part of them, in such great Quantities, that the very Walls of their Houses are built of crystalline Salt. In a Valley in *Peru*, about eighteen Miles from *Lima* to the Northward, are found deep and large Pits of Salt, where every one may take away what Quantity he pleases, because it continually increaseth, and seemeth impossible to be exhausted. In *Africa* there is no other Salt used, but such as is dug out of Pits, or Quarries, like Marble, of a white, greenish, or Ash, Colour. All *India* fetch their Salt from the great Salt-Mines of *Bagnagar* in *Cormandel*, &c. We shall treat of Salt-Springs in another Chapter.

PROPOSITION II.

A Wood is a multitude of Trees extended over a large Tract of Land, which spring up without planting, and grow without being cultivated.

SEVERAL Woods produce only one sort of Trees, from which they receive their Names; so that as there is a great Variety in Trees, there is also the same in Woods, *viz. Palm Woods, Oak Woods, Osier Woods, Beech Woods*, &c. Groves and Forests, are also thus distinguished. Divers Countries, especially those more remote, produce different Sorts of Woods. In *Africa*, about *Cape Verd*, there are whole Woods of Lemon and Orange-Trees, which the Sailors may pluck for a very small Matter. In *France*, there are whole Woods of Chesnut-Trees: In *Ceylon* there are Woods of Trees, whose Bark yieldeth Cinnamon: In the *Molucca* Islands, there grow Clove-Trees: In the *Banda* Islands, there groweth plenty of Nutmegs: In *Brazil* there groweth a hard sort of Wood, which we call *Brazil* Wood: In *Africa*, especially in *Numidia*, there grow Grapes, of which are made Raisins of the Sun: In the Island *Madagascar*, and in other Places of *India*, there are Trees which bear Tamarinds: In Mount *Lebanon* there are Cedars, and whole Woods of them in *Japan*; of which they make Masts of Ships. In *Spain, France*, and *Italy*, there are whole Woods of Olive and Myrtle Trees. In *Germany* there are Woods that produce Fir, Oak, Alder, Beech, Pine, Juniper, Maple, Poplar, Ash, and Elm.

THE most noted Woods are, the *Hercynian* Forest, which formerly overspread almost all *Germany*, and at this Day taketh up large Tracts of Land in several Countries, and under several Names.
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The ancient *Caledonian* Wood in *Scotland*, with several others in other Countries; especially in *Norway*, where there grow more large Trees than in any other Country, and from whence all *Europe* procures Masts for their Shipping. *Lithuania* is also overspread with Woods, and Forests; from whence large Taxes are raised for the King of *Poland*.

PROPOSITION III.

Desarts are vast Tracts of Land uninhabited by Men.

THESE are of two sorts, such whose Soil is barren and unfruitful, properly called Desarts; and such whose Ground is fertile enough, but are nevertheless said to be desart, because they are uncultivated by Men. In *Muscovy*, and in Places near the *Caspian Sea*, along the Banks of the *Wolga*, there are large Tracts of fertile and fat Meadow Ground, which lie desart and uncultivated; in the former Place, by reason of it's Plenty, and the Laziness of the Inhabitants: And in the later, by the Wars of *Tamerlane*, when these Countries were laid waste, and depopulated. But such as these are improperly called Desarts.

THERE are four kinds of Desarts (properly so called) *viz. sandy Desarts*, *marshy Desarts*, *stony Desarts*, *and heathy Desarts*; which last produce Woods and Forests in several Places, and are more useful and easy to be cultivated.

1. THE *Desarts of Africa* are almost all sandy, and there is not any part of the Earth so much over-run with Desarts. Those in *Libya* surround all *Egypt*; and are accounted the largest upon Earth.

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2. THE Desarts of *Arabia*, are some of them sandy, and others stony: the greatest is vulgarly called the *Sand-Sea*.

3. THE Desarts about the Mountain *Imaüs*. The *sandy* Desart of [*Xamo*] in *Mongul*, where the rich Kingdom of *Cathaia* formerly was (tho' falsly) supposed to be.

4. THE Desarts of *Cambodia*.

5. THE rocky Desarts of *Nova Zembla*.

6. THE Desarts of *Norway*, *Lapland*, *Sweden*, and *Finland*.

7. THE Desarts of *Germany*, are all Heath; hence those in *Lunenburg*, are called *Lunenburg-Heath*, &c.

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SECT. IV.

Containing HYDROGRAPHY; *which is explained in six Chapters.*

CHAP. XII.

Of the Division of the Ocean by the Interposition of Lands.

HAVING treated of the *Division of the Earth, and it's Parts*, in the foregoing Chapters; Order requires that we also consider the Situation and Division of the *WATERS*, which make the other Part of the Terraqueous Globe, and explain such of their Properties as belong to *Geography*.

IN the second Proposition of Chapter vii. we divided the Waters into four Species, *viz.* 1. The Ocean and Seas. 2. Rivers and fresh Water. 3. Lakes and Marshes. 4. Mineral Waters. In this Chapter we shall Discourse of the Division of the *Ocean*.

PROPOSITION I.

The Ocean, in a continued Extent, encompasseth the whole Earth, and all it's Parts, nor is it's Superficies any where interrupted, or altogether broken by the interposed Earth; only a larger Tract of Sea, or a wider Communication is in some Places wanting.

THE Truth of this Proposition cannot be proved but by Experience, which is chiefly gained by sailing round the Earth, which hath been often attempted and happily accomplished; first by the *Spaniards* under Capt. *Magellan*, who first discovered the Streights, called by his Name; then by the *English*, *viz.* by Sir *Francis Drake*, Sir *Thomas Cavendish*, and others; after by the *Dutch*, &c.

THE Antients never doubted that the Ocean was thus continued; for they supposed the old World to be raised above the Waters, and every where surrounded thereby (and some of them thought it floated). But when *America* was discovered (which is extended in a long Tract from North to South, and seems to hinder the Continuation of the Ocean) and also the Arctic and Antarctic Continent, then they began to think otherwise; for they imagined, that *America* was joined to some Part of the South Continent (which was not unlikely) in like Manner as most of our modern Geographers, suppose that *North America* is joined to *Groenland*. If both these Conjectures had been true, then indeed the Ocean had not encompassed the whole Earth. But *Magellan* removed all Doubts and Scruples about it, by discovering, in the Year 1520, the Streights between *America* and the South Continent, which join the *Atlantic* to the *Pacific Ocean*. What therefore the Antients happened to stumble upon, by a wrong way of arguing, we have found out to be a real Truth by Experience. The same may be said about *Africa*; for the Antients, without any Hesitation, supposed it to be bounded to the Southward by the Ocean, and not to be extended so far beyond the Equator, as it really is; but when the *Portuguese* had sailed along the western Coast of *Africa*, and found it to be extended a great way beyond the Equator, it was questioned whether *Africa* could be sailed round (so far as to afford a Passage to *India*), that is, whether *Africa* was extended Southward or

encom-

encompassed by the Ocean. But this Doubt was also removed by *Vasco di Gramma*; who, in the Year 1497, first sailed round the most southern Promontory of *Afric*, called, *The Cape of Good-Hope*; which Name it had received from *John* II, King of *Portugal*, in the Year 1494, when *Barthel Diaz* (who first returned from it, tho' he did not double the Cape for want of Provision, and by Reason of tempestuous Weather) had given him a large Account of the stormy troubled Sea about this Promontory.

PROPOSITION II.

The Ocean, taken altogether, is formed by the Land into several Portions, of which there are three Species, viz. 1. *Oceans, or great Seas.* 2. *Bays or Gulphs.* 3. *Streights.*

1. THE Word Ocean is taken in a double Sense, sometimes for that general Collection of Waters which surround the whole Earth; and very often for a Part of that Collection, which is joined on both sides to other Parts by broad Tracts. Thus we say, The *Atlantic Ocean*, The *German Ocean*, The *Ethiopic Ocean*, and *Indian Ocean*. We shall here use the Word *Ocean* sometimes in the later Sense according to Custom, instead of Sea; which also is a Part of the whole Ocean, because the Word Sea is often used in a somewhat different Sense, as will be shewed by and by.

2. A BAY, or Gulph, is a Part of the Ocean which flows between two Shores, and is every where environed with Land, except where it communicates with other Bays, or the main Ocean. It is very often called a Sea.

A STREIGHT is a narrow Passage, either joining a Gulph to the Neighbouring Ocean,

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or one Part of the Sea or Ocean to another. These Differences are found in the Ocean, as will appear from what follows.

PROPOSITION III.

The main Ocean is divided into four large and particular Parts, which are also each of them called Oceans, and answer to the four Continents, or great Islands of the Earth. These are,

1. THE *Atlantic* Ocean, which is placed between the western Shore of the old World, and the eastern Shore of the new World. It is also called the western Ocean, because it lieth to the westward of *Europe*. It is best divided into two Parts, by the Equator; whereof the one is contiguous to the *Hyperborean* Ocean, the other to the Icy or South Sea.

2. THE *Pacific* Ocean, or great South Sea, which is placed between the western Shore of *America* and *Asia*, and is extended to *China*, and the *Philippine* Islands.

3. THE *Hyperborean*, or northern Ocean, about the *Arctic* Continent.

4. THE southern Ocean, about the South Continent, of which the *Indian* Ocean is a Part.

OTHER Geographers divide the main Ocean into four Parts, after this Manner: They make the *Atlantic* one Part, but do not extend it beyond the Equator, where they begin the *Ethiopic*: They also reckon with us the *Pacific*, and add thereto the *Indian*; but we, in our Division, have more regard to the four great Continents. Some make but three Parts, *viz.* the *Atlantic*, *Pacific*, and *Indian*; but then they extend the *Atlantic* further. Let every one use what Division he likes best, it is

no

no great matter which; for these are not made by Nature, but contrived by the Fancy.

PROPOSITION IV.

Some Parts of the Ocean borrow a Name from the Countries which they bound.

THUS we say the *German* Ocean, the *British* Sea, the *Indian* Ocean, the Gulph of *Venice*, &c.

PROPOSITION V.

Some Bays are oblong, others broad; some primary, and others secondary; the former flow out of the Ocean, the latter out of some other Bay: and such may be called Arms or Branches. The oblong are,

1. THE *Mediterranean* Sea, which breaks out from the Ocean, between *Spain* and *Barbary*; and runs a long space between *Europe* and *Africa*, even as far as *Syria*, *Asia-minor* and *Thracia*. The entrance is called by way of Eminence the Streights. Hence to sail up the Streights, is to visit by Sea, *Italy Greece*, *Syria*, *Sicily*, *Venice*, and the rest of the Countries that lie upon the Coast of this Bay.

THERE are several *secondary Bays*, or Arms, which proceed from it, *viz.* the *Adriatic*, Sea, or Gulph of *Venice*, the *Archipelago*, &c.

IT may be reasonably enquired, whether the *Euxine* Sea be a Part of this Bay. Of which see Chap. xv.

THE *Mediterranean* hath divers Names from the several Coasts it reaches; on the North it hath *Spain*, *France*, *Italy*, *Sicily*, *Sclavonia*, *Greece*, *Candia*, *Romania*, *Asia-minor*; on the South it hath *Morocco*, *Fez*, *Tunis*, *Tripoli*, *Egypt*. From whence it is called the Gulph of *Lyons*, the *Tuscan* Sea, the *Ionian*

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Ionian Sea, the *Levant*, &c. It is extended from West to East, and receives into it many Rivers.

2. THE *Baltic* (or East Sea, improperly so called) breaketh out from the Ocean between *Zeeland* and *Gotland*, part of the Continent of *Sweden*, and also between *Zeeland* and *Jutland*, from whence it flows a long way to the South-East, and afterwards winding to the northward, it reaches a prodigious length between the Provinces of *Mecklenburg*, *Pomerania*, *Courland*, and *Livonia*, on the East; and on the West, *Sweden* and *Lapland*. It sends out two Arms, *viz.* the *Bothnic* Bay, and the Gulph of *Finland*; to which may be added the *Livonian* Sea, or Gulph of *Riga*. It receiveth several great Rivers.

3. THE *Arabian* Gulph, or *Red Sea*, floweth out of the *Indian* Ocean between *Aden*, a Town in *Arabia*, and Cape *Musledon* in *Africa*, having *Africa* on the West, and *Arabia* on the East. It runs to the Eastward as far as the Isthmus of *Africa*, to the Town of *Suez*, where there is a Harbour for the *Turkish* Fleet, and receiveth only a few small Rivers, but not one out of *Africa*. It is extended from the South-East to the North-West.

4. THE *Persian* Gulph [or Gulph of *Balsora*] floweth out of the *Indian* Ocean, near the Island of *Ormus*, from the South-East to the North-West, between *Persia* on the East, and *Arabia* on the West, as far as the ancient *Chaldæa*, where it receiveth the *Euphrates* and *Tigris*, joined a little before in one Chanel; but few Rivers of note besides.

5. THE Gulph of *California*, or *Red-Sea*, runs from South to North, between the West of *Mexico* in *America* and *California*, and ends at *Tatonteac*, an unknown Part of *America*. Modern Discoverers will have *California* to be an Island; and this not to be a Gulph or Bay, but a Streight or Sea (*a*).

(*a*) *See Note* (*e*) Chap. viii.

6. THE

6. THE Gulph of *Nankin* [or *Gang*] runs northwards, between *Corea* and *China*, towards *Tartary*, where some place *Tenduc*, in the Kingdom of *Cathaia:* others will have *Corea* to be an Island. It receiveth but a few Rivers.

TO these may be added several lesser Bays, such as the Gulph *Cambaya*, &c. Only the two first of these, *viz.* The *Mediterranean* and the *Baltic*, afford secondary Bays.

PROPOSITION VI.

The broad and open Bays are seven in Number, viz.

1. THE Gulph or Sea of *Mexico*, which flows out of the *Atlantic* Ocean from East to West, between North and South *America*, where it is stopped by the long Isthmus that joins these two Continents, and separates the *Atlantic* from the *Pacific* Ocean. It receiveth a great many Rivers and for Multitude of Islands may compare with the *Archipelago*.

2. THE Gulph of *Bengal*, or *Ganges*, strikes out from the *Indian* Ocean, towards the North, between *India* and the *Peninsula* of *Malacca*; it is bounded by *Orixa*, *Bengal*, *Pegu*, &c. Kingdoms of *India*, and receives, besides the *Ganges*, a great many famous Rivers.

3. THE Bay of *Siam*, between *Cambodia* and *Malacca*, is extended northward to the Kingdom of *Siam*.

4. THE *White-Sea*, or *Russian* Gulph, flows from the Northern Ocean towards the South, between *Lapland*, and the remote Shores of *Russia*. It stretcheth out an Arm towards *Lapland*, and endeth at *Archangel* in *Muscovy*; which is a Mart much frequented by the *English* and *Dutch*. It receives several great Rivers.

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5. THE *Lantchidal* Sea, is a Bay between [*New Holland*] and *New Guinea*; two *Peninsula's* of the South Continent. It is extended Southward, and terminated at *Carpentaria*.

6. THERE is another Gulph a little to the westward of the last, between [*Nuyt's* Land] and *Van Diemen's* Land (two Sea Captains, by whom these Parts were discovered).

7. *HUDSON*'s *Bay* is bounded by *New Britain*, *New France*, *New Denmark*, &c. and runneth out of the Northern Ocean. To which may be added, *Baffin*'s *Bay*, the Bay of *Biscay*, &c.

PROPOSITION VII.

Streights either join the Ocean to the Ocean, or the Ocean to a Bay, or one Bay to another.

OF Streights we reckon fifteen, *viz.*

1. THE Streights of *Magellan*, tho' they may yield to others for Antiquity, are neverthelefs, accounted very famous for their exceeding long Reach, thro' which there is a free Paffage from the *Atlantic* to the *Pacific* Ocean. The Streight is in Length, from East to West one Hundred and ten Leagues; but the Breadth is various, in some Places two Leagues, one League, and in some Places but a quarter of a League. *Magellan* first discovered it, and failed thro' it in the Year 1520. Tho' it is reported, that *Vascus Nunnius* of *Valboa*, had before (*viz.* in the Year 1513) taken notice of it when he failed that Way, to make Discoveries to the Southward. It lieth in 52 *degr.* 30 *min.* South Latitude, between *Patagon*, a Part of South *America* on the North, and the Iflands of *Terra del Fuego* on the South.

2. A little further, to the southward, are the Streights of *La Maire*, which are much shorter than those

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those of *Magellan*. They have a Part of the South Continent on the East, and the Islands of *Terra del Fuego* on the West. A Passage is more expeditiously made thro' these into the great South-Sea, than the other. They lie in 54 *degr.* 30 *min.* South Latitude.

3. THE Streights of *Manila*, between *Luconia* and *Mindanao*, and others of the *Philippine* Islands, are said to be one hundred Leagues in Length, and are a very dangerous Passage to Ships, by reason of dreadful Quick-sands in several Places. They are extended from East to West, and join, in part, the *Pacific* to the *Indian* Ocean, which are also not far from thence, joined by broader Streights in many Places.

4. THERE are several other Streights among the *Indian* Isles, and between them and the Continent; as between *Ceylon* and *India*; between *Sumatra* and *Malacca*; between *Sumatra* and *Java*, &c.

5. THE Streights of *Waygats*, thro' which there is supposed to be a Passage from the *Russian* or North Sea, into the *Tartarian* Ocean; but it is so shut up with Ice, that it never could be sailed thro' by the *Europeans* (*b*). It lies between *Samoieda* and *Nova Zembla*.

6. THE Icy Sea, between *Nova Zembla* and *Spitzbergen*, or *New Greenland*.

7. *DAVIS*'s Streights, between North *America* and *Greenland*, have not been yet sailed thro; therefore we are in a doubt, whether it be a Streight or a narrow Sea.

8. *FORBISHER*'s Streights, which afford a Passage from the *Atlantic* Ocean into *Hudson's Bay*.

9. THE Streights of *Anian*, between North *America* and *Tartary* in *Asia*, through which there is said to be a Passage between the *Tartarian* Ocean,

(*b*) *See Note* (*d*) Chap. viii.

and

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and the *Pacific* Sea; but this is as yet unsettled. They who have sailed in that Part of the *Pacific* Ocean pretend to be certain, that there are Streights, or Sea, both between *America* and *Tartary*, and also between *America* and *Greenland*, by reason that for seven hundred Leagues from *Japan* towards North *America*, the Currents set strongly from the North North-West, tho' the Wind be variable, and blow from other Points of the Compass: but when they are come within one hundred Leagues of *New Spain*, these Currents cease, and others flow to the Northward, as if it were to some broad Sea on the North of *New Spain*. Also in these seven hundred Leagues sailing, Whales are daily seen, and other sorts of Fish, that are known to delight in Streights and narrow Seas, which it is probable, come from the Streights of *Anian*, to that Part of the *Pacific* Ocean; because they are not found elsewhere (*c*). However, several of our modern Geographers take no notice of these Streights, but place a vast unknown Ocean, between *Tartary* or *Corea* and *America*.

10. THE Streights of *Gibraltar*, thro' which the *Atlantic* Ocean gusheth into the *Mediterranean* Sea. They lie between *Spain* and *Africa*, and are about two Leagues over at the straitest Place, but much longer. The Ancients believed that there were

(*c*) It is certain the Sea of *Corea* and *Japan*, is annexed to the *Tartaric* Ocean, and also to the Sea of *Greenland*; because that some *Hollanders* affirm, (who were shipwreck'd upon *Corea*, a Peninsula of *China*) that they saw there a Whale, upon whose Back stuck a Harpon Iron of *Gascony*, which not being questioned by any, it is most probable to be conjectured, that this Whale passed from *Spitsberg* thro' the nearest Arm of the Sea, rather than thro' the more remote. But be it how it will, we may hence safely conclude, that the Sea which lies beyond *Japan* and *Spitsberg*, is passable; and thro' more perhaps than one Arm or Chanel, by which they communicate. *See Note (a)* Chap. viii. and *Philos. Transact.* abridged by *Lowthorp*. Vol. iii. Page 612.

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were no such in the first Ages of the World, but that they were made by the breaking in of the Sea upon the Land.

11. THE Streights of *Denmark* [or the Sound] lie between *Zeeland* and *Schonen*, thro' which the *Atlantic*, in part, flows into the *Baltic*, where they are straitest. They are about half a *German* Mile over. Near to this there are two other small Streights, the one between *Zeeland* and *Funen*, and the other called the *Belt*, between *Funen* and *Jutland*.

12. THE Streights of *Babelmandel*, at the Mouth of the *Arabian* Gulph, near the Sea-Port *Aden*, thro' which there is a Passage out of the *Indian* Ocean into the Red-Sea.

13. THE Streights [of *Ormus*] at the Mouth of the *Persian* Gulph, are not properly so called, because they are but little narrower than the Gulph itself.

14. THE *Hellespont*, a Streight famous among the *Grecians*, thro' which there is a Passage from the *Archipelago* to the *Propontis*; near to this there is another narrow Sea, called the *Thracian Bosphorus*, which joins *Propontis* to the *Euxine* Sea.

15. THE *Faro*, or Streights, of *Messina*, between *Italy* and *Sicily*.

MANY have been of Opinion, that there were Streights somewhere northward of *Virginia*, which is in 40 *degr.* North Latitude, whereby the *Atlantic* is joined to the *Pacific* Ocean, and thro' which they might find a free and open Passage to *China*, and the *Philippine* Islands: but this, in the Year 1609, was in vain attempted thro' *Hudson*'s Streights.

THUS have we explained and pointed out the Parts of the Ocean, distinguished by the Situation of the Land, in like manner as in Chapter viii. we described the different Plans of Countries, occasioned by the breaking in of the Ocean. That the Geographer

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grapher may keep all these in his Memory, it will not be unserviceable to him to trace out the Perimeter of the Sea Coast, and to take a transient View of the Shores and Bounds of each Country, and also how they are situated, and joined one to another.

PROPOSITION VIII.

[*To trace out the Sea Coasts, that environ the four Quarters of the Earth*, viz. *The old and new World, and the North and South Continent.*]

1. THE old World, (comprehending *Europe*, *Asia*, and *Africa*,) is extended northward to the Streights of *Waygats*, adjoining to *Samoieda*; upon the West of which is the Kingdom of *Muscovy*, where the White Sea is received into a large Bay from the North; on the further Side of which is *Lapland*, and next to that, on the West, *Norway*, whose Shore runs North and South; then winding to the East, we came to the Shore of *Gotland* and *Schonen*, where there is a Gulph that receiveth the *Baltic* Sea, which is bounded by *Sweden*, *Finland*, *Livonia*, *Prussia*, *Courland*, *Pomerania*, *Mecklenburg*, *Holstein*, and *Jutland*; then turning southward on the further Side of *Jutland* and *Holstein*, we find the Shores of *Westphalia*, *Holland*, *Flanders*, *France*, and *Spain*; where there is another Inlet that receives into a vast Bay the *Mediterranean* Sea, which is hemmed in by *Spain*, *France*, *Italy*, *Sclavonia*, *Greece*, *Romania*, *Asia minor*, *Egypt*, *Barbary*, and *Morocco*, over-against the *Spanish* Shore; then we turn along the Western Shore of *Africa*, to Cape *Verd*; and from thence the Shore bends eastward along *Guinea*, and southward by *Congo* and *Angola*, to the Cape of *Good Hope*; where it is again reflected northward, and gives Bounds to *Sofala*, *Zam-*

guebar,

guebar, and [*Anian*]; here the *Arabian* Gulph, or *Red-Sea*, is extended to *Egypt*, which is joined to the *Arabian* Shore, and to the Shores of the *Persian* Gulph: upon the East of these, are the Shores of *Persia*, *Cambaya*, *Indostan*, *Malacca* in *India*, *Bengal*, *Cambodia*, *China*, *Tartary* at *Corea*, to the Streights of *Uries*; where follow the unknown Coast of Northern *Tartary*, and the *Samoieds*, which is [very likely] joined to the Streights of *Waygats*, where we began.

2. *AMERICA* is thus encompassed by the Ocean. On the North at the Streights of *Davis*, there is *Hudson*'s Bay, from whence follow in order to the southward the Shores of *New-Britain*, *New-England*, *New-France*, *Virginia*, *Florida*, *Mexico*, and *New-Spain*, on the Isthmus; then *New-Castle*, *Guinea*, *Brasil*, and *Patagon*, at the Streights of *Magellan*, where the Shore from running southward begins to turn towards the West; thence from South to North are extended the Shores of *Chili*, *Peru*, *New-Spain* and *New-Mexico*, which is bounded by the Gulph of *California*; [where follow the unknown Shores of *Mozembec*, &c. (bounded perhaps by the Streights of *Anian*) which may be contiguous (for any thing that we know) to those of *Davis*'s Streights.]

3. THE *Arctic* Continent is extended to *Davis*'s Streights, and from thence begin the Shores of *Greenland*, which run a little to the South, and then return northward to *Spitsberg*, where they are called the Shores of *New-Greenland*: these are stretched out over against *Nova Zembla*, and the North of *Tartary*; from whence the rest of the Shore to *Davis*'s Streights is unknown.

4. THE South Continent stretches to the Streights of *La Maire*, whence the Shore is perhaps continued to *New-Holland*, where the *Lantchidol* Sea is received into a Gulph, on the other

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Side whereof is *New Guinea*, which [very probably] is contiguous to the Shores at the Streights of *La Maire*.

LET us now trace out the Perimeter of the Ocean. Between *Davis*'s Streights, and *Nova Zembla* there is the northern Ocean, and Icy Sea, or Sea of *Greenland*; which is continued till between *Europe* and *America*, where it is called the *German* Ocean, the *British* Ocean, the *French* and *Spanish* Ocean, and, in the whole, the *Atlantic* Ocean; (and maketh three Bays, *viz.* the *Mediterranean*, the *Baltic*, and the *Mexican* Gulph) which, when it comes between the Coasts of *Africa* and *Brasil*, is called the *Ethiopian* Sea on the one Hand, and on the other the Sea of *Magellan*: further to the East, between *Africa* and the South Continent, is the southern Ocean, and between *Asia* and the same Continent the [eastern or] *Indian* Ocean; also between *Asia* and South *America* is the *Pacific* Ocean [or great South Sea] which is extended northward to the Streights of *Waygats* and *Anian*, and southward to the Streights of *Magellan* [and *La Maire*] by which it is joined to the *Atlantic*. It goes under several Names along the Coast of *America*, as the Sea of *Chili*, *Peru*, *Mexico*, *California*, &c.

The Terraqueous Globe is divided into Land and Water. Again Water is divided into the main Ocean, Lakes, Morasses, and Rivers. The main Ocean is formed by the Earth into three sorts of Portions.

1. *The Ocean, whose prime Parts are four.*

1. The

1. The *Atlantic* [or western Ocean] with the *Ethiopic* Sea, between *Europe* and *Africa* on the one Hand, and *America* on the other. It obtains various Names from the Places it watereth, *viz.*
- The *Britannic* Ocean,
- The *German* Ocean,
- The *Spanish* Ocean, *&c.*

2. THE *Pacific* Ocean, or great South Sea, between the furthest Parts of *Asia* and the *Indian* Islands, on the one hand; and the western Shore of *America* on the other.

3. THE northern Ocean, about the *Arctic* Continent, sometimes called the Icy Sea, *Tartarian* Ocean, *&c.*

4. THE southern Ocean, about the *Antarctic* Continent, a Part of which is the *Indian* Ocean.

2. *Bays or Gulphs.*

Of which these six are oblong:

1. The *Mediterranean* Sea between *Europe* and *Africa* as far as *Asia minor* —— it's Parts are [The *Tyrrhene* Sea. The *Ionian* Sea. The *Levant*, *&c.*]

   secondary Bays are
   - The Gulph of *Venice*,
   - The *Archipelago*,
   - The *Euxine* Sea, *&c.*

2. The *Baltic* Sea with it's secondary Bays, *viz.* the *Bothnic* Bay, the Gulph of *Finland*, the *Livonian* Sea, *&c.*
3. The *Arabian* Gulph, or Red-Sea, between *Africa* and *Arabia*.
4. The *Persian* Gulph, or Gulph of *Balsora*, between *Arabia* and *Persia*.
5. The Sea of *California*, between *California* and *New-Mexico*.
6. The Gulph of *Nankin*, between *Corea* and *China*.

These seven are broad and open, and want Streights,

1. The Gulph of *Mexico*, between North and South *America*.
2. The Gulph of *Bengal*, between *Indostan* and *Malacca*.
3. The Bay [of *Siam*] between *Malacca* and *Cambodia*.
4. The White Sea, between *Lapland* and *Muscovy*.
5. The *Lantchidol* Sea, between *New-Holland* and *New-Guinea*.
6. The Gulph between *Nuyt*'s Land, and *Van Diemen*'s Land.
7. *Hudson*'s Bay; between *New-France* and *New-Denmark*.

3. *Streights.*

1. THE Streights of *Magellan*, which join the *Atlantic* to the *Pacific* Ocean. These are longer than any of the rest.

2. THE Streights of *La Maire* near those of *Magellan*, and of the same use.

3. THE supposed Streights of *Anian*, which join the *Pacific* to the *Tartarian* Ocean.

4. *DAVIS*'s Streights which join [*Baffin*'s Bay] to the *Atlantic*, near which are *Forbishers*'s Streights.

5. THE Streights of *Waygats*, which join the Icy Sea, perhaps, to the *Tartarian* Ocean, if the Ice do not interpose.

6. THE Streights of *Gibralter*, which join the *Atlantic* to the *Mediterranean* Sea.

7. THE Streights of *Denmark*, or the Sound, join the *Atlantic* to the *Baltic*.

8. THE Streights of *Babelmandel*, at the mouth of the *Arabian* Gulph.

9. THE Streights of *Ormus*, at the mouth of the *Persian* Gulph.

10. THE

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10. THE *Hellespont* and *Bosphorus*, which join the *Archipelago* to the *Euxine* or Black Sea.

WHETHER the *Caspain* Sea be a Lake or a broad Bay, which is joined to the main Ocean by some subterraneous Streights, is not settled among Geographers.

CHAP. XIII.

Of the Ocean, and certain Properties of it's Parts.

PROPOSITION I.

The Surface of the Ocean, and of all other Liquids, is round and spherical: Or the Surface of the watery Part joined to the Surface of the dry Part, do both together make up the Superficies of the terraqueous Globe.

THE Truth of this Theorem is proved from the Arguments used in Chapter iii. to prove the spherical Figure of the Earth, for they hold as well here as there; but because those Proofs are chiefly built upon the Phænomena that are reasonably supposed to proceed from such a Figure, that is, rather from the Effects than the Cause; we shall propose, in this Place, a Demonstration which is wholly founded upon natural Causes, and by which *Archimedes* proved the Superficies of all liquid Bodies to be spherical: in order to which he took for granted the three following Postulata: 1. That the Earth hath a Center, and is therefore spherical. 2. That it is the Nature of all Liquids, whose Parts are continued and lie at equal Distances from the Center, that the Parts less pressed are expelled from their Places by those that are more pressed, as is manifest from Experience. 3. That every Part of the Liquid is pressed by that Part which is above it, perpendicularly towards the Center of the Earth, if the whole be descending, or is pressed by any other Body. Besides these Postulata, *Archimedes* uses a Geometrical Proposition which is not found demonstrated any where in the Elements; and therefore he demonstrates it himself, which is this: If a Superficies be cut by several Planes, all passing thro' one Point, and each Section be the Periphery of a Circle, whose Center is that one Point, then will the Superficies be spherical, and that Point the Center of the Sphere; as is easily demonstrated.

LET the Superficies of any Body be cut by the Plane I F K E P (*Fig.* 16.) thro' D, and let the Perimeter of the Section I F K E P be circular, having D for it's Center; also let every other Section, made thro' D, have circular Perimeters, and D for their Center. It is to be shewn, that the Superficies of this Body is spherical, and that D is it's Center; *i. e.* that all the Points in the Superficies are equidistant from D. For we may imagine several right Lines to be drawn from D to other Points of the Superficies, and we must prove them to be all equal. We may suppose a Plane to pass thro' any of them drawn from D to the Superficies, and also thro' D F (for two right Lines cutting one another, or meeting, are in the same Plane by *Euclid Lib.* ii. *Prop.* 2.) and the Periphery of the Section will be circular by the Hypothesis; therefore, the supposed Line drawn will be equal to DF, and so will all other Lines drawn from D to the Superficies be in like manner equal to DF (*a*). Hence we prove the Superficies to be spherical, having D for it's Center (*b*). This being premised, the Superficies of all Liquids are thus demonstrated to be spherical. Let us suppose a Liquid at Rest, in the form of EFGH, (*Fig.* 17.) and let the Earth's Center be D, and imagine this Liquid to be cut by a Plane passing thro' D, so as the Section may be represented in the Superficies by EFGH. We are first to prove that this Line EFGH is circular, or an Arch of the Periphery of a Circle, whose Center is D. If it were possible not to be circular, then would two Lines, drawn from D to it, be unequal. Let the unequal Lines DE, DG be drawn, *viz.* let DG be greater than DE, also let the one be the least, and the other the greatest that can be drawn from D. Then draw another right Line DF to EFGH, bisecting the Angle GDE, so as to be longer than DE, but shorter than DG. With this DF as a Radius upon the Center D, describe in the same Plane the Arch IFKH, which will cut the Line DE produced in the Point I, and the Line DG on this Side G, in the Point K.

LIKEWISE with the Radius DL, something less than DE, upon the Center D, describe the Arch LMN within the Liquid in the same Plane IFKH. Then are the Parts of the Liquid within the Arch LMN continued, and at equal distances from the Center D: but the Parts between MN are more pressed than those between LM, having above them a greater Quantity, and therefore a greater Weight of Water.

(*a*) By the Definition of a Circle Chap. ii. Article 3.

(*b*) By the Definition of a Globe Chap. ii. Article 12.

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AND the Parts of the Liquid within LM, being less pressed, are driven out of their Places by those within MN which take them up, and put the Liquid in Motion. But it was before supposed to lie in this Form at Rest, and still; So that the Liquid, by this, will be both at Rest and in Motion, which is inconsistent. Wherefore the right Lines, drawn from D to EFGH, are not unequal, but equal; and so the Line EFGH is an Arch of a Circle, whose Center is D. The same may be demonstrated in all Planes cutting the Superficies of the Liquid, and passing thro' D, *viz.* that the Section is an Arch of a Circle whose Center is D. Therefore since, in the Superficies of Liquids, all Planes passing any how thro' D, are found to produce circular Sections, it will follow, from the foregoing Proposition, that the Superficies of all Liquids is spherical; having the Point D, that is, the Center of the Earth, for their Center; as will more manifestly appear from the Proof of the following Proposition.

PROPOSITION II.

The Sea is not higher than the Land, and therefore the Earth and Water are almost every where of the same Altitude, high Mountains excepted.

THE Truth of this is demonstrated by the preceeding Proposition. For if the Superficies of the Ocean be spherical, and have the same Center with the Superficies of the Earth, and also if the Sea, near the Shore, be no higher than the Land, neither will the middle of the Ocean be elevated above the Earth, because both their Surfaces make up the Superficies of one and the same Sphere. But some perhaps will not believe the former Proposition, by Reason of the assumed Hypothesis; therefore

therefore we shall shew the Truth of this Theorem, without that, from it's known Effects.

1. WE know, by Experience, that Water, if it is not hindred, will flow from a higher to a lower Place. If therefore there were about the Shore any Place lower than the middle of the Ocean, the Water would continually settle from thence towards the Shore, and be always flowing, and in Motion; but the contrary is observed when the Weather is calm.

2. IF the Ocean, far remote from the Shore, was much higher than the Sea Coast, it might be seen at a greater Distance than if it were spherical, even over all the intervening Parts that were of a less Altitude. But Experience sheweth to the contrary, that when we come from the Inland Parts nearer the Shore, we discover by little and little the more remote Parts of the Sea, and the nearer we approach the Shore, the further we can see upon the Ocean. Therefore the remote Parts of the Ocean are not elevated above the Sea Coast, but are of the same Altitude with them and the Earth.

3. SAILORS cannot discover any Difference between their Altitude, at the Sea Coast, and in the middle of the main Ocean, tho' they use the most accurate Instruments; which certainly they might, if the remote Parts were elevated above the rest, as a Tower, or a Mountain. For as we can find the Altitude of a Mountain, or Tower, above the Places of Observation by Instruments, so might they (if there were any) find the superior Altitude of the middle of the Ocean above the Parts next it, by such accurate Instruments as are now in Use.

4. THERE are found, in several Places, great Numbers of Islands, which are, some of them, extended far into the main Ocean, and others

others almost contiguous to the Continent. Therefore no Part of the main Ocean is higher than the Land; because it is not higher than the Shores of these Islands.

5. THE Waves upon the Ocean never keep long upon a Heap, but are naturally diffused 'till they make a smooth Surface: wherefore it is unreasonable to suppose, that the Water should be heaped up towards the middle of the Ocean.

6. IF the Waters in the main Ocean are higher than the rest, why do they not flow into the Chanels of the Rivers, whose Waters are more depressed? for we find, by Experience, that Water naturally flows from the Place where it is, to any other that is lower, which is the Cause of so many Inundations.

FROM the whole I think it sufficiently appears, that the Sea is not higher than the Shores; and but very few Shores are elevated to the Height of the Inland Parts, for these are often observed to rise gradually above the other, 'till they become high Mountains: from whence we conclude that no Part of the Ocean is higher than the Superficies of the Earth. That the Inland Parts are more elevated than the Sea Shores, appears also from the Rise and Currents of Rivers, which, for the most part, break out, and are directed, from these Mediterranean Places, towards the Ocean. These Places therefore are higher than the maritime Parts, because they pour down their Waters upon them. Not but that there are some Countries which are situated a little lower than the Surface of the Ocean, but then they are defended either by the Altitude of the Shores, or by Banks, or long Ridges, of interposed Ground. Some Countries also are not fenced with Banks, because they fear a calm and settled Sea should overflow them, but lest, when it is ruffled with Winds and made impetuous,

impetuous, it should violently break in upon them.

COROLLARY.

IT is therefore in vain to tell us, that the Sea is higher than the Land, and that by a miraculous Providence it is kept from overflowing the whole Earth, and causing another Universal Deluge; for we have shewed, that both Land and Water are included within our spherical Superficies, and that most Parts of the Earth, at least the Shores are higher than the middle of the Ocean, which for that Reason cannot overflow Countries, or cause a Deluge, unless the Shore or Banks are wasted, and their Height diminished, or a greater Quantity of Water force them open, or overpower them, and then indeed there may happen an Inundation. Neither is it impossible, or contrary to Nature, that the whole Earth by such Means might be overflowed, as will be made evidently appear at the End of this Chapter.

PROPOSITION III.

Why the Ocean, seen from the Shore, appears to rise and swell to a greater Altitude, by how much the more remote it is.

THIS is a Deception of Sight, or to speak more accurately, in the Estimation, which hath brought many into an Error, and by which divers have supposed the Sea to be in some Places several Furlongs higher than the Land. But it is a wonder they have never taken notice of a common Experiment, which is to be met with every Day, whereby this Fallacy is easily detected. If we look upon a long Pavement, or Area, or upon a row of Pillars,

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Pillars, the Parts that are remote, will appear higher than those that are near, and the whole Pavement, or Area, will seem to be elevated by little and little, as it's Parts are more remote from us, notwithstanding, in Truth, it be every where of the same Altitude. After the same manner we estimate the Height of the Sea; for if we take a levelling Instrument, and observe from the Shore the remote Parts of the Sea, we shall find it not to be elevated above us, but rather depressed below the Horizon where we stand.

THE Cause of this Deception is thus explained from Optics. Let the Eye at A observe a Pavement, or the Superficies of the Water, a pretty way extended *a e* (*Fig.* 18). Let the Angle *a* A *e* be divided into four equal Parts, or Angles *e* A *d*, *d* A *c*, *c* A *b*, *b* A *a*, by the right Lines A *b*, A *c*, A *d*. These will divide the right Line *a e* into four unequal Parts, *a b*, *b c*, *c d*, *d e*, of which the more remote will be the largest, as appears by the Figure, *viz.* E *d* larger than *d c*, and *d c* larger than *b c*, and *b c* than *a b*. Altho' these Parts are very unequal, yet, by a Deception of the Sight, they will be judged to be all equal, and at an equal Distance from the Eye; so that A *b*, A *c*, A *d*, A *e*, will seem to be A *f*, A *g*, A *h*, A *k*, where *a f*, *f g*, *g h*, *h k*, are equal; and thus the Parts *b c*, *c d*, *d e*, seem elevated, as if they were *f g*, *g h*, *h k*.

O R *shorter thus*. Because the Eye is raised to see things at a Distance, and depressed to view things near, therefore things at a Distance seem elevated, and things near depressed. Or because we measure the Distance of the Parts that are near by the elevation of our Eye, and therefore they seem low; but we cannot do so by the Parts at a Distance, and therefore they seem not low, but raised more than they really are.

HENCE

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HENCE we gather, that tho' the Ocean may seem to be raised above the Shore, and the more the further off, yet we are not to think that it is really so.

SOME imagine the Ocean to be higher than the Earth, because unless it was so, they think it impossible that Water should flow from it to the Heads of Rivers (which are commonly placed very high in inland Countries) since it never flows, but from a higher to a lower Place. But we shall discuss this Point, when we treat of the Origin of Springs.

OTHERS may infer, that the Pike of *Teneriff* is not so high as to be seen on the Ocean at so great a Distance as sixty *German* Miles, or four Degrees, unless either the Foot of the Mountain, or the Ocean itself, be higher than the Sea upon the Coast of *Teneriff*; the like may be said of other Mountains. What is to be answered here appears from Chapter ix. where we treated of the Altitude of Mountains.

PROPOSITION IV.

To explain the Cause and Origin of Bays and Streights.

BAYS, properly speaking, are in the Earth and not in the Sea, and therefore they ought to be called the Arms, Branches, or procurrent Parts, of the Ocean. For those are more properly called Bays of the Ocean, where it receives Peninsula's, such as *Malacca*, *Jutland*, &c.

BUT custom hath obtained that the word Bay, should, contrary to it's Signification, belong to the Ocean, and be the same as an Arm or Branch of it.

THESE Bays or Gulphs are thus produced. When a part of the Sea Shore is by some external

Cause

Cause shattered and rent in two, so as to leave an Opening, whose Surface is lower than the Surface of the Ocean, the Water naturally gusheth in between the Cliffs, and is not stopped till it meet with more elevated Ground, by which it is bounded, and formed into a Bay.

STREIGHTS are from this Cause also produced.

THE reason why these Parts are now and then so miserably torn in Pieces, as to admit Inundations (by which Bays and Streights are formed) is the impetuous Motion and violent dashing of the Waves against the Shore, being forced by Winds, or some other Cause, almost daily, to wash away and waste them: whereby, in process of time, the Earth is broken and disjoined, and made unfit to resist the rushing of the Ocean. But this is more likely to happen if the Shore be low, and consist of loose and crumbling Earth, easy for the Sea to work upon, which will with small resistance burst, and make room for a whole Bay of Water.

IT is manifest, that some new Bays and Streights are thus produced, but we must not thence conclude, that all which are at this Day found in the Earth were so generated: for it is very likely, that a great many of them are of the same Date with the Earth and Ocean; and the rather, because none, nor any thing like them, have been produced in the memory of Man. Tho' the ancient *Grecians* have such Fables; and tell us, that the Mountain *Calpe* upon the *Spanish* Shore, and *Abyle* in *Africa* were formerly joined, but afterwards separated by *Hercules*; from whence these Mountains were called *Hercules*'s Pillars, and the Streights, *Hercules*'s Streights (*a*).

IT

(*a*) There are a great many Testimonies of Authors, and several other Reasons, to induce us to believe, that *Britain* was not

IT was a common Opinion of the Ancients, that the Streights between *Italy* and *Sicily*, were made by the Irruption of the Sea, which we do not so much doubt of: nor do we think it impossible, that the like small Streights have been and are still generated. Streights also may be turned into Bays, and Bays into Streights; as if, for Example, the Mouth of the Streights of *Magellan* or *Manilha*, should be stopped on the one side or the other, they would be changed into long Bays: or if (on the other hand) the *Isthmus* between *Africa* and *Asia*, should be removed, then the *Red-Sea* would be joined to the *Mediterranean*, and they both become Streights, and afford a Passage to the *Indian* Ocean.

PROPOSITION V.

Whether the Ocean be every where of the same Altitude.

IT appears from the first Proposition, that the Face of the Ocean in it's natural Situation, and when no Obstacle hinders, is every where of the same Altitude, having, as was there proved a spherical Surface, and being concentrical with the Earth: but it may be here doubted, whether for some Reasons, it may not in one Place be higher than in another; which is very worthy of Observation, and of great Moment to be well understood, by those

not an Island from the Beginning, but was formerly joined to *France* by an *Isthmus*, between *Dover* and *Calais*, and that this *Isthmus*, in process of Time, being continually beat upon by two impetuous Tides every Day on both Sides, was wore away and wasted. The great Dr *Wallis* was of this Opinion, and so was Dr *Musgrave*. See both their Arguments in *Philos. Trans.* abridged by *Motte*. Part 4. Page 35, 40.

those that propose the cutting thro' of Isthmus's, and joining one Part of the Ocean to another.

SEVERAL will have both the Sea and Land to be higher towards the Northern Parts, than about the Equator, and this was *Aristotle's* Thought (in *Lib.* 2. *Chap.* ii. *de Cœlo*) (*c*). The Reason they bring for it is, that the Ocean seems to flow from the Northern Parts as from a Fountain; but this does not prove it's superior Altitude there: for whether the Northern Countries, or rather the Northern Chanels, be higher or lower than the Chanels near the Equator (as is yet doubtful, or at least not sufficiently proved from that Motion which is not generally found in all the Northern Parts) it does not follow, if they were so admitted, that the Ocean is there higher; because that to lower that superior Height, and to make the other equal with it, the Ocean is constantly flowing towards the Equator. *Aristotle* in the forecited Place adds another fabulous Reason, taken from the Poets, which is not worth an Answer, *viz.* that the Sun when it sets, hides itself beyond the great Bulk of the Northern Regions.

THIS Opinion of the superior Altitude of the North Pole, seems to arise from hence; that when we turn our Faces that way, we imagine the Pole to be raised above the Horizon of the Place we are in, and therefore judge the Countries thereabouts to be elevated above us.

SOME think the *Indian* Ocean to be higher than the *Atlantic*, which they endeavour to prove from the Flux of the Sea in at the Streights of *Gibralter*, and of the *Arabian* Gulph: but then, this doubt is to be considered, whether the Altitude of Bays, especially in their extream Parts, be the same

(*b*) The Earth and Ocean are highest about the Equator. See the Note (*b*) on Chap. iii.

with

with that of the Ocean, or less; and chiefly those Bays which are joined by very narrow Streights to the Ocean.

THAT the *Atlantic* and *Indian* Ocean are higher than the extream Parts of the *Mediterranean*, near *Egypt* and *Asia minor*, none need doubt; for unless the Streights of *Gibralter* (where the *Atlantic* floweth into the *Mediterranean*) were something lower than the Ocean, there would not be such a strong Current there as it is. Perhaps at the Streight's mouth there may be but little difference; but then further, to continue the Flux all over that large Tract between *Europe* and *Africa*, the depression of the Bay must by Degrees be greater, otherwise the Water could not flow when it is so often obstructed by Rocks, Islands, Peninsula's, and other Obstacles, which repel the Current of the Water, and diminish the Force of the Influx. We need not doubt of this, if it be true what is recorded of *Sesostris*, *Darius*, and other Kings of *Egypt*, by some Authors of good Credit, how they attempted to cut a Chanel between the *Red-Sea* and the *Nile*, that out of the *Indian* Ocean and thro' the *Red-Sea*, they might sail that Way from the Mouth of the *Nile* into the *Mediterranean*; which would be of great Advantage to *Egypt* and other Countries upon the Coast of the *Mediterranean*. But they were forced to desist from this Enterprise, when the *Red-Sea* was discovered by the Artificers to be much higher than the *Inner Egypt*. If therefore the *Red-Sea* be higher than the Land of *Egypt*, it will be also higher than the Water of the *Nile* and the *Mediterranean* itself, into which the *Nile* flows; and consequently the *Red-Sea*, and also the *Indian* Ocean, are both higher than the *Mediterranean*, especially the furthest Parts of it about *Egypt*, *Romania*, and the *Archipelago*.

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MOREOVER, other Kings of *Egypt* of old, and of late the *Egyptian* Sultans, and *Turkish* Emperors, had frequent Consultations about cutting through that *Isthmus* that joins *Africa* to *Asia*, and separates the *Mediterranean* from the *Red-Sea*; but the Reason, as we are told, why they did not set about it was, that the *Indian* and *Red-Sea* were found to be much higher than the Shores of the *Mediterranean*: and therefore it was feared, that the *Red-Sea* should overflow them, especially *Egypt*, which is reckoned by every one to be a very low Country.

THAT the *Red-Sea* is higher than the *Mediterranean* appeareth from these Observations; but this, not without Cause, may be doubted by some, because they are both Bays, the one of the *Atlantic* and the other of the *Indian* Ocean. Therefore to give a plausible Reason, why the one should be higher than the other, it will not be amiss to consider, that tho' they are both depressed more than the Seas from which they flow; yet the Difference is less sensible in the extream Part of the *Red-Sea*, which is nearer the *Indian* Ocean, than the extream Parts of the *Mediterranean* are to the *Atlantic*. For I cannot think that the *Indian* Ocean is higher than the *Atlantic*, as some imagine.

IF therefore the Isthmus was cut through, no doubt but a great Quantity of Water would flow from the *Red-Sea* into the *Mediterranean*; but I cannot think so much as to bring *Egypt*, and other Places about the *Levant*, into danger of being overflowed: because if the *Indian* Ocean poured in more Water, the *Atlantic*, would very likely emit less, that so they might each retain the same Altitude in Proportion.

BESIDES this, I suppose the Sultans of *Egypt* and the *Turks*, were induced by other Political

Causes and Reasons to omit cutting through this Isthmus.

THE first scruple was no doubt the greatness of the Work, for it would be no small Labour and Expence to cut thro' an Isthmus, whose Breadth at the narrowest Part is at least forty *German* Miles, and the Earth rocky; besides there must have been Dams and Wears made in several Places, which could not have been done without skillful Workmen, which those Nations have always wanted.

THE second Reason was, because they supposed the Christian Nations in *Italy*, *Venice*, *France*, *Spain*, &c. would receive greater Benefit than they themselves from this Canal, by sailing thro' it to *Persia* and *India*, and bringing thence those precious Commodities, which the *Turks* and *Egyptians* at present carry at their own Prices by Land, and for which they receive large Duties, which bring considerable Revenues into the Grand Seignior's Coffers. See *Maffeus*'s History of *India*, Book iii. where he tells us, how much the Sultans of *Egypt* were formerly offended at the *Portuguese* sailing and trading into *India*.

A third Cause why they neglected this was perhaps, because they knew the Christians excelled them in Navigation; and were therefore afraid lest they should invade those Streights, and the adjacent Countries, or even *Medina* itself, the Sepulchre of *Mahomet*. For a considerable Fleet would in a short time transport a great Army of Men, and all necessary Provisions from *Europe* to *Arabia*, by this Canal.

BUT *Alphonsus Albuquerce*, Governor of the *Portuguese Indies*, was of another Opinion, when he had intended to have turned the *Nile* from *Egypt*, by cutting a Chanel thro' *Abyssinia* (which borders upon *Egypt*, only a few Desarts interposing) to the *Red-Sea*, that by this means he might

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render *Egypt* barren and unfruitful to the *Turks*; but he died before he could undertake it.

THUS far, concerning the Altitude of the *Mediterranean* compared with that of the *Red-Sea*, *Atlantic*, and *Indian* Ocean. We were obliged to explain it; because from thence some take Occasion to argue the unequal Altitude of some Parts of the Ocean.

BUT these things may be confirmed by another Example, if we may compare great Things with small. The *German* Ocean, which is a Part of the *Atlantic*, running between *Friesland* and *Holland*, forms a Bay; which tho' it be but small, in comparison of these famous ones just now mentioned, yet it is called a Sea, and watereth *Amsterdam* the Capital of *Holland*. Not far from thence is the Lake of *Harlem*, which is also called the Sea of *Harlem*: this is as high as the forementioned Bay, and sends out a Branch to *Leyden*; where it is divided into several lesser Canals. And because neither the Lake nor the Bay overflows the bordering Country (when they are settled and at quiet, and they have Bulwarks provided against a Storm) it appears that they are not higher than the Lands of *Holland*. But that the *German* Ocean is higher than these Countries, hath been experienced by the Inhabitants of *Leyden*, when they undertook to cut a Canal from their City to the *German* Shore, near the Town of *Catwic*, which is about two *Holland* Miles in Length; so that the Sea being let in, they might sail into the *German* Ocean, and from thence to other Countries. But when they had finished a great Part of it, they were forced to leave off, having at length found, by Observation, that the *German* Ocean was higher than the Ground between it and *Leyden*; from whence the Place where they left off is called by the *Dutch*, *Het malle Gat*, i. e. unprosperous. Therefore the

German Ocean is something higher than [the *Zuyder Zee* or] the Bay of *Holland.*

BUT all Bays are not depressed below the Ocean, for those that run out into the Land at broad and open Passages, such as those of *Mexico, Bengal,* &c. are, without doubt, of the same Altitude with the Ocean itself: tho' I know the *Spaniards* doubted this (whether the *Pacific* Ocean was higher than the Bay of *Mexico*) when they consulted about cutting thro' the Isthmus of *Panama,* that they might with more Expedition sail to *Peru, China,* and the *Indian* Islands. But besides this Suspense, we understand that they had a Political Reason for not doing it; they were afraid lest the *English, Dutch,* and other Nations should make use of it, and lie in wait at the Entrances, or invade *Peru.* For the *English* and *Dutch* would not care to make such long and dangerous Voyages thro' the Streights of *Magellan* or *La Maire,* when, with a well furnished Fleet, they could force their way thro' those Streights, and perhaps take *Peru,* or at least crush the force of the *Spaniards* there.

THAT we may put an end to this, it is best to determine, that the divers parts of the Ocean and broad Bays are all of the same Altitude, (as was proved in the first Proposition) but long Bays, and chiefly those produced from narrow Streights, are somewhat depressed, especially at their extream Parts: but I could wish there were more diligent and accurate Observations made by those who have the Opportunities of making them, to remove, if possible, the following Doubts, *viz.* 1. Whether the *Indian, Atlantic,* and *Pacific* Ocean are of the same Altitude, or the *Atlantic* be lower than the other two. 2. Whether the northern Ocean, near the Pole, and within the *Frigid Zone,* be higher than the *Atlantic.* 3. Whether the *Red-Sea* be higher than the *Mediterranean.* 4. Whether the

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Pacific Sea be higher than the *Mexican* Bay. 5. Whether the *Baltic* be as high as the *Atlantic*. And theſe Differences ought to be obſerved in *Hudſon*'s Bay, the Streights of *Magellan*, and others. We ſhall treat of the *Euxine* Sea in Chapter xv.

THE continual Flux and Reflux of the Sea, and Currents, make the Face of the Ocean mutable, and it's Parts of a different Altitude, at different Times; but theſe ariſe from external Cauſes, and we here only conſider the natural Conſtitution of the Water: beſides, they do not ſeem to alter the Altitude ſo much in the middle of the Ocean, as near the Shores.

COROLLARY.

THEREFORE we cannot aſſent to *Papyrius Fabianus* and *Cleomedes*, who determined the greateſt Height of the Ocean to be fifteen Furlongs, or half a *German* Mile; unleſs they mean the Depth, which is not at all well expreſſed by the Word Altitude, as it appears in the Tranſlation of *Ariſtotle*, Book i. *Meteor*. Chap. xi. at the end, where βάθεα τȣ πόντȣ is explained of the Altitude of the Sea.

PROPOSITION VI.

The Depth of the Sea, or Ocean, in moſt Parts may be tried with a ſounding Lead; and there are but few Places where the Bottom cannot be reached.

THE Depth of the Ocean varies according to the greater or leſſer Depreſſion of the Chanels; being found $\frac{1}{80}$ of a *German* Mile, $\frac{1}{20}$, $\frac{1}{10}$, $\frac{1}{4}$, $\frac{1}{2}$, *&c.* deep; and in a few Places a whole *German* Mile or more, where the Line was commonly not long enough to try how much, tho' even there it is likely the Bottom is not at a vaſt Diſtance, unleſs

unless perhaps in some Places there may be deeper Pits than ordinary, or subterraneous Passages.

THE Depth of Bays is not so great as that of the Ocean, and their Chanels are less hollowed by being nearer the Land: for the same Reason the Ocean is not so deep near the Shore, as in remote Places; which happens by reason of the concave Shape of the Chanel.

SAILORS find the Sea's Depth with a sounding Lead, in the Shape of a Pyramid, of about twelve Pound Weight, fastened to a Line about two hundred Perches long, tho' some require a Lead of a greater Weight: yet they may be sometimes deceived in this Observation if the Line should be carried away by a Current or Whirlpool, so as not to descend perpendicularly, but obliquely.

BUT when the Depth is so great that no Line is sufficient to sound it, some have thought of a Method to try it thus (*d*). In the first Place they observe, how long a known Weight of Lead will be in descending a known Depth; then they fasten

O 4 a Cork

(*d*) The learned Dr *Hook* has given us a Method (much like the following) to sound the Depth of the Sea without a Line, which, because it promiseth Success, we shall here describe from the *Philos. Trans.* No 9. *Page* 147.

Take a Globe of Fir, or Maple, or other light Wood, as A; (*Fig.* 19.) let it be well secured by Varnish, Pitch, or otherwise, from imbibing Water; than take a Piece of Lead, or Stone, D, considerably heavier than will sink the Globe: let there be a long wire Staple B in the Ball A, and a springing Wire C, with a bended End F, and into the said Staple, press in, with your Fingers, the springing Wire on the bended End: and on it hang the Weight D, by it's Hook E, and so let the Globe and all sink gently into the Water, in the Posture represented in the Figure, to the Bottom, where the Weight, D, touching first, is thereby stopped; but the Ball, being by the Impetus it acquired in descending carried downwards a little after the Weight is stopped, suffers the springing Wire to fly back, and thereby sets itself at Liberty to re-ascend.

And

a Cork or a blown Bladder to the Lead, so as it may be disengaged from it, as soon as the Lead shall touch the Bottom: this being done, they let down the Lead, and observe the time between it's touching the Bottom, and the Cork's rising to the Surface of the Sea; from whence by comparing this with the aforesaid Observations, and stated Pro-

And by observing the Time of the Ball's stay under Water, (which may be done by a Watch, or a good Minute Glass, or best of all by a Pendulum vibrating Seconds, (which must be three Foot three Inches and one fifth of an Inch long) you may by the help of some Tables, come to know any Depth of the Sea. Which Tables may be calculated from the following Experiments made by the Lord Visc. *Brounker*, Sir *Robert Murray*, and Mr *Hook*, in the Chanel at *Sheerness*; mentioned in *Philos. Trans.* N° 24. *Page* 439.

	Oz.	Gr.
A wooden Ball A weighed — — —	$52\frac{2}{16}$	00
Another wooden Ball B — — —	30	20
A Lead A — — — — —	30	00
Another Lead B — — — —	$30\frac{1}{4}$	00

The Ball B and the Lead B were let down at sixteen Fathoms; and the Ball returned in forty eight single Strokes of a Pendulum, held in the Hand, vibrating fifty eight single Strokes in a Minute.

A second time repeated with the same Success; wherefore the Motion was four Foot every Second.

Again the Ball A, and the Lead B, whose Nail was bended into a sharper Angle; the Ball returned in thirty nine Strokes. A second time repeated with the same Success, at the same Depth.

Ball A, Lead A, at eight Fathoms and one Foot, returned at twenty; repeated at eight Fathoms, returned at nineteen.

Tried the third time at ten Fathoms four Foot, returned at twenty eight.

A fourth Tryal at the same Depth, just the same.

A fifth, at ten Fathoms five Foot. returned at twenty seven.

A sixth Tryal, just the same.

A seventh at twelve Fathoms five Foot, returned in thirty-seven.

An eighth Tryal just the same.

But if it be alledged, that it must be known, when a light Body ascends from the Bottom of the Water to the Top, in what Proportion of Time it rises; it may be considered, that in these Experiments the Times of the Descent and Ascent are both taken and computed together; so that for this Purpose, there needs not the Nicety which is alledged.

portions,

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portions, they find the Depth of the Ocean. But there is ſuch a Nicety required in making theſe Tryals, and the time of Obſervation is ſo ſhort, that it is very rare to find the true Depth by this Method. However it appeareth, that the Depth of the Ocean is every where finite, and not extended to the *Antipodes*; becauſe if two Portions of Earth were divided by any Part of the Ocean, which might be continued thro' the Center to the oppoſite Side of the Globe, unleſs they were ſupported with Arches, they would immediately fall together at the Center, becauſe the Earth is heavier than the Water. Beſides, the whole Bulk of Earth and Water is finite and ſpherical; and therefore the Depth of the Ocean cannot be infinite.

MOREOVER, from the Obſervations of the Depth in divers Places, it is manifeſt, that the Chanels in Depth are nearly equal to the Mountains and inland Parts in Elevation, that is, as much as the one is raiſed, ſo much the other is depreſſed, and as the Altitude of the inland Parts is gradually increaſed from the Shore, ſo is the Sea deeper and deeper towards the Middle of the Ocean, where the Depth is for the moſt part greateſt.

THE Depth of the Sea, is in the ſame Place often altered by theſe or the like Cauſes. 1. By the Flux and Reflux. 2. by the Increaſe and Decreaſe of the Moon. 3. By the Winds. 4. By the mouldering and ſubſiding of the Shores; whence the Chanel is made higher in proceſs of time by Sand and Mud.

PROPOSITION VII.

The Ocean doth not flow from Springs, but is contained within the Cavities of the Earth; tho' it is not always numerically the ſame, but continually increaſing and diminiſhing.

WE

WE know by Experience that the Water of Rivers is produced by Springs, and because it hath been so for many Ages past, it necessarily follows, that the Water which is continually flowing to the Sea, returns again to the Fountains, either by subterraneous Ducts, or some other way. The Philosophers of old were also of Opinion, that the Sea issued forth at several Springs; neither could the Magnitude nor the Perpetuity of it's Bulk convince them of their Error, for they said, that it was conveyed by subterraneous Fissures to these Fountains, which therefore kept continually flowing. *Aristotle* (Book ii. *Meteor.* Chap. ii.) endeavours to prove the contrary, and to refute the Arguments of the Ancients, but says very little to the Purpose; we think these following will be more effectual to disprove them. If the Ocean have Springs they must either be in the raised Parts of the Earth, or in that Part which is covered with the Ocean, that is in the very Chanel of the Sea. That there are no such upon the dry Land is apparent, because there were never yet found any; and to say that they are in the unknown Countries towards the North or South Pole is to take a Thing for granted without any manner of Reason for it, because most of these Countries are covered with Ice continually, and as many as are discovered of them afford no Springs at all. Neither can they pretend to say that they are in the Chanel of the Sea; for if they were, they would be no further distant from the Center than the Ocean itself; and therefore the Water in them would not flow, but be at Rest, because it is against Nature that it should ascend from a lower to a higher Place; and the Springs of all Rivers are higher than the Waters they emit. Some indeed may object that this Motion is violent, because that the Bottom of the Ocean, being perforated into Ducts, Meanders, Fissures, or Ca-

nals,

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nals, (which you'll pleafe to call them) is not terminated in the Earth's Bowels, but extended to another Part of the Bottom of the Ocean by more Intercourfes than one; fome of which convey the Water one way, and fome another, fo that it iffueth out of each, as if they were fo many Springs. And fince (fay they) it is not contrary to Reafon to fuppofe many of thefe Paffages or Intercourfes, nothing hinders but that there may be alfo as many Springs in the very Chanel of the Ocean. But thefe are all vain Fancies, and no way agreeing with the Nature of Water; for tho' the Water be continued thro' thefe Orifices, it will not flow thro' one or the other, but be at Reft, unlefs it be urged by fome external Caufe; and tho' it be preffed by the incumbent Water on this fide the Intercourfe, it will not difcharge itfelf at the other; becaufe it is as much preffed by the incumbent Water there, which keeps it in *Æquilibrio*, and at Reft, as may be proved by Experiment thus:

Let ABCD (*Fig.* 20.) be a Veffel full of Water, and AB it's fpherical Superficies. Let RPEF be a hollow Beam of Wood, lying obliquely under Water, fo that the whole at *g* under A may be higher than the Hole at *h* under B. Then the Water will flow in at both ends of the Beam 'till the hollow Part be full; but there will be no Flux at either Orifice; not at *g* becaufe it is higher nor at *h*, becaufe, tho' it be lower than *g*, yet the greater Weight of the Water about B will ftop the Flux (*e*).

(*e*) For, by the Laws of Hydroftatics, the Weight of the greater Column of Water under B is of the fame force to prefs the Water upwards at the Hole *h*, as the leffer Column of Water under A, and it's own relative Gravity in the declining Bore is to prefs it downwards at the Hole *g*: therefore it remains in *Æquilibrio*, and at Reft.

IF

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IF it ſhould be again objected, that the incumbent Water upon the one Orifice is of a leſs Altitude, and therefore not of ſo great Force to repel the Flux of Water, which is immitted at the other: We anſwer, 1. That ſuch a thing may be, if the Superficies of the Water, which preſſeth one Orifice, be ſeparated or not continuous to the Superficies of the Water that preſſeth the other Orifice; but if theſe two Surfaces are continuous, the Water will ſooner deſcend by that Continuation to the lower Place, than by this ſubterraneous Duct. 2. If what was objected be allowed, this Motion would in a ſhort time ceaſe, *viz.* when ſo much Water was run out by the Intercourſe from the higher to the lower Place, as to make both their Surfaces of an equal Altitude. And further, ſuppoſe one part of the Ocean was perpetually higher than the other, there could be no Reaſon given, why the Water ſhould circulate, or interchangeably be poured from one Part into another.

FROM whence it is evident, that the Ocean hath no Springs, but is a vaſt Collection of Waters contained in Chanels.

YET there are ſome things to be taken notice of, which are commonly objected againſt this, *viz.*

1. THAT our proof is built upon a Suppoſition, that the Ocean, as to it's natural Conſtitution, is continually at Reſt, without taking notice of it's being moved by any external Cauſes: but there is no time in which the Ocean is not in Motion, either by the Wind or Tide, or ſome other violent Agent, which cauſes the Altitude and quantity of the Water to be greater ſometimes in one Place and ſometimes in another; and then the Water which is more elevated, is poured into thoſe ſubterraneous Intercourſes, and ruſhes towards the Parts that are of a leſs Altitude, and where the incumbent Water is

leſs

less able to resist the Eruption. To which I answer, that tho' this is possible, yet it cannot be proved either by Reason or Experience, so neither can the contrary, therefore this Problem is a Dilemma, or doubtful. That there are indeed subterraneous Receptacles and Cavities in some Parts of the Bottom of the Sea we cannot deny, because in some Parts it is of an immense Depth, where the neighbouring Places are but shallow; but if this were admitted it will not follow, that the Water runs thro' these Passages, or that they extend from one Chanel of the Ocean to another: or even if they were, since they are not in all Places, and since these external Causes operate sometimes in one, and sometimes in another Part of the Ocean, it will not be granted, that there are perpetual Springs of the Ocean in any one Place, but that the Water flows sometimes from one Part of the Chanel, and sometimes from another, according to the Place and Continuance of the external Cause.

2. SOME may thus argue, that there is a continual Current of the Sea from North to South, between both Sides of *America* and the *Old World*; but that we cannot perceive a Current in any Place whereby the Water is conveyed towards the Northern Regions: therefore since the Flux is perpetual, and hath no apparent Source there, nor Conveyance thither, it is probable, that the Water flows to the North thro' subterraneous Passages, and issueth out at the Holes in the Bottom of the Chanel, as out of a Spring; from whence it returns again to the southward. There is another Cause taken from the former, *viz.* That the Sea-Water in the *Torrid Zone* is much heavier than in the Northern Regions, as we shall prove in Proposition 8, and 12; and therefore there is a greater Pressure and Force to push forward the Water thro' the Passages there, than there is to resist it at the Northern End of the Intercourses,

Intercourses, where, for want of an equal Pressure, it breaks out at the Holes in the Bottom of the Chanels. To this we answer, that the Flux of the Ocean from the North is not so great as is supposed, and as the Ancients imagined; (who would have the Water to flow from the Pole thro' four Chanels, as is represented in some old Geographical Maps;) nor are the Currents constant, but only frequently observed, by reason of the frequent North-Winds, and the great quantities of Snow and Rain which very often raise the Waters, and cause them to flow towards the South. And further, in other Parts another Motion of the Sea is observed, of which see the following Chapter.

3. IT is no Notion, but a real Truth, that all the Springs of Rivers, which flow into the Sea, are Springs of the Ocean: For since there is in Process of Time a vast quantity of Water poured into the Sea, no doubt but it returns from the Ocean to the Heads of the Rivers thro' subterraneous Passages, or by Dew and Rain. We shall not contend about this; for we do not, in the Proposition, mean such Springs as these; but whether there are Springs in the Caverns of the Earth, under the Chanel of the Sea, which supply the Ocean with Water.

4. IT appears probable, that there are such Springs in the Chanels of the Sea; because there is found, in some Places, fresh Water at the Bottom of the Sea, which must certainly arise from Springs in the very Chanel. *Linschoten* tells us, that in the Gulph of *Ormus*, near the little Island *Bareyn*, there is brought up fresh Water, by the Divers, at four or five Fathoms depth; and the like Springs are found at the Bottom of the Seas and Bays. To this we answer; that there are but few such Springs found, and those not sufficient

to

to supply the Ocean with Water; besides the Question is not about such, as we said before.

FROM these Things it appears, that the Sea may be rightly said to have Springs in some Sense, tho' different from what we mean by the Springs of Rivers; in which Sense this Proposition ought to be understood. Hence also we know what to think of the Question; Whether the Ocean be always one and the same, and constantly remains so, or whether it be a Body whose Parts are consumed and renewed again perpetually.

PROPOSITION VIII.

The Saltness, or Salt Taste, of the Sea-Water proceeds from the Particles of Salt which are mixed with it: but whence these Particles proceed, or how they are continued and increased, is uncertain.

EXPERIENCE proves the first Part of this Proposition, for every Body knows that Salt is made either by evaporating Sea-Water with the Sun, or by boiling it with the Heat of our Fires. In *Germany*, and other Countries, they make use of Fire to separate the Water from it. But in *France*, where the Sun is hotter, the Sea-Water is let into Pits or Ponds, where in a few Months, by the extream Heat of the Sun, it's fresh Particles are exhaled or evaporated, and it's salt ones are concreted and formed into Grains of Salt. Also upon the Shores of several Countries, as *England*, *&c.* there is gathered abundance of Bay-Salt, which the Sea (continually overflowing them) leaves daily in moist Particles, from whence the most subtile, or fresh, Parts are exhaled, and what is left becomes Heaps of Grains of Salt, whose Blackness is taken off by boiling; tho' this sort of Salt is washed away and dissolved from many Shores by the

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the Violence of the Ocean, and therefore is not found upon all Shores. And since this is a common Experiment which every one knows, *Aristotle* need not have instanced a false one (by letting down a Vessel of Wax into the Sea) to prove the Truth of this Proposition.

HENCE it appears, that the true Cause of the Saltness of Sea Water, is the Particles of Salt which are contained in it, and mixed with it. Therefore the *Aristotelians*, with their Master, speak improperly, and obscurely, when they assert that this Saltness is caused by the Water's being extreamly heated by the Rays of the Sun; but of this we shall say more by and by.

BUT the chief Controversy is about the other part of the Proposition, *viz.* whence these Particles of Salt proceed?

ARISTOTLE was of Opinion that the dry Exhalations, or Fumes, (which he thought were burnt, and of a saline Nature) being elevated from the Earth, and mixed with moist Particles, when they are turned into Rain, fall down with it into the Sea, and that from thence proceed the saline Particles, and the Saltness in the Sea-Water. These are his express Words in *Lib.* ii. *Chap.* vii. *Meteor.* And he takes a great deal of Pains to defend this Opinion, because by it he could shew a Reason why the Sea continues always salt.

OTHER Peripatetics (who also pretend to have *Aristotle* on their Side) assert, that the Sea is salt in itself, by reason of it's being perpetually scorched with the Sun-Beams; and for this Reason they say it is fresher towards the Bottom, and saltest at the Surface.

BOTH these Opinions labour under such great Difficulties and Absurdities, that it is a Wonder so many learned Men and Philosophers could be satisfied with them.

THESE

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THESE things may be objected against *Aristotle*'s Hypothesis; 1. That Rain-Water, according to this, ought to taste salt, upon the Ocean, which is contrary to Experience, for it is found not to taste salt at all. And *Scaliger*'s Remedy for this is insufficient, who says, that it ought not to taste so at first, because the hot Vapour hath not had time to be condensed, being more rare, and also having lately descended from a colder Region of the Air; but such Rain-Water hath been preserved several Days by Mariners, in which time it would certainly have tasted salt, if it had held any in it. 2. The less it rained the less salt would the Sea-Water taste, which is found to the contrary.

THE other Opinion hath these Absurdities: 1. It is false that the Sea is not so brackish nearer the Bottom; for this only happens where Springs of fresh Water rise from the Bottom of the Chanel. 2. Experience shews that fresh Water doth not become salt by long boiling, or by being long exposed to the Sun. *Scaliger* likewise endeavours to obviate this Objection by a subtile Argument. He says that this happens so by reason of the smallness of the quantity of that Water which is used in the Experiment, which doth not thicken but is dissolved. But let us take ever so great a Quantity, and put it over a gentle Fire, that the dissolution (into Vapours as he means) may be hindred, yet the Water will taste no more brackish than it did at first. 3. Lakes and Marshes, though they are constantly heated by the Sun-Beams, yet do not grow salt. *Scaliger* also would wave this Objection, saying, that this happens because of the continual Succession of fresh Water. But if we observe Lakes and Morasses that are fed only by Rain and melted Snow, where there is no such Succession, we shall find

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them rather to dry up, thro' a long want of Rain, than to become brackish, or be turned into salt.

THEREFORE, rejecting these false Opinions concerning the Origin of Salt in the Ocean, let us lay hold of some others that seem more probable (*f*).

1. THESE

(*f*) The most probable Cause of the saltness of the Ocean is thus explained by Dr *Halley*, in *Philos. Trans.* N° 344. 'I have observed (says he) that all the Lakes in the World, properly so called, are found to be salt, some more some less than the Ocean Sea, which, in the present Case, may also be esteemed a Lake; since by that Term I mean such standing Waters as perpetually receive Rivers running into them, and have no Exit or Evacuation.

'The number of these Lakes, in the known Part of the World, is exceeding small, and indeed, upon enquiry, I cannot be certain there are in all any more than four or five, *viz.* 1. The *Caspian* Sea. 2. The *Mare Mortuum*, or *Lacus Asphaltites*. 3. The Lake on which stands the City of *Mexico*; and 4. *Titicaca* a Lake in *Peru*, which, by a Chanel of about fifty Leagues, communicates with a fifth and smaller, called the Lake of *Paria*, neither of which have any other Exit. Of these the *Caspian*, which is by much the greatest, is reported to be somewhat less salt than the Ocean. The *Lacus Asphaltites* is so exceeding salt, that it's Waters seem fully sated, or scarce capable to dissolve any more; whence, in Summer time, it's Banks are incrustated with great Quantities of dry Salt, of somewhat a more pungent Nature than the *Marine*, as having a relish of *Sal Ammoniac*; as I was informed by a curious Gentleman that was upon the Place.

'The Lake of *Mexico*, properly speaking, is two Lakes divided by the Causways that lead to the City, which is built in Islands in the midst of the Lake, undoubtedly for it's Security; after the Idea, it is possible, it's first Founders borrowed from their Beavers, who build their Houses in Damms they make in the Rivers after that manner. Now that part of the Lake which is to the northwards of the Town and Causways, receives a River of a considerable Magnitude, which being somewhat higher than the other, does with a small fall exonerate itself into the southern Part which is lower. Of these the lower is found

'to

1. THESE Particles are coëval with the Ocean itself, and therefore it is the same thing to enquire about the Origin of the terraqueous Globe, and the Fabric of the whole World, as to dispute how the Ocean came to be salt.

2. IF this Opinion do not please, we will propose another, *viz.* that these Particles were, in times past, washed and disjoined from the Earth, and dissolved in the Water; for we need not doubt but that there are several Mountains and Rocks of Salt in the Chanel of the Sea. The Island of *Ormus* is nothing but white hard Salt, of which they make the Walls of their Houses, and there

'to be salt, but to what Degree I cannot yet learn; 'though the upper be almost 'fresh.

'And the Lake of *Titicaca*, 'being near eighty Leagues in 'Circumference, and receiving 'several considerable fresh Rivers, has it's Waters, by the 'Testimony of *Herrera* and '*Acosta*, so brackish as not to 'be potable, tho' not fully so 'salt as that of the Ocean; 'and the like they affirm of 'that of *Paria*, into which the 'Lake of *Titicaca* does in part 'exonerate itself, and which 'I doubt not will be found 'much salter than it, if it were 'enquired into.

'Now I conceive, that as all 'the Lakes mentioned do receive Rivers, and have no 'Exit or Discharge, so 'twill 'be necessary that their Waters 'rise until such time as their 'Surfaces are sufficiently extended, so as to exhale in 'Vapour that Water that is 'poured in by the Rivers; and 'consequently that Lakes must 'be bigger or lesser according 'to the Quantity of the fresh 'Water they receive. But the 'Vapours thus exhaled are perfectly fresh, so that the saline 'Particles that are brought in 'by the Rivers remain behind, 'whilst the fresh evaporates; 'and hence 'tis evident, that 'the Salt in the Lakes will be 'continually augmented, and 'the Water grow salter and 'salter. But in Lakes that have 'an Exit, as the Lake of *Gennesaret*, otherwise called that 'of *Tiberias*, and the upper 'Lake of *Mexico*, and indeed 'in most others, the Water being continually running off, is 'supplied by new fresh River-Water, in which the saline 'Particles are so few as by no 'means to be perceived.

'Now if this be the true 'Reason of the Saltness of 'these Lakes, 'tis not improbable but that the Ocean itself 'is become salt from the same 'Cause, &c.

is not one Spring of freſh Water in the whole Iſland. There are alſo ſeveral Mines of Salt in the Earth, as every one knows, ſome of which we have deſcribed in Chapter xi. But there is no need of particular Examples; let us conſider the whole Earth, and we ſhall find a great Part of it to be nothing but Salt; it's Coherence and Compoſition is by Salt, and, as Chymiſts and Natural Philoſophers rightly obſerve, all ſolid Bodies are concreted and joined by Salt; which Experience alſo proves; for if any hard Body be burned and conſumed to Aſhes, much Salt will be found in it.

NOTHING can be alledged againſt this Opinion of any Weight, and which may not be eaſily refuted. Some have thought it impoſſible that theſe ſalt Particles of the Earth ſhould perpetually ſuffice, and ſhould not at ſome time be quite waſhed away by the Water of the Ocean, which conſtantly takes away ſome Part of them: To which we anſwer; that the Salt, thus wrought upon, is not ſo much leſſened as to need great recruiting; and if any be disjoined, or ſhaken from the reſt, it is not carried without the Ocean, but laid up in ſome other Place.

PROPOSITION IX.

Whether the Sea-Water be freſher nearer the Bottom? and why, in ſome Places, freſh Water is drawn from the Bottom of the Ocean?

TO theſe Queſtions I anſwer; That we have not found it freſher near the Bottom, except in ſome particular Places; where, it is very probable, there are Springs of freſh Water. For it is againſt Nature that Salt Water ſhould float above freſh, when it is heavier.

THOSE

THOSE Places of the Sea where there seem to be fresh Water Springs, at the Bottom, the Studious may collect out of Geographical Authors (*f*).

PROPOSITION X.

The Water of the Ocean is less salt by how much it is nearer the Poles, and saltest about the Equator, or in the Torrid Zone.

THIS is only to be understood of most Parts of the Ocean, for the Proposition admits of some few Exceptions.

THERE are several Reasons for this unequal Saltness, *viz.*

1. THAT the Heat of the Sun in the *Torrid Zone* exhales more Vapours than in the northern Countries, and these Vapours are all fresh Water for the Particles of Salt are not so easily evaporated by reason of their Gravity; and therefore the

(*f*) That the Curious may not be at a Loss to examine the Saltness of the Water at several Depths, Dr *Hook* invented an Instrument to fetch it up at any Depth, which is described in *Philos. Trans.* N° 9. *Page* 149. and N° 24. *Page* 447. or in *Lowthorp's Abridgment, Vol.* 2. *Page* 260. Thus:

Let there be made a square wooden Bucket C, (*Fig.* 21.) whose Bottoms EE, are so contrived, that as the Weight A sinks the Iron B, to which the Bucket C, is fastened by two Handles DD, on the end of which are the moveable Valves or Bottoms EE, and thereby draws down the Bucket; the Resistance of the Water keeps up the Bucket in the Posture C, whereby the Water hath, all the while it is descending, a clear Passage through; whereas, as soon as the Bucket is pulled upwards by the Line F, the Resistance of the Water to that Motion, beats the Bucket downwards, and keeps it in the Posture G, whereby the included Water is kept from getting out, and the ambient Water kept from getting in.

By the advantage of this Vessel, you may know the Constitution of the Sea-Water in several Depths; and whether it be salter at, and towards, the Bottom.

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Water that is left in the Ocean ought to be more salt about the Equator than towards the Poles, where there is not so much fresh Water exhaled because of the wak Heat of the Sun.

2. A second Cause is the Heat and Coldness of the Water; for the same Water, salt Meat, pickled Beef, Pork, &c. taste salter when hot than when cold, as every one knows from his own Observation: because the Heat, or the Particles of Fire, agitate and sharpen the Particles of Salt contained in such Meat, and separate them one from another; so that they strike and prick the Tongue more sharply. Therefore, because the Sea-Water near the Equator is hotter, and coldest towards the Poles, it follows, that tho' every Part of the Ocean were admitted to be of equal Saltness, yet it ought to taste saltest about the Equator, and freshest near the Poles.

3. A third Cause is a greater or less quantity of Salt in divers Parts of the Chanel of the Sea; for as we find not Mines of Salt all over the dry Land, nor a like quantity of Salt in the Places where they are found, the same may be supposed at the Bottom of the Ocean, where some Shores and Chanels are not so full of Salt as others. Therefore where there is a greater quantity of Salt at the Bottom of the Ocean, there the Sea-Water is more salt, because there is greater Plenty of this Mineral imbodied or soaked in it, as is easy to conceive. For this Reason the Sea-Water near the Isle of *Ormus* is extream salt, because the Island itself is all Salt. But whether there be a greater quantity of Salt Mines under Water in the *Torrid Zone* than about the Poles is uncertain for want of Observations; but some think it probable (because of the greater Heat of the Sun whereby the fresh Particles are exhaled)

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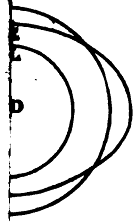
Plate . IV.



.17 p.183.

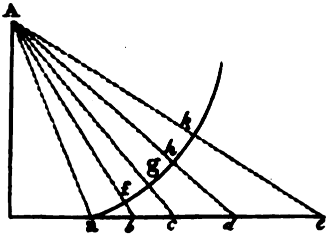
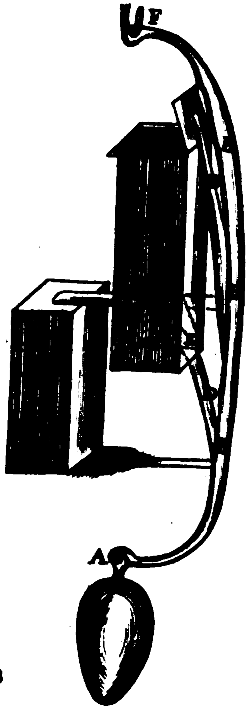
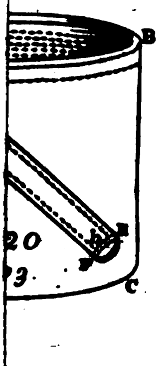


Fig. 18 p.188.

Fig. 21
p.213.





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that there is more Salt in the former: tho' this be but a weak Reason.

4. A fourth Cause is the frequency and scarcity of Rain or Snow. In the northern Countries they have both very frequent: but under the *Torrid Zone* they have no Rains at all for some Parts of the Year, and at other Times they are almost constant. Therefore, in these Places, the Ocean, near the Shores, is not so salt in rainy Months as it is in dry ones. Yea in several Places on the Coast of *Malabar*, in *India*, the Sea-Water tastes sweet in the rainy Months, by reason of the vast quantity of Water which flows from off Mount *Gate*, and falls there into the Sea. This is the Reason why, at different Times of the Year, the same Parts of the Ocean are of different Degrees of Saltness. But because in the northern Countries there are constant Rains and Snow almost throughout the whole Year, therefore the Sea there is less salt than in the *Torrid Zone*.

5. A fifth Cause is the different quality of the Water to dissolve and mix the Salt with it; for hot Water dissolves Salt much sooner than cold: and therefore tho' there were the same quantity of Salt under Water in the Chanels of the Sea, near the Poles, as about the Equator; yet because the Water is cold there, it cannot so quickly dissolve it into minute Particles and mix with it, as the Water in the *Torrid Zone* which is hotter.

6. A sixth Cause is the great and many large Rivers that empty themselves into the Sea; but these only cause an Alteration upon the Coasts; for the main Ocean is not sensibly affected by them. Mariners relate that upon the Coast of *Brasil* where the *Rio de la Plata* empties itself into the Sea, the Ocean loses it's salt Taste, at almost fifteen Leagues Distance from the Shore; and the same

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may be said of the *African* Ocean on the Coast of *Congo*, and in several other Places, as about *Malabar* in *India*, (as was observed before) *&c.* To these Causes we may add the springing up of fresh Water in some places from the Bottom of the Sea.

THESE Causes (whether separate or united) make a great variety of Saltness in different Parts of the Ocean, and by these that variety is explained and accounted for.

HENCE there is given a Reason why the Water of the *German* and northern Ocean will not yield so much Salt by boiling, as the Water of the western Ocean about *Spain*, the *Canary* Islands, and Cape *Verd* in *Africa*, (from whence the *Dutch* fetch abundance of Salt and transport it to several northern Countries, *viz.* to *Prussia*, *Poland*, &c.) because these Coasts are nearer the *Torrid Zone* than the other; tho' perhaps both their Chanels may contain an equal quantity of Salt.

THE Sea-Water in the *Ethiopic* Ocean, over against *Guinea*, yields white Salt, with once boiling, as fine as Sugar, such as neither the *Spanish* Ocean, nor any other in *Europe* will produce at once boiling.

PROPOSITION XI.

Why Rain-Water catched in the middle of the Ocean is found to be sweet and fresh, when it proceeds from the Vapours which are exhaled from the Sea; whereas the Water, which, by boiling or distilling, we separate from the salt Water of the Sea, is found to be salt.

THOSE that have diligently searched into the Secrets of Nature, I mean the learned Chymists, (not those ignorant Pretenders to Chymistry) have

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have hitherto laboured in vain to find out a Method of distilling or extracting fresh Water from the Sea-Water, which would be of great use and advantage to Navigation (*g*). And tho' both by Decoction and Distillation, which are in Effect the same, there is Salt left in the Bottom of the Vessel,

(*g*) Mr *Hauton* first found out the Secret of making Sea-Water sweet. It consists first in a Precipitation made with the Oil of *Tartar*, which he knows to draw with small Charges. Next he distils the Sea-Water; in which the Furnace taketh up but little Room, and is so made, that, with a very little Wood or Coal, he can distil twenty four *French* Pots of Water in a Day; for the cooling of which he hath this new Invention, that instead of making the Worm pass thro' a Vessel full of Water (as is the ordinary Practice), he maketh it go thro' a Hole, made on purpose out of the Ship, and to enter in again thro' another; so that the Water of the Sea performeth the cooling Part; by which means he saveth the Room which the common *Refrigerium* would take up; as also the Labour of changing the Water when the Worm hath heated it. But then, thirdly, he joins to the two precedent Operations Filtration, whereby perfectly to correct the malignity of the Water. This Filtration is made by means of a peculiar Earth, which he mixeth and stirs with the distilled Water, and at length suffers to settle at the Bottom

He maintains that this distilled Sea-Water is altogether salubrious: he proves it from Experience, it having been given to Men and Beasts, without any ill Effect at all upon them. *Secondly*, from Reason grounded on this, that that peculiar Earth being mixed with the distilled Water, blunts the Points of the volatile Spirits of the Salt, and serveth them for Sheaths, if I may so speak, taking away their Force and malign sharpness. *Philos. Trans. abridged by Lowthorp. Vol.* 2. *Page* 297.

I have been credibly informed by experienced Sailors (particularly some that had an Engine on Board) that Salt-Water made fresh by Distillation, would not quench Thirst; but that, when they had drank as much as they could get down, their Thirst, was not at all abated. So necessary are the Impregnations, which the Waters receive in their passages about the Earth, to make them nutritive. And the richer, and more sulphureous, those Impregnations are, so much the richer, and better, such Waters are accounted. An instance of which we have in the Richness and Spirituousness of the *Thames-Water* at Sea, which no doubt it receives from it's Impregnations by the Soil, and Filth, of the *London* Kennels.

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Vessel, yet the Water thus separated is still salt, and not fit for drinking, which seems strange to those that are ignorant of the Cause of it. This is taught by Chymistry (which is the truest Phliosophy), by the help of which there are found two kinds of Salt in all Bodies, which tho' they perfectly agree in Taste, yet they exceedingly differ in other Qualities: Artists call the one fixed Salt, the other volatile. The fixed Salt, because of it's Gravity, is not evaporated by Distillation, but remains in the Bottom of the Vessel: but the volatile Salt is spirituous, and indeed nothing but a most subtile Spirit, which is easily raised with a very gentle Fire; and therefore in Distillation ascends with the sweet Water, and is well mixed with it by Reason of the subtilty of it's Particles. This fixed and volatile Salt is found, by Chymists, to be not only in Sea-Water, but almost in all Bodies, tho' more in some than in others; in Herbs that taste sharp there is more, but in oily and insipid Things less. The Difficulty therefore lies in separating the volatile Salt, or the salt Spirit from the Water; for it is this which hath rendered all the Efforts hitherto fruitless.

BUT why Rain-Water should be as sweet and fresh on the main Ocean as it is at Land, when it is generated from Exhalations, which arise from the Sea by the Heat of the Sun, or is exhaled by the Force of subterraneous Fire, which Evaporation no way differs from Distillation, there seemeth to be a fourfold Cause.

1. A slow and gentle Evaporation, by which only the more subtile Part is exhaled out of the Ocean, which tho' it contain the volatile Spirit of Salt, yet it is in a less quantity than when the Evaporation is made by a strong Heat. 2. The long Space which this Vapour passes thro' before it arrives at that Region of the Air where it is con-

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densed into Rain: in which Passage it is possible that the saline Spirit may be by degrees separated from the watery Particles. 3. The Mixture of other fresh Particles of Water that are in the Air. 4. The Refrigeration and Coagulation or Condensation of the Vapour. For these Vapours in their ascent from the Ocean become, by degrees, colder, and mixing with others in their Way, they are condensed and turned in Clouds; and in this Refrigeration and Condensation the saline Spirits fly away, with fiery Particles, into a higher Place of the Air.

BUT why this doth not happen in Distillation (where the Vapours exhaled become more cool and condensed) proceeds from hence: 1. In this short Passage the saline Spirit sticketh close to the watery Particles. 2. The Vapour is kept in a Vessel which doth not admit the Spirit to fly thro' it.

PROPOSITION XII.

Sea-Water is heavier than fresh; and Sea-Water in one Place is heavier than in another (*b*).

THE Reason of this is plain from what we have said before, *viz.* that the Sea-Water contains a fixed Salt which is a much heavier Body than fresh

(*b*) Mr *Boyle* having recommended this Matter, among others, to a learned Physician that was sailing to *America*, and furnished him with a small hydrostatical Instrument to observe, from time to time, the differences of Gravity he might meet with; this Account was returned him; 'that he found, by 'the Glass, the Sea-Water to 'increase in Weight the nearer 'he came to the Line, 'till he 'arrived at a certain Degree 'of Latitude; as he remembers 'it was about the 30th; after 'which the Water seemed to 'retain the same specific Gravity '’till he came to *Barbadoes*, or '*Jamaica*. *Lowthorp's Abridgment* of *Philos. Transact.* Page '297. Vol. 2.

fresh Water: and we have shewn that there is a different quantity of Salt in different Parts of the Sea; which must cause the Gravity of the Water to be unequal. But some Sea-Water may happen to taste more salt than others, and yet be not more weighty; because it perhaps contains a greater quantity of volatile Salt, which does rather diminish than increase it's Weight, tho' it make it more salt.

PROPOSITION XIII.

Sea-Water doth not so easily freeze as fresh; or a greater Degree of cold is required to congeal Sea-Water, than to congeal fresh.

EXPERIENCE shews this, contrary to the Opinion of the *Peripatetics*, who mention that by how much Water is more pure, it is less liable to freeze, and that Sea-Water being more elementary than fresh will freeze the sooner; which is false.

BUT the Cause is, that in Salt there is a certain Spirit which resists Coagulation, and this being separated from it, will not congeal in the hardest Frost, as is well known to Chymists: for they frequently make use of this Spirit of Salt (*i*).

(*i*) The Particles of two different Bodies, which would be more at Rest when separate, when they are mixed are put into new Motions by Attraction, which acts upon them only when they approach one another; and causes them to meet and clash with great Violence, and to keep hot with the Motion. So that Water mixed with Salt, is more in Motion than Water alone; and therefore the Particles of Sea-Water are not so easily congealed, or made to rest, as the Particles of fresh, which do not resist the cold with such violent Motions. See *Newton's Optics*. Pag. 355.

PRO-

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PROPOSITION XIV.

Why the Ocean is not enlarged when it receives so many Rivers.

THE Cause is; 1. The Water returns from the Sea, thro' subterraneous Fissures to the Heads of the Rivers. 2. Plenty of Vapours are raised from the Ocean, a great Part of which being turned into Rain, fall partly into the Ocean, and partly on the dry Land (*k*).

PRO-

(*k*) Since the Ocean constantly receives a prodigious quantity of Water, both from Rivers that exonerate themselves into it, and also from the Air, in Dew, Rain, and Snow, that fall; it is impossible but it should be enlarged, and encrease to an immense Bulk, unless it be as much lessened some other way. And seeing there hath not been observed any such great increase in the Sea, and that the bounds of the Earth and Ocean are found to be in all Ages the same, it remains that we inquire by what means the Ocean loses so much Water as it receives from Rain and Rivers flowing into it. There are two Hypotheses among Philosophers; one is, that the Water of the Sea is carried, by subterraneous Conduits to the Springs of Rivers, and, in it's draining thro' the Fissures, loses it's Saltness: the other is, that it happens by the Vapours that are drawn up from it's Surface. The former is now rejected by most, it being difficult, if not impossible, to explain how the Water of the Ocean, being more depressed than the very Mouths of the Rivers, can come up to their Springs, which are, for the most part, on very high Mountains; but in the latter Hypothesis we have no Occasion to explain this, neither to hinder the Growth of the Ocean, nor to supply the Springs with Water; both which may be more easily done by the Vapours, which we certainly know to be drawn up from the Surface of the Sea.

The quantity of Vapours drawn up from the Sea was tried by Dr *Halley*, who made the following Computation. *Philos. Transact.* N° 189. Page 366.

By an Experiment made with great Care he found that Water, salted to the same Degree as is common Sea-Water, and heated to the same Degree of Heat, which is observed to be that of Air in our hottest Summers,

PROPOSITION XV.

Some Parts of the Ocean differ in Colour from others.

WE observe that towards the North Pole, the Sea seems to be of a black Colour, and in the *Torrid Zone* of a dusky Colour, and in other Places of a green Colour. Upon the Coast of *New Guinea*, the

mers, to exhale the thickness of a sixtieth Part of an Inch in two Hours. From whence it appears that a Bulk of Water a tenth Part of an Inch high will be exhaled into Vapours in twelve Hours.

So that if the Superficies of the whole Ocean, or a Part of it, as the *Mediterranean* Sea be known, it may also be known how much Water arises in Vapour from it every Day; supposing the Water to be equally hot with the Air in Summer.

" For from what hath been " laid down, a Superficies of " ten square Inches emits daily " a cubic Inch of Water; " one square Foot, half a " Pint; a Square whose sides " are 4 Feet, one Gallon; a " square Mile, 6914 Tuns; " and one Degree square, (sup- " posed consisting of 69 *Eng-* " *lish* Miles) 33 Millions of " Tuns."

This learned Gentleman estimates the *Mediterranean* to be about forty Degrees long, and four broad; allowances being made for the Places where it is broader by those where it is narrower, so that it's whole Superficies may be accounted one hundred and sixty square Degrees; and consequently the whole *Mediterranean* must lose in Vapour, according to the forestated Proportion, in a Summer's Day, at least five thousand two hundred and eighty millions of Tuns. For what quantity of Water is licked off the Surface by the Winds, (which is even more sometimes than is exhaled by the Heat of the Sun) seems impossible to be reduced to any Rule.

It remains that we compare this quantity of Water with that which is carried daily into the Sea by the Rivers, which is very difficult to do, when we can neither measure the Breadth of the Chanels of these Rivers, nor the Velocity of the Currents. One thing is left, that a Comparison being made between these and the River *Thames*, and by supposing them rather greater than they are, we may have a greater quantity of Water than is really poured by them into the *Mediterranean*.

The *Mediterranean* receives these nine considerable Rivers; the *Iberus*, the *Rhone*, the *Tiber*, the

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the Sea in some Parts appears white, and in others yellow: In Streights, or narrow Seas, it appears whitish. Upon the Coast of *Congo*, not far from *Baya d'Alvaro*, where the small River *Gonzales* falls into the Sea, the Water is of a reddish Colour which Tincture it receives from a red mineral Earth, thro' which the River flows. But the most famous for it's Colour is the *Arabian* Gulph, being therefore called the *Red Sea*. Some will have it to be only a bare Name, and taken from *Erythrus*, some time King on that Coast; others will have it to be called red from a certain Brightness peculiar to it, which is caused by the reflected Rays of the Sun (*l*). But the most probable Opinion, and which

the *Po*, the *Danube*, the *Neister*, the *Borysthenes*, the *Tanais*, and the *Nile*; all the rest being of no great Note. Each of these Rivers, this ingenious Gentleman supposes to be ten times greater than the *Thames*, not that any of them is so great in Reality, but to comprehend with them all the small Rivulets that fall into the same Sea.

He supposes the River *Thames*, at *Kingston* Bridge, where the Flood seldom reaches to be in breadth about 100 Yards, and in depth 3; and the Water to run two Miles an Hour. If therefore the breadth of the Water, 100 Yards, be multiplied by 3, the depth, and the Product 300 square Yards by 48 Miles, or 84480 Yards, which the Water runs every Day, the product will be 25344000 cubic Yards of Water, or 20300000 Tuns that are carried every Day into the Sea.

Now if each of the aforesaid nine Rivers yield ten times as much Water as the *Thames*; it will follow, that each of them carries every Day into the Sea 303 Millions of Tuns: and the whole nine, 1827 Millions of Tuns in a Day.

But this is but little more than one third of what is proved to be raised, in Vapour, out of the *Mediterranean* in twelve Hours time. Hence it appears that the *Mediterranean* is so far from increasing or overflowing by the Rivers running into it, that in a short Time it would rather be evaporated, and drawn out, unless the Vapours that it exhaled returned in Dew or Rain upon it.

Jurin's Appendix.

(*l*) Some will have this to be the same with *Esau* or *Edom*, who first inhabited *Idumæa*, a Country near the *Arabian* Gulph, from whence, say they, it came to be called the *Red-Sea*, *viz.* from *Edom*, i. e. *Red*.

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is confirmed by Experience, is, that it came to be so called from the red Sand that lies upon the Shore, and is often contrary to it's Nature, mixed with the Water by the vehement Flux and Reflux of the Sea, which is extraordinary in this Gulph; insomuch, that it tosses it to and again like Ashes, and keeps it from falling to the Bottom by it's violent Agitation. This is related by Sailors, who tell us, that it sometimes appears as red as Blood; but if it be kept in a Vessel without shaking, the red Sand will subside, and may be seen in the Bottom. It very often happens, that violent Storms blowing from the *Red-Sea*, towards *Arabia* or *Africa*, carry with them such Heaps of red Sand, as to cover whole Caravans, or Troops of Men and Beasts, whose Bodies in time are thus converted into true Mummy. There are other Opinions among Authors, about the Name of this Gulph, but they are all of no Weight, as appears from Experience.

WHETHER the same or some other Cause, hath urged Mariners to call the Gulph of *California* or (*Vermejo*) the *Red-Sea*, I have not yet found observed by Authors.

PROPOSITION XVI.

There are certain Peculiarities observed in some Parts of the Ocean.

THE Sea called by the *Portuguese di Sargasso*, begins about the Salt Islands, nor far from *Cape Verd*, and extends itself from the 20th Degr. of North Latitude, and to 34 Degr. South. It seems to be of a green Hue, tho' this be not it's proper Colour, but owing to a certain small leaved Herb, (not unlike Water-cresses) which we call the Sea-Lentile, or small leaved Parsley, but the *Portuguese Sargasso*. The Leaves of this Weed are so mutually

tually intermixed one with another that they cover the Surface of the Ocean in this Place; so that the Water can scarcely be seen, and Sailors afar off take it to be an Island or green Fields; nor can they sail thro' this Knot of Herbs unless they be driven by a tolerable Wind. The Herb bears a small Berry, not unlike our red Currants, but insipid and hollow within. Whence they proceed is uncertain, not from the Land for that is too far off this Sea, nor from the Bottom (as I think) because the Ocean is here of a vast Depth and in many Places unfathomable.

BETWEEN the Cape of *Good-Hope* and the Islands of *Tristan de Cunha*, there are several long Stalks like Reeds of a considerable thickness, found floating on the Water, and these very often are entangled with Sea-Alkanet, or with Sargasso. The Sailors call them Thrombs, and they take it for a sure Sign if they meet with it at Sea, as they are sailing to *India*, that either they are near the Cape of *Good-Hope*, or have passed it.

UPON the Coast of the Island of *Madagascar*, the Ocean casts out red and white Coral, which grows like a Shrub under Water: and tho' they are soft in some Places, yet between *Madagascar* and *Africa*, there are said to be Rocks of hard Coral (*m*).

UPON the Coast of *Prussia* in the *Baltic*, the Sea casts up excellent Amber, which the Inhabi-

(*m*) Mr *Guisony* is of Opinion, that Coral is so far from being a Plant that 'tis a meer Mineral, composed of much Salt, and a little Earth; and that it is formed into that Substance by a Precipitation of divers Salts, that ensues upon the Encounter of the Earth with those Salts. This Sentiment he confirms by alledging that he can shew a Salt of Coral, which, being cast into Water, and there dissolved, upon the Evaporation of that Water by a gentle Heat, is presently coagulated and converted into store of small Sticks resembling a little Forest. *Philos. Trans.* abridged by *Lowthorp*, Vol. 2. Page 493.

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tants are taught to draw to the Shore with Nets of Wire, when certain Winds blow.

THE Ocean casts up Ambergris only in the *Torrid Zone*, (if we may believe some Authors) *viz.* at the Shore of *Brasil* (where a *Dutch* Soldier once found a Piece weighing five hundred Pound, and presented it to Count *Maurice* of *Nassau*); also at *Madagascar*, at the Cape of *Good-Hope*, at the Island of *Maurice* (by the *Portuguese* called *de Cerne*), at *Sumatra*, and other *Indian* Islands. *Garcias* relates, that there was a Piece one time found of two thousand Pound Weight, and that some Islands are all of Ambergris; but he does not tell us where they are situated (*n*).

THE *Ethiopic* Ocean, at *Guinea*, *Congo*, and *Angola*, has this peculiar Property; that Shells as green as Grass stick to the Sides and Keels of Ships; while they remain or sail there, which retard their Course and eat out the Timber.

UPON the Coast of *Bretagne* in *France*, wild Fowls are generated on the Sides and Keels of Ships, being at first unshapely, but afterwards are formed by degrees, and having their Bills fastned into the Wood, they begin to move, and at last pull themselves off, and swim in the Sea like Ducks. [These we call *Barnacles.*]

(*n*) Ambergris is found in several other Places; as at Cape *Comorin*, there was taken up a Piece of three hundred Weight, and another weighing fifteen hundred Pound; at *Ambergris-Point* in *Jamaica* there was found a Piece one hundred and fifty Pound Weight; and in several Places without the *Torrid Zone*, as upon the Coast of *New England*, on the western Coast of *Ireland*, &c. Some will have it to be the Wax or Honey of some living Creature; others say it issues out of the Root of a Tree, that grows in the Sea, like Gum; others that it is a Bitumen, and comes from the Entrails of the Earth, which is the most likely Opinion. See *Philos. Trans.* No 92. Page 611. No 232. Page 711. and No 263. Page 573.

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THE Excrement of the Ocean, which we call Froth, is obſerved to float in ſeveral Places, and more in ſome than in others.

THERE are found Water Lentils in ſeveral Parts of the Ocean, as between *England* and *France*, upon the Coaſt of the South Continent, and elſewhere.

ON the Coaſt of *Malabar* and *Cambaya* there are found Serpents upon the Surface of the Water: from whence Sailors gueſs at their approach to theſe Countries.

ABOUT four Leagues from *New-Spain*, ſeveral Roots, Reeds, and Leaves, like thoſe of the Fig-Tree, float to and again, upon the Water, which they commonly eat; and their Taſte is ſomething like Cabbage.

WE read in the firſt Voyage of the *Dutch* to the Streights of *Magellan*, that on the twelfth of *January* 1599. the Water of the Ocean, not far from the Mouth of the *Silver River*, (*Rio de Plata*) appeared of a red and bloody Colour; but when they had drawn up a Bucket, and obſerved it more narrowly, they found in it an innumerable Multitude of little Worms of a red Colour, which, being taken into their Hands, leaped up and down like Fleas. Hence the Seamen call them Sea-Fleas *, and believe that they are vomited by Whales, at a certain Time of the Year. Others think they proceed from an innumerable Company of

* Dr *Derham* in his *Phyſ. Theol.* lib. iv. c. 11, Note (*n*) ſaith, the Inſects that for the moſt part diſcolour the Waters, are the ſmall Inſects of the *Shrimp-Kind*, called, by *Swammerdam*, *Pulex aquaticus arboreſcens*. Which are ſometimes ſo numerous in the Summer Months, as to change the Water red, or yellow, according to the Colour they are of. Of which Dr *Florence Schuyl* told *Swammerdam* this merry Story, ' That one day, when ' he was very intent in his ' Study, he was diſturbed with ' a horrible Rumour; and ' when

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of small Crabs, that fill the Sea towards the South Continent, so that in a weak Light, as in the Morning and Evening Twilight, the Ocean appears to Sailors of a bloody Colour.

BUT this is not the Place for treating of Animals of different Kinds that are found in different Parts.

PROPOSITION XVII.

Why the Sea appears bright and shining at Night; especially if the Waves are violently agitated with a Storm.

THIS Phænomenon requires the Knowledge of that difficult Point, the Cause of Colours. The Opinions of Philosophers are divided about it. They that explain Colours by certain and various Motions best solve the Phænomenon; the more accurate Explication of which belongs to Physics (*o*).

'when he was scarce gotten up 'to enquire what was the 'matter, his Maid, half dead 'with the fright, came running, and sighing told him, 'that all the Water of *Leyden* 'was changed to Blood.' The Cause of which, upon examination, he found to be from the numerous Swarms of those *Pulices*.

The Cause of this Concourse and Appearance of those little Insects, Dr *Derham* says is for their *Coitus*. At which time they are very venereous, frisking, and catching at one another; and many of them conjoined Tail to Tail, with their Bodies inclined towards one another.

(*o*) The following Query of Sir *Isaac Newton* will perhaps give us the best Notion of this Appearance. 'Do not (says he) 'all fixed Bodies, when 'heated beyond a certain Degree, emit Light, and shine? 'And is not this Emission 'performed by the vibrating 'Motions of their Parts? And 'do not all Bodies, which abound with terrestrial Parts, 'and especially with sulphureous 'ones, emit Light as often as 'those Parts are sufficiently agitated, whether that Agitation be made by Heat, or by 'Friction, or Percussion, or Putrefaction, or by any vital Motion, or any other Cause? as 'for Instance; Sea-Water in a 'raging Storm, &c. *Optics* '*Page* 314.

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PROPOSITION XVIII.

The Ocean, and indeed all Waters, cast on the shore terrestrial Bodies, especially about the Time of Full-Moon.

IT is not difficult to explain the Reason of this Property, which is found to be true by Experience. For the Water being in Agitation continually, either one way or other, carries with it the terrestrial Bodies towards that Part whereto it is moved: which is always towards some Shore, where the Motion ceasing they are left upon the Sand.

BUT this Agitation of the Ocean is greatest at the Full-Moon.

THEREFORE their Opinions are absurd who believe the Ocean to be a sensible living Creature, and that it continually purgeth itself of Dregs and terrestrial Bodies. The Reason of it is here plain.

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CHAP. XIV.

Of the Motion of the Sea in general; and of it's Flux and Reflux in particular.

PROPOSITION I.

Water has but one natural Motion, by which it moves from a higher to a lower Place. And if the adjoining Places are of an equal Altitude, or higher than the Superficies of the Water, it naturally rests, and is not moved out of it's Place but by some external Cause.

COMMON Experience manifests the Truth of this Proposition. For if you take a Vessel of Water and move it, the Water will fluctuate, and be in Motion, 'till no part of it be higher than another; that is, 'till it's Superficies be spherical, as was said in Chapter xiii. And although perhaps this Motion may proceed from an external Cause, *viz.* the Pressure of the Atmosphere, or the Motion of the Air round the Globe; yet because there are great Disputes about this Cause, and the Motion is so apparent in the Water itself, that it doth not seem to proceed from any external Agent, therefore it may be called natural, to distinguish it at least from other Motions of the Water. And this Motion is towards that Part which is more depressed.

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PROPOSITION II.

When any Part of the Ocean is moved, the whole is moved, or all the other Parts of the Ocean move successively; but the Motion is greater by how much it is nearer the Part first moved.

BECAUSE when one part of the Ocean is moved, it necessarily changes it's Place, and leaves that it was in, to be taken up by the Water that was next it; whose place is again supplied by the Water next that, and so on. But the Motion becomes less in the more remote Parts; because that there the Water was first moved, the next to it rushes in, not from one Part, but all round about; so that it leaves a round Space like the Periphery of a Circle, which is supplied from a larger Periphery, and that again from a larger, and so on. But the greater the Periphery is from whence the Water flows, the less is the progressive Motion inwards, being distributed into a larger Space. Just as, when a Stone is thrown into the Water it forces it into a Round, and that forces the next Water to it into a larger Round and so on; and the further these Peripheries are from the Immersion of the Stone, their Motion is diminished and less sensible; and tho' there may at last seem to be none all, yet there will be still some very small Undulation, except it be hindered by another Motion of the Water.

PROPOSITION III.

To find which way the Current of the Sea sets.

CHUSE a Time, if possible, when no great Winds are stirring, and cast a Body into the Wa-

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ter of almost the same Gravity with it; mark the Place where it was thrown in, and let a Boat remain there immoveable; then, when the Body is carried by the Current a little way from the Place where it was thrown in, let another Boat be placed there; and observe how the one Boat bears from the other, and you have the Point of the Compass toward which the Current sets (*a*).

PROPOSITION IV.

The Motion of the Sea is either direct, vortical, or tremulous.

I call the Motion direct, when the Water runs towards a certain Point; and vortical, when it turns round in a Whirl-Pool, and is at Times absorbed and vomited up; and tremulous, when it quakes, and is troubled without the least Wind. We shall defer the Consideration of the two last to the end of this Chapter; and treat, first, of the direct Motion, which we shall call, in general, the Motion of the Sea.

PROPOSITION V.

Of the Motions we observe in the Sea, some are general, some particular, and others accidental.

(*a*) The Method that Sailors commonly use, in the Gulph of *Mexico*, to keep the Boat immoveable where the Sea is deep, and perhaps not to be sounded is this. They sink down a Plummet of Lead about forty or fifty Pound Weight, to a certain number of Fathoms deep, as they are taught by Experience, and tho' the Lead is nothing near the Bottom, yet will the Boat turn Head against the Current, and ride as firmly as if it were fastened by the strongest Cable and Anchor to the Bottom; this Method will perhaps succeed in several other Places where there are under-Currents, such as have been observed in the *Downs*, at the *Streights-Mouth*, and in the *Baltic*. See Dr *Stubb*'s Observations in a Voyage to the *Caribbee* Islands. *Philos. Trans.* No 27.

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I call that a general Motion of the Sea, which is observed in all it's Parts, and at all Times.

I call those proper or particular Motions, whereby only some Parts of the Ocean are moved, which are twofold, either perpetual or anniversary; the former continue without Cessation or Intermission; the latter are inconstant, and only observed at some certain Months or Days.

THE accidental Motions of the Sea are such as now and then happen, without any regular Order; and such as these are infinite.

PROPOSITION VI.

The Winds cause the accidental Motions of the Sea, by blowing the Waters toward some opposite Point; nor is the Sea ever free from such Motions.

THE Wind, being nothing but a violent Motion of the Air, and a Pressure of it towards the Earth, endeavours to impel the Water of the Sea out of it's Place; and because the Sea is a Fluid, and cannot resist the Force and Pressure of the Air, it is hereby moved out of it's Place, towards the opposite Point, and drives the adjacent Water before it, and that again the Water before it, and so on.

AND since there is always some Wind in the Air towards one Point of the Compass or another, and very often towards different Points, in divers Countries, at the same Time; it follows, that some of these Motions continually affect the Sea, but more sensibly where the Wind blows hardest; because it being a Fluid is soon put in Agitation by so violent an Agent.

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PROPOSITION VII.

The general Motion of the Sea is twofold; the one is constant, and from East to West: the other is composed of two contrary Motions, and called the Flux and Reflux of the Sea, by which, at certain Hours, it flows towards the Shores, and at others back again.

THAT the Ocean is continually moving from East to West, is chiefly proved from the Motion of the Sea which lies between the Tropics in the *Torrid Zone*; where it is strongest, and less impeded by other Motions.

THIS Motion of the Sea is manifestly perceived by those that sail from *India* to *Madagascar*, and *Africa*; also in the *Pacific* Ocean between *New-Spain* and *China*, and the *Moluccas*; likewise in the *Ethiopic* Ocean, between *Africa* and *Brasil*.

THUS the Currents set strongly, and run with a rapid Motion, from East to West, thro' the Streights of *Magellan*; which induced the first Discoverer (whether *Magellan*, or some other before him) to conjecture, that there were Streights thro' which they might sail out of the *Atlantic* into the *Pacific* Ocean. Ships are carried by the Currents, from East to West, thro' the Streights of *Manilha*, and also thro' the little Chanels between the *Maldivies*. The Sea runs impetuously into the Gulph of *Mexico*, between *Cuba* and *Yucatan*, and flows out again, thro' a rapid Chanel, between *Cuba* and *Florida*. There is so rapid a Flux into the Gulph of *Paria*, that the Streights are called the *Dragon's Jaw*. This Motion is also remarkable at the Land of *Canada*. The Sea seems to run out of the *Tartarian* Ocean thro' the Streights of *Waygats*, as appears by the setting

of

of the Current, and the great Flakes of Ice which are commonly found in these Streights. Upon the northern Coast of *America*, the *Pacific* Ocean flows towards the Streights of *Anian*; there is also a Current from *Japan* towards *China*; and another from East to West, thro' the Streights of *Macasser*. In short, the whole *Atlantic* Ocean makes towards the Shores of *America*, and the *Pacific* from them, as is most remarkable about Cape *Correntes*, between *Panama* and *Lima*.

PROPOSITION VIII.

The Winds frequently change the general Motion of the Sea, especially those called Periodical Winds, or Monsoons, which we shall treat of in Chapter xxi.

BECAUSE these Winds blow most frequently from the North or South, or from other collateral Points, they must needs obstruct the general Motion of the Sea, which is from East to West, and cause it to turn aside, from the West, towards the North-West, or South-West. And even the constant, or Trade-Winds, which seldom blow directly from the East, but from some other collateral Points, change this general Motion of the Sea in many Places. Also the North Winds make a most sensible Difference in this general Motion in the northern Ocean, where these Currents are not strong, except in a few Places.

PROPOSITION IX.

The Cause of this general Motion of the Sea from East to West is uncertain.

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THE *Aristotelians* (tho' neither they, nor their Master, nor any *European* Philosopher, had the least Notion of these Things, before the *Portuguese* sailed thro' the Ocean in the *Torrid Zone*) suppose, that it is caused by the Prime Motion of the Heavens, which is common not only to all the Stars, but even, in part, to the Air and Ocean; and by which they, and all things, are carried from East to West. Some *Copernicans* (as *Kepler*, &c.) altho' they acknowledge the Moon, to be the prime cause of this Motion, yet they make the Motion of the Earth not a little contribute to it, by reason that the Water, being not joined to the Earth, but contiguous only, cannot keep up with it's quick Motion towards the East; but is retarded and left towards the West; and so the Sea is not moved from one Part of the Earth to another, but the Earth leaves the Parts of the Sea one after another.

OTHERS, who are satisfied with neither of these Causes, have recourse to the Moon; which they will have to be the Governess of all Fluids, and therefore to draw the Ocean round with her from East to West. If you ask, how she performs this? They Answer, it is, by an occult Quality, a certain Influence, a Sympathy, her Vicinity to the Earth, and such like. It is very probable indeed the Moon, some way or other, causes this Motion, because it is observed to be much more violent at the New and Full Moon, than about the Quadratures, when it is, for the most Part, but small.

THE ingenious *des Cartes* mechanically explains how the Moon may cause this Motion, both in the Water, and the Air. He supposes, according to his general Hypothesis, that there are an infinite number of Atoms, which revolve about the Earth, and fill up the Space between

tween it and the Orbit of the Moon, so as not to leave any Vacuum; this Space he calls the Earth's Vortex (*b*). Let FEHG (*Fig.* 22.) be the Earth, 2143 the Water, 6587 the Air, BADC the Vortex of the Earth, and B the Moon. Now, says he, if there was no Moon in the Vortex BADC, it's Particles would without any Impediment revolve about the Center T; but since the Moon is there, the Space, thro' which the celestial Matter flows, is narrowest between B and T; therefore this Matter flows swifter between B and T, and by that means presses both the Superficies of the Air at 6, and of the Water at 2, more than if the Moon had not been in the Diameter of the Vortex B D: and because both the Air and the Water are Fluids, and easily give

(*b*) The Flux and Reflux of the Sea, which *des Cartes* has endeavoured to explain, by an imaginary Plenum and Vortices, may be more easily and fully explained upon other Principles (as shall be shewn hereafter); for these are mere Fictions, and no way agreeable to Nature and Motion, as appears from the following Arguments.

1. If some Vacuities were not supposed to be interspersed among the Particles of Bodies, it would be very hard to conceive how Motion could be any way performed. For if we suppose every Place to be absolutely full, a small Body cannot move ever so little, without moving all the Bodies in the Universe, and whither, or to what Place they should move, when all Places are already full is not easy to conceive.

'2. Since Comets are carried 'with a continual Motion thro' 'the heavenly Spaces, from 'every Part, and all Ways, and 'to all Parts; it is evident 'from thence, that the heavenly 'Spaces must be void of any 'sensible Resistance, and consequently of any sensible 'Matter. *Newton's Optics*, '*Page* 310.

3. The Hypothesis of Vortices, and a Plenum, directly contradicts the Astronomical Phænomena, and tends more to confound the celestial Motions than to explain them, See *Newton*'s *Princip.* Book 2. Schol. to Prop. 53, and the general Scholium at the end; and *Clarke*'s Notes upon *Rohault*'s Physics. Part 1. Chap. 8. Art. 2. and on Part 2. Chap. 25. Art. 22.

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way to Preſſure, they ought to become lower under B, at 2, and higher under A, at 1. And while the Earth is turned from E, by F, towards G, or from Weſt to Eaſt, the ſwelling of the Water 412, and of the Air 856, which is now higheſt at E, moves by little and little to the weſtward, and in ſix Hours time is higheſt at the Part of the Earth H, and after twelve Hours at G. Hence it follows, that both the Water and the Air are perpetually moving from Eaſt to Weſt. Thus far *des Cartes*. The ſtreſs of his Demonſtration lies here; that the Earth EFGH, and Water 1234, are revolved round the Center T, together with the celeſtial Matter in the Vortex, between BADC and 6587; but the Moon, being in B, makes the Space B6 narrower, whereby the celeſtial Matter is ſqueezed thro', and in it's Paſſage preſſes the Air and Water below B, at 6 and 2, towards 5 and 1, and while E paſſes beneath B, it is preſſed towards H and F, and ſo round. Nor doth this celeſtial Matter, ſtrained between B and 6, rebound upward being ſuppreſſed, becauſe all things are full of Matter. And tho' it preſs the Air and Water from 62F not only towards the Weſt E 15, but alſo towards the Eaſt 73G, yet becauſe the Parts between F and G, to the eaſtward, are, by degrees, removed from the Streight B6, and the Parts towards E, to the weſtward, do more and more approach it, therefore this Force is chiefly received by theſe.

BUT the following Particulars ſeem wanting in this ingenious Explanation.

1. IT ſhould then follow, that the Sea would ſettle when the Moon approached it, and riſe in thoſe Places that are diſtant a Quadrant, or ſix Hours, from it, *viz.* it would fall at 2, where the Moon is vertical, and riſe at 6. But this is contrary to Experience; for at 2, under the

the Moon, it rises, and at 1 it falls. How this Absurdity may be avoided, we shall shew in the following Proposition.

2. IT is not plainly shewed (*des Cartes* himself totally omitting it) why, when the celestial Matter in the Streight B6 presses the Air at 6, and the Water at 2, it is not equally moved towards G37, seeing that the Earth, and Air, and Water, are all carried that way, as well as the celestial Matter, which should therefore enforce the Air and Water rather towards the East than the West.

3. THE Moon approaching any Sea, there should a stronger Wind blow from East to West than at other Times; but this seldom happens.

4. IT is more likely that the Sun should cause this Motion of the Air, and these constant Winds, because in many Places they are observed to blow fresher a little before, or about, Sun-rising, when it is distant a Quadrant from the Vertex of the Place (*c*). These things are worthy to be considered in the aforesaid Explication, not to say any thing for or against the Hypothesis itself.

I very much doubt whether this Motion of the Sea has any relation to the general, or Trade-Winds; because these Winds, in the *Torrid Zone*, are constant; and therefore should cause the Motion of the Water to be constant also (*d*). Indeed when the Wind blows harder the Motion is perceived to be greater; but this is no Argument that they have a Dependance, or proceed one from another. What hinders is, that there appears to be a Corre-

(*c*) See the Notes upon Chap. xxi. Prop. 2 below, where the Cause of these Trade-Winds is explained.

(*d*) As periodical Currents are produced by the shifting Winds or *Monsoons*: so this constant one, without doubt, is effected by the Trade-Winds, which constantly blow from East to West, tho' notwithstanding the Moon may interfere, and alter or divert it's ordinary Course.

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a Correſpondence between the Motion of the Sea, and that of the Moon, for when this approaches the other, it cauſes it to ſwell at 2, and the Currents are obſerved to ſet ſtronger to the weſtward at the New and Full Moon, than at the Quadratures. This laſt is excellently explained by *des Cartes*'s Method; for ſince the Moon is nearer the Earth at the New or Full than when ſhe is in the Quadratures, the Paſſage for the celeſtial Matter, B6, is then made narrower, and therefore the Preſſure is greater (*e*).

IF any ſhould alledge, that perhaps the greater Light of the Moon, at Full, cauſes the greater Intumeſcence; I anſwer, that at the Change all her Light is taken away; which ſhews that Light is not the Cauſe of this Motion, but rather that Preſſure of *des Cartes*, which we ſhall further explain below.

PROPOSITION X.

The ſecond general Motion of the Sea is it's Flux and Reflux, by which, in about twelve Hours and a half's Time, the Water is found to flow towards the generality of Shores, and to ebb back again, viz. *to flow when the Moon approaches the Meridian Circle above or below; and to ebb when it departs from thence towards the Horizon.*

(*e*) 'Neither the Moon's 'greateſt Diſtance, nor her 'leaſt, falls in the Quadratures 'but both there and in the 'Conjunction or Oppoſition; 'contrary to the Opinion of '*des Cartes*; who aſſerts, that 'the Orbit is elliptical indeed, 'but ſo that the leſſer Axis of 'it is always in the Conjunctions and Oppoſitions, or 'paſſeth thro' the Center of 'the Sun, and the greater 'in the Quadratures. Which 'Aſſertion is very wide of the 'Truth. *Whiſton*'s Aſtronomical Lectures, *Page* 107.

WE

WE are first to enquire whether the Sea flows towards one certain Point by this Motion, *viz.* from East to West, or from West to East.

FOR the Shores of Bays, and the Chanels of Rivers, where this Flux and Reflux is chiefly observed, more than in the main Ocean, are divers ways extended; some from West to East, as the *Mediterranean* Sea, and others from South to North, as the *Arabian* Gulph, *&c.* And in all these the Water flows thro' the Streights towards the furthest Point of their extent; and therefore in different Bays, this Flux of the Ocean tends towards divers Points of the Compass. We must therefore first be resolved, whether this Flux, or Motion, tends indifferently to any Point, or only observes two, *viz.* the West in flowing, and the East in ebbing; or even only the West in both ebbing and flowing? In my Opinion the last is truest, *viz.* that the whole Ocean is moved from East to West, both in it's Flux and Reflux, and that the difference is, that in it's Flux it is moved with greater violence and in a greater Quantity: but in it's Reflux (or more properly it's Deflux) tho' it be not moved a contrary Way, yet it seems to be so, because there flows a less Quantity of Water.

HENCE we may determine, that the Flux and Reflux of the Sea is no way distinct from that general Motion, which we explained in the former Proposition, whereby the Ocean is perpetually moved from East to West; for it is only a certain Mode or Property of that Motion. And therefore if this Motion be observed, and rightly considered in the main Ocean, where it is not obstructed, we shall find it not to be so much a Flux and Reflux of the Sea, as a Flux and Deflux, or (that we may distinguish, by proper Terms, the Quality of the Motion or Flux from the Mo-

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tion or Flux itself), it is most aptly called the Swelling and Swaging of the Sea.

FOR the Sea perpetually flows from East to West, and only seems to flow back again, when it's more violent Force is slackened and wasted, which a little before was quickened and augmented. But this is called the Reflux, because the Sea seems, on Shores and in Bays, to approach and retire by fits, which is not owing to the quality of the Motion itself, but to the Situation of the Shores and Bays, which requires that the Water should fall back to the contrary Point; but the settling of the Sea in general doth not proceed from the Situation of the Shores, but from the quality of the Motion of the Water.

BUT the Motion of the Sea can by no means be estimated by it's approach to the Shores, for whatever this Motion be, or to what Point soever it is made, it will always fluctuate towards the Shores; which happens by reason of the fluid Nature of the Water.

THAT the Sea moves towards the same Point, that is, from East to West both in the Flux and Reflux (or Swelling and Swaging) and never moves the contrary way appears from the following Observations. 1. In the main Ocean between the Tropics, there is no other Motion perceived than this from East to West. 2. In Streights that join the Parts of the Ocean and run directly East and West, as the Streights of *Magellan*, *Manilha*, *Java*, and others among the *Indian* Islands; in these, I say, the Sea rises and settles in 12 Hours Time, but in settling it doth not flow back out of the Streights to the eastward; but is carried by other Passages, still to the westward; which is a plain Sign that this Ebbing and Flowing are not two contrary Motions, but a Modification of the general Motion from East to West.

So

So that *Scaliger* and all the rest are deceived, who represent this as a double Motion to and again.

IT is to be understood, that when we say this Motion is from East to West, we do not mean punctually the two cardinal Points, but include all their Collaterals, even to the North and South Poles, towards which however the Motion is weaker.

PROPOSITION XI.

To explain the Cause of the Swelling and Swaging of the Sea, vulgarly called it's Flux and Reflux (*f*).

THERE

(*f*) Sir *Isaac Newton* most successfully explains as well the *Flux* and *Reflux* of the Sea, as most other Appearances of Nature, from his *universal Principle of Gravity* or Attraction. Gravitation is a certain Force imprinted on all Bodies by the Author of Nature, by which they mutually endeavour to accede; but how this Force is exerted we know not. Thus the Globe of the Sun and Planets gravitate mutually towards each other in proportion to their several Magnitudes, and Distances from one another. As to this Earth of ours, it hath but little Communication with the other Planets, whose Bodies are too small to affect us much, at such a vast Distance; only the Sun and Moon are respected by it, the one because it is placed so near us, and the other by reason of the Bulk of it's Body; which tho' it be at a vast Distance, yet acts with a strong attractive Force. For a Body is more forcibly attracted by how much the Distance of the Attrahent is nearer, or it's Bulk greater.

1. Thus; Let L (*Fig.* 23.) be the Moon, supposed to be above any Part of the Earth, covered with the Ocean as *b*; it is evident that this Place, being nearer the Moon than any other Part of the Earth, is more strongly drawn thereby, and swelleth up towards it: But the Water in the Place *a* being diametrically opposite to the Place *b*, and further off from the Moon than the rest of the Earth, hath a less Tendency towards it than the other Parts; and therefore, being left as it were by the Earth, is lifted up, or swelled, the contrary Way in *a*. Hence the Water flowing from *d* to *e* towards A and B, makes two Protuberances in the Ocean, the one in B directly under the Moon, the other in A just opposite to it; and these always shift and accompany the Moon in it's seeming Motion

THERE is no Phænomenon in Nature that hath so much exercised and puzzled the Wits of Philoso-

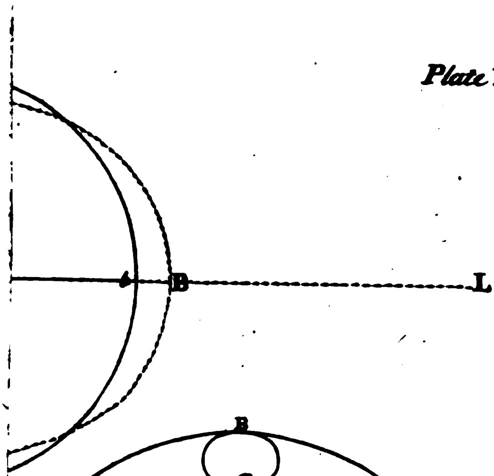
about the Earth, and occasion thereby two Floods and Ebbs in the same Place, every five and twenty Hours.

2. Of these two Tides that happen in the Time of one diurnal Revolution in any Place, that is the greatest, wherein the Place cometh nearest the Eminence of the Water A or B. Thus, in such a Figure as the last, let, P*p* (*Fig* 24.) be the Poles, ÆQ the Equator, FG a Parallel to it, which any place describes by it's diurnal Motion; it appears that the two High-waters happen in the Place, when it is situated in G or F, having the Moon in the Meridian; but the highest Tide is found in the Point G, which comes nearest the Eminence of the Waters in B. It further appears from the Figure, that the Moon, in the Time of the highest Tide, is above the Horizon of the Place, if she is on the same side of the Equator with the Place itself: but if she decline the contrary Way, she is under the Horizon in the Point A, at the Time of the highest Tide. For Example, in *Europe* the diurnal Tides are the highest of the two when the Moon is found in the elevated Semicircle of the Meridian, or in the Northern Signs of the Ecliptic; but the lowest when she is in the Southern Signs.

Moreover, the Height of the Tides is varied generally all over the Earth, according to the day of the Month and the time of the Year.

3. For, because the attractive Force of the Sun reaches the Earth as well as that of the *Moon*; when both these Forces conspire, or are united, they raise the Waters highest, and make what we call *Spring Tides*; but when the *Sun* depresses what the *Moon* heaves up, then happen the lowest or *Neap Tides*. Thus we observe higher Tides when the *Sun* and *Moon* in Conjunction or Opposition, are right over any Place B, or diametrically opposite over A and B, than when they are in the Quadratures, *viz.* when the *Sun* is in the Point H or I, and the *Moon* in the intermediate Point A or B. But the Force of the *Sun* is small compared with that of the *Moon*; because the Semidiameter of the Earth CB, by which the Water in B is nearer the *Sun* than the Center C, is scarce sensible, if compared with the immense Distance of the *Sun*.

4. Since the Eminences of Water are carried round the Earth by the diurnal Motion, the Motion, Agitation, and Height, of the Tides, are the greater, the larger the Circle is in which the Waters revolve. So the *Moon* being in the Equinoctial, and leading about the two opposite Eminences of Water in the Equator, makes greater Tides (*cæteris paribus*) than when she is in the Tropics.



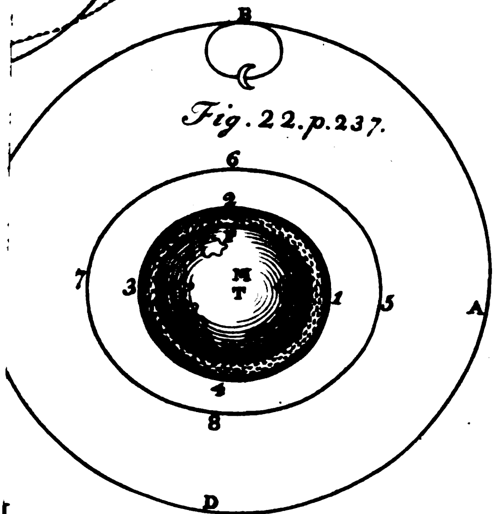
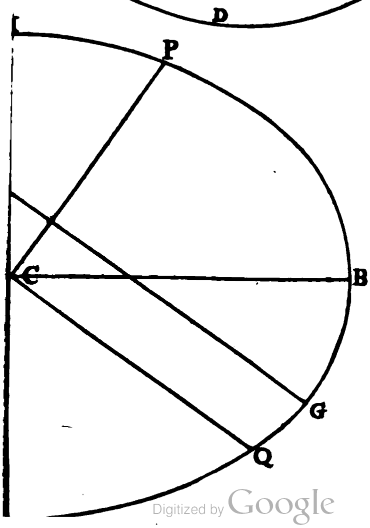


Fig. 22. p. 237.



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Philosophers and learned Men as this. Some have thought the Earth and Sea to be a living Creature, which, by it's Respiration, causeth this ebbing and flowing. Others imagined that it proceeds, and is provoked, from a great Whirl-pool near *Norway*, which, for six Hours, absorbs the Water, and afterwards disgorges it in the same space of Time. *Scaliger*, and others, supposed that it is caused by the opposite Shores, especially of *America*, whereby the general Motion of the Sea is obstructed and reverberated. But most Philosophers, who have observed the Harmony that these Tides have with the Moon, have given their Opinion, that they are entirely owing to the Influence of that Luminary. But the Question is, what is this Influence? To which they only answer, that it is an occult

Hence also both the Luminaries, placed in the Equinoctial at the Time of their Conjunction or Opposition, which happens near the Equinoxes in *March*, or *September*, produce the highest Tides in the whole Year.

Which Experience also confirms, because the Sun is a little nearer the Earth in the Winter than in the Summer; therefore the highest Spring Tides happen a little before the Vernal Equinox, and a little after the Autumnal, *viz.* in *February* and *October*, rather than precisely upon the *Equinoctial Days*.

5. The librating Motion of the Waters, which are apt to retain the Motion impressed upon them, and continue to move tho' the Actions of the Luminaries cease, make the greatest *menstrual Spring Tides* (explain'd in Artic. 3.) not precisely on the *New* and *Full Moons*, but generally they are the third Tides after them.

6. Things would happen constantly and regularly thus, if the whole Earth were covered with very deep Sea; but by reason of great and small Islands which stop the Tide, and the Streights between them, also the Shelves and Shallows along which the Tides are to be propagated, the Variety of this Phænomenon is almost infinite, and scarcely to be explained by this Theory; but when just Observations are diligently made, all these particular Causes may be found out and known. *See* Newton's Prin. Math. Phil. *Book* 3. *Prop.* 24. Greg. Phys. *and* Geometr. Astron. *Book* 4. *Prop.* 64, 65. *also* Halley's *Dissertation in* Phil. Trans. No 226.

Jurin's Appendix.

 Quality,

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Quality, or Sympathy, whereby the Moon attracts all moist Bodies. But these are only Words, and signify no more than that the Moon does it by some means or other, but they do not know how: Which is the Thing we want.

DES Cartes explains it by his general Hypothesis thus: In the forementioned Figure of Proposition 9. let ABCD be the Vortex, with the Earth in it's Center, and which, with the Earth and Moon in it, is carried in a larger Vortex about the Sun. Let M be the Center of the first Vortex, EFGH the Earth, 1234 the Superficies of the Sea, which for plainness we will suppose to cover the whole Earth; and 5678 the Superficies of the Air surrounding the Sea. If therefore there were no Moon in the Vortex, the Point T, the Center of the Earth, would coincide with the Point M, the Center of the Vortex; but since the Moon is about B, the Center of the Earth must be between M and D; because, since the celestial Matter of this Vortex moves something swifter than the Earth or Moon, which is carried only with it, unless the Point T were a little further distant from B than from D, the Presence of the Moon would hinder it from moving so freely between B and T, as between T and D; and seeing the Place of the Earth in the Vortex is not determined, but by the equal Force of the circumambient celestial Matter, it is plain that it ought therefore to approach somewhat towards D. And for the same Reason, when the Moon shall be in C, the Center of the Earth ought to be between M and A, so that always the Earth may recede a little from the Moon. Moreover, since we supposed the Moon to be about B, not only the Space between B and T, but also that between T and D, thro' both which the celestial Matter flows, is made something narrower; hence it follows, that the celestial

ſtial Matter floweth faſter there, and therefore preſſeth more, both the Superficies of the Air at 6 and 8, and of the Water at 2 and 4, than if the Moon had not been in the Diameter of the Vortex BD. Now ſeeing the Air and Water are both Fluids, and eaſily give way to the Preſſure, they muſt be more depreſſed about F and H, than they would be if the Moon were not in this Diameter BD; and alſo more elevated towards G and E, where both their Superficies bulge or are prominent. And further, becauſe the Part of the Earth at F, under B, where the Sea is now loweſt, in ſix Hours Time will be at G, under C, where it is now higheſt, and after other ſix Hours in H, under D, and ſo on: or rather, becauſe the Moon is moving a little in the mean Time from B towards C, ſo as to perform the whole Revolution ABCD in a Month, by which the part of the Earth that is now in F under the Moon's Body, will be in ſix Hours, twelve Minutes Time, or thereabouts, a little further than G, in that Diameter of the Vortex, which is 90 Degr. diſtant from the Place into which the Moon in the mean Time hath moved; therefore the Water will in that Time increaſe and be higheſt at F, and in other ſix Hours, twelve Minutes, when the Moon is got beyond D, will ſettle and be loweſt there, *&c.* Hence it is plain, that the Water of the Sea muſt conſtantly ebb and flow in the ſame Place, every twelve Hours, twenty four Minutes Time.

THIS is *des Cartes*'s Demonſtration, which is very ingeniouſly contrived to account both for the Tides that happen when the Moon is in the Meridian of the Place, and thoſe alſo that occur when ſhe is in the oppoſite Point of the Meridian Circle under the Horizon.

BUT according to what we obſerved in the ninth Propoſition, there are ſeveral Imperfections in this Demonſtration. As firſt, it is a wonder that *des Cartes* did not conſider, that, according to his Demonſtration, the Water ought to ebb at 2 and 4, when the Moon approaches the Meridian B: and, on the contrary, to flow, when the Earth or Moon (*viz.* either of them) is removed ſix Hours from each other; but this is contrary to Experience, for when the Moon approaches the Meridian of any Place, the Waters flow in that Place, and ebb, back again, at it's departure. But both *des Cartes*'s Words and Figure ſhow the contrary; ſo that to take away the Abſurdity (and in *des Cartes*'s Method) let us ſuppoſe the Vortex of the Earth ABCD, and the Waters 1234, to be interſperſed equally about the Center T without any Protuberance, and to revolve with the Earth and the celeſtial Matter between ABCD and 5678. Let us ſuppoſe again the Moon to happen into this Vortex at B, and therefore the Space TB to become narrower, and the Water at 2 to be preſſed towards E by the celeſtial Matter ſqueezing thro' it.

THEN while the Water is expelled from 2 to E, I aſk where the greateſt ſwelling will be, whether in the Place E, which is diſtant a Quadrant from F (where the Moon is vertical), or in the Place next to F towards E? If you anſwer, the ſwelling is greateſt about the former Place E, I deny it, becauſe it is contrary to Experience; but Experience ſhews the latter to be true, and even Reaſon convinces us, that when the Moon is over the Place F, the Water will be forced from 2 towards 1, which happens becauſe the greateſt ſwelling is about 2, not about 1, for here it will be leaſt; hence the Places to the weſtward have their Tides later, as we know by Experience. And Reaſon and the Laws of Hydroſtatics require this.

For

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For if Water be poured in at 2, that it may flow towards E, there will be the greatest quantity of Water at 2, and a little less in the next Place, but least of all at E; and the same Thing will happen if it be expelled or driven towards E. But by the Circumrotation of the Earth, E comes into the Place of F, where at length there will be the greatest Protuberance at E, and the Water will be repelled towards H.

THEREFORE *des Cartes's* Figure and Demonstration is to be changed, that the swelling may arise somewhere about 2, *viz.* where the Moon is vertical. What more might be said here we refer to our Treatise upon *des Cartes's Physics.*

PROPOSITION XII.

The general Motion of the Sea from East to West is stronger, and the Tides are higher at New and Full Moon, than at the Quadratures.

THE Truth of this Proposition appears from Experience. For People that use the Sea testify, that at New and Full Moon, the Face of the Ocean is constantly rough and troubled, but calm and quiet at the Quadratures. This is easily accounted for by the aforesaid Hypothesis; for when the Moon is at the New or Full, she is nearer the Earth than at any other Time of her Age, and is furthest distant in her Quadratures, as is shewn by Astronomers (*g*). But when the Moon is nearer the Earth, that is, when the Space BT is less, the celestial Matter being hindered, or obstructed, presses with greater force the Water from 2 towards 1. But happens otherwise in the Quadratures.

(*g*) This is false. *See the Note* (e) *above.*

YET in ſome Places there are higher Tides at the Full Moon than at the New, which I cannot account for, unleſs they be the Effects of it's greater Light at that time. Nor can it be otherwiſe explained, why at the Full Moon Vegetables and Animals are impregnated with a greater quantity of Sea Moiſture, than at the New, tho' even then the Tides are every whit as high. It is very wonderful what one *Twiſt*, a *Dutchman*, relates in his Deſcription of *India*. He ſays, that in the Kingdom of *Guzarat* (where he lived many Years) their Oyſters, and Crabs, and other Shell-Fiſh, are not ſo fat and juicy at the Full Moon as at the New, contrary to their Nature in all other Places. Nor is it leſs admirable, that on the Coaſt of the ſame Kingdom, near the Mouths of the River *Indus*, the Sea ſwells, and is troubled, at the New Moon, when not far from hence, *viz.* in the Sea of *Calicut* the greateſt Riſe of the Waters is at the Full. But it is requiſite that we ſhould have repeated Enquiries and Obſervations about theſe Matters, before we pretend to ſolve their Phænomena.

PROPOSITION XIII.

The Flux and Reflux of the Sea varies with the Seaſons of the Year, and the Tides are obſerved to be higheſt about the Equinoxes ; i. e. at the Spring and Fall ; but loweſt at the Solſtices.

DES *Cartes* pretends to account for this Phænomenon by his Hypotheſis, but I cannot apprehend his Meaning by his Words, nor how it can be deduced from it (*b*). It is probable, that the Sun and the general Winds may contribute much

(*b*) *See the true Reaſon of this in Artic.* 3. *of Note* (f) *above.*

to

to raise these Tides, when, in the Equinoxes, the Sun is vertical to the Ocean in the middle of the *Torrid Zone*, and therefore may cause both the Wind and Water to rage, and the former to agitate the latter. The contrary of which may happen about the Solstices. Or we may say, that these extraordinary Tides then happen by the same Reason, and proceed from the same Cause that frequent Rains and Inundations proceed from in these Seasons.

PROPOSITION XIV.

In some Parts of the Ocean, Bays, and Shores, the Tides ebb and flow very high; and in others but low: and in some few Places there are no sensible Tides at all.

THOSE Places have the greatest Tides; 1. which are in the *Torrid Zone* between the Tropics, where the Moon, being almost constantly vertical, presses the Water with greater force; 2. those which lie directly East and West with their Collaterals; 3. those Bays that are long and narrow; 4. those Places where there are but few Islands or Forelands.

THE Tides are therefore greater or less in a Place, according as it is situated or extended.

THE greatest known Tides are observed in the Bay of *Guzarat*, at one of the Mouths of the River *Indus*, and has struck many with Admiration. The Water there recedes from the Shore very quick, and leaves it uncovered for a great Space; so that this Bay is, not without Reason, thought to be the same into which *Alexander the Great* sailed, when he attempted to transport his Army by Sea into *India*, but was hindered, as it is reported, by the Sea which retired quick from

from the Shore, and left all his Ships a-ground, so that he could not proceed further, but thought that the Gods had there fixed Bounds to his Expedition. This Story is reported for a Truth by the Inhabitants of *Cambaya*. The Cause of this is the shallowness of the Chanel, which makes the Water in it's Ebbing leave so much more Ground uncovered, tho' perhaps some other Cause may conspire with this.

AT the Town of *Daman*, not far from *Surat* in *India*, the Tide rises and falls two Fathoms and a half, and the Sea recedes from the Shore half a *German* Mile.

IN the Bay of *Cambaya* the Tide flows five (or as some say seven) Fathoms high, which violent Flux causes many Ships to be lost by unexperienced Seamen; for at the Ebb, when the Water falls back, they are frequently split upon the Rocks.

UPON the Shores and Bays at the *Magellanic* Streights, there is no constant Time observed between the Tides, which ebb and flow irregularly, sometimes in three Hours, and sometimes in twelve Hours; which variety is caused by the violent breaking of the Sea into these Streights, and the frequent Agitation of it by the Winds.

PRODIGIOUS high Tides are observed about *Malacca*, and in the Streights of *Sunda*.

IN the *Arabian* Gulph, or *Red-Sea*, the Tide of Ebb is so great, that as some of the Antients have writ, (quoted by *Scaliger*) *Moses*, and the *Israelites*, might, at low Water, have passed thro' it without a Miracle. But this is false, for it never ebbs so much as to leave the Chanel dry.

IN *Button*'s Bay, near *Hudson*'s Streights, when Mr *Thomas Button*, an *Englishman*, wintered there in the Latitude of 57 Degr. North Latitude, he observed the Tide of Flood to rise fifteen Foot and above;

above: and in the Latitude of 60 Degr. the Summer after, he found it to come up to the same Height; tho' in neither *Hudson's* nor *James's* Bay it rises much above two Foot.

THERE are prodigious high Tides upon the Coast of *China*, and about the Islands of *Japan*.

AT *Panama*, a Town on the Coast of *America*, the *Pacific* Sea flows very high, and immediately ebbs again; at the Full Moon the Agitation is so great that it drives the Water into the Houses of the Town. All along this Shore the Tides of the great South Sea are strangely high; so that in their Reflux they retreat two Miles of Ground, and in some Places the Water falls of out Sight.

IN the Bay of *Bengal*, on the Shore of *Siam*, the Tide rises fifteen Foot.

BUT in the *Mediterranean* Sea, which flows from West to East thro' the Streights of *Gibralter*, there is no sensible Tide at all; because it's Entrance is situated opposite to that Point, to which the Ocean Sea in general flows. It may perhaps increase a little, but in the main it is not sensible, only in the Gulph of *Venice* there is a small Agitation perceived, by reason of the great length and narrowness of the Bay, which, in the broader Parts of the *Mediterranean*, is no where perceptible. Therefore the Flux and Reflux of the Sea was unknown to the *Grecians*, and also to the *Romans* in the Time of *Scipio Africanus*; and therefore when they found it in other Places, accounted it a Miracle; as appears from the forementioned Expedition of *Alexander the Great*, and the Wars of *Scipio* with *Carthage*; but in *Cicero's* Time this was well enough known to the *Romans*. A small Tide is observed at *Marseilles* in *France*, and an inconsiderable Rising is perceived along the Coast of *Barbary*.

IN

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IN the *Baltic* Sea, and all over the northern Ocean beyond *England* and *Norway*, the Tides are not in the least perceptible; nor in the northern Parts of the *Pacific* Ocean (*i*). The Reason is not well known, unless we fix it upon the great Distance these Seas are from the way of the Moon, and their being extended from West to East, and North-east, with the many Islands and Forelands, all which conspire to obstruct the Flux of the Tides in these Places. But this cannot be said of *Hudson*'s Bay; which is properly extended from East to West, to receive the Flux of the Tides; and therefore it is no Wonder if they are much more remarkable here than in the *Baltic*, or in the northern Ocean.

PROPOSITION XV.

The Flux of the Sea is forced by a strong Impulse; but the Reflux is the natural Motion of the Water.

THE Flux is caused by the Pressure of the Moon, or the celestial Matter, between it and the Sea, and continues no longer than the Cause forces it: but in the Ebb, the Sea only flows from a higher to a lower Place, which is the natural Motion of the Water.

(*i*) The Tides are very small in several Parts of the Northern Ocean, yet they may be felt in some particular Places. Thus on the Coast of *Nova Zembla* the Water was observed by Capt. *Wood* to rise eight Foot. See Note (*a*) on Chap. 8. above.

LEMMA

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LEMMA.

The Place of the Moon in the Zodiac *being known, from an Ephemeris, or by Calculation, or Astronomical Observation, and also it's Latitude, and the Hour of the Day; to find, on the Terrestrial Globe, what Place the Moon will be vertical to at the given Hour, and to shew all the Places that the Moon will pass over, one after another, that Day.*

THIS Problem is of great Use for observing the Flux and Reflux of the Sea. You will find the Method of solving it in Chapter xxx. Proposition 14. where it is more commodiously explained. However the more knowing Reader may anticipate it here, or learn it aforehand from the Rules there delivered.

PROPOSITION XVI.

The Tides are highest in those Places over which the Moon is vertical, unless some of the Obstacles above-mentioned in Proposition 14 *hinder; but the further any Place is from that, the less* (cæteris paribus) *is the Flux and Reflux.*

BECAUSE those Places are more pressed, and the swelling of the Sea is greater, over which the Moon squeezeth the celestial Matter, whereby greater Tides are produced: but where the incumbent Matter is less squeezed, and other Causes conspire, the Alteration will be less.

PRO-

PROPOSITION XVII.

The Altitude of the Tides are divers in the same Place at different Times, and they are high and low, according as the Moon is further from or nearer to the Zenith of the Place.

SINCE the Moon every Day changes her Place in the Ecliptic, she will be vertical now to one Place, and then to another, and consequently varies her Distance from the Zenith of any particular Place. Which being granted, it follows, as a Corollary of the last Proposition, that the Tides in any one Place are constantly altering, whether their Variation be sensible, or insensible.

PROPOSITION XVIII.

The greatest swelling of the Ocean, or High-Water, ought to be in that Place when the Moon is in the Meridian Circle (above or below); but in divers Places it is High-Water when the Moon is otherwise posited.

SINCE the Moon, in the Meridian, is nearer any Place than when she is in the Horizon, (because the Hypotenuse of any right-angled Triangle is longer than the Perpendicular) it follows (by Proposition 16, of this Chapter) that then it ought to be High-Water in that Place (where she is full South). And when she is full North, or in the lower Part of the Meridian Circle, it ought to be also High-Water in the same Place, because, tho' she be not there, yet the opposite Part of the Vortex of the Earth is straitned, and hath the same Effect, as if the Body of the Moon itself were present.

BUT

BUT there are many Places and Shores where it is not High-Water precisely at the Time of the Moon's southing or northing in the Meridian Circle, (as the Philosophers of the former Age thought) but perhaps a little before, or after, she makes her appulse to the Meridian, *viz.* when she approacheth a Vortex something distant from it, East or West. Neither doth a full Tide always happen when the Moon is in the same Azimuth; but it is very often High-Water, especially at the New and Full Moon, a little before the constant Time, or before the Moon approaches that Azimuth. At *London* it is High-Tide when the Moon is three Hours from the Meridian, or South-West, and North-East (*k*). On the Shore of *China*, in the Harbour of *Maccao*, a *Portuguese* Sailor thus stated the Time of High-Water. The Elevation of the Pole, or the Latitude of the Place, is 22 *degr.* 20 *min.* In the Year 1584 on the nineteenth Day of *September* it was Full Moon, and the same Day, it was High-Water half an Hour, or three quarters, past Eight in the Morning; so that the Moon was then three Hours and a quarter distant from the Meridian; hence the Azimuth, or Point she was then in, may be found by a Problem in Chapter xxx.

IN the Year 1585, *February* the third, which was also the third from the New Moon, it was observed to be High-Tide a little after twelve; and therefore at the New Moon, which was *February* the first, it was full Sea about forty Minutes after Ten.

HENCE the Azimuth the Moon was then in may be found.

(*k*) *See the Note* (m) *below.*

IN the Year 1585, *February* the sixteenth, it was observed to be High-Water, at Full Moon, almost at Noon, *viz.* at half an Hour past Eleven.

IN the Year 1585, *June* the second, which was the fourth Day after the New Moon, it was High-Tide exactly at twelve, therefore at the Conjunction it was High-Tide at nine in the Forenoon.

THE same Sailor adds, that the Time of High and Low-Water doth not agree with the Time that is computed from the Motion of the Moon, except for five Days before and after the New Moon. But there is some Ambiguity in these Words, and others following, which we have therefore omitted. But the Cause of this Variation is, that the Sea rises nine Hours in the Port of *Maccao*, and ebbs only three, as is observed in the next Proposition.

HERE follow some Observations made by a *Dutch* Sailor of the Time of High-Water, on the Days of the New and Full Moon, at different Places.

AT twelve o'Clock (on the New and Full Moon Days) it is High-Water along the Shore of *Flanders*, at *Enckhuysen* in *Holland*, at *Hoorn*, at *Emden* in East *Friesland*, at the Mouth of the River *Elbe*, at the Mouth of the *Eyder*, at the Islands of *Jutland*, at *Dover* in *England*, &c.

AT forty five Minutes past twelve, at *Flushing* in *Zealand*.

AT half an Hour past one, at the western Shore of the Isle of *Wight*, at *Calais*, at the Mouth the River *Thames* in *England*, along the Shores of *Zealand*, at the Mouth of the River *Schelde*, in the *Mause*, at [*Gorcum*].

AT three o'Clock, at *Amsterdam*, *Rotterdam*, *Dort*, and *Newcastle* in *England*, before the *Flemish* Sand-Banks, at *Armentier* in *Flanders*, at the

Mouth of the River *Garonne*, along the South Shore of *England*, on the Coast of *France*, *Gascoigne*, *Biscay*, *Gallicia*, *Portugal*, and *Spain*; on the western Shore of *Ireland*, all the way to *Shetland*.

AT a quarter before four in the Afternoon, at *Rohan* in *France*, in the *Maese*, at *Rochelle* in *France*, in the River *Garonne*, in the Bays upon the Shore of *Spain*, *Portugal*, *Gallicia*, in the Bays on the Southern Shore of *Bretagne* in *France*, on the Shore of *Gascoigne*, on the western Shore of *Ireland*.

AT half an Hour past four, from the *Texel* to the southern Shore of *Ireland*.

AT a quarter past five, in all the Ports on the South of *Ireland*, at *Plymouth* in *England*, and at other southern Places between that and *Wales*.

AT six o'Clock in the Morning and Evening, at *Hamburgh* in the *Elbe*, at *Bremen*, on the East side of the *Texel*, at *Antwerp*, in the *English* Chanel as far as the *Scilly* Islands.

AT a quarter before seven in the Evening, at *Falmouth*, and in *Bristol* Chanel, at *St Nicolas* and *Podessamke*, as far as *Weymouth* and *Hartpool*.

AT half an Hour past seven at the Road in the *Texel*, at *Kilduyna*, in the middle of the Chanel, beside *Plymouth*, and as far as the Foreland of *Lizard-Point*.

AT a quarter past eight in the Evening, about the *Isle of Wight*, at the West side of the *Flie* Island.

AT nine o'Clock, at the Mouth of the River *Eems* in *Friesland*, on the East side of the *Flie* Island, along the Shores of *Friesland*, and on the eastern Shore of the *Isle of Wight*.

AT half an Hour past ten, at the Mouth of the River *Thames*, on the Shore of *Normandy* and *Picardy*.

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AT a quarter past eleven, in the River *Thames*, and other Places in *England*.

IT is very difficult to explain the Cause of these wonderful, and extraordinary Differences of the Tides in all Places, tho' it properly belongs to Naturalists, and Geographers, to do it. It is likely that the various windings of the Shores, and their different Situation to the Sea-ward, the Resistance of the Islands, the Concurrence of several Tides, the Distance of Places from the Moon's Way, the various Winds, chiefly those that are general and constant, the Declivity and Shoalness of the Shores, and other things, very much contribute to this surprising Diversity. For Example, at the Port of *London* the Tide rises 'till the Moon comes to the South-West, when she hath South Latitude, and only then begins to ebb, not when she approaches the Meridian: for which we give this Reason, *viz.* that while the Moon is moving from the Meridian of *London* towards *Brasil* (or from *Brasil* towards *London*) the Water ought not to settle, but still to rise, because the Shore of *America* repels the Water towards *England*, which is drawn thitherward by the Moon, since there is no Passage for it to proceed any further. But it may be asked why, when the Moon hath North Latitude, it should happen to be High-Water before she approaches the Meridian of *London*, *viz.* when she is in the South-East Point? To which I answer, that when the Moon hath North Latitude she is much nearer *England* than when she hath South, and therefore raises up the Water sooner; and the Reason why the Flux is not continued so long as 'till the Moon approaches the Meridian is, because she impels the Ocean more towards the *American* Coast, and *Hudson*'s Bay, where the greatest Floods are then observed,

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AND for this Reason it is High-Water along the Coasts of *China*, before the Appulse of the Moon to the Meridian, because the continual East Winds drive the Sea towards the West.

BUT all these Allegations are not sufficient to satisfie me in these Matters, and therefore I would have the curious Naturalists examine them with greater Scrutiny. For to find the true Cause, it is requisite, that we be furnished with accurate Observations how the Tides ebb and flow in different Places, and what Azimuth the Moon is in when it is High-Water in those Places; and how her Bearing varies according to her Place at the Change and Full; especially in those Places where the Moon is vertical, and those that bear from them directly East, West, North, and South (*l*). It is also to be diligently observed, what height the Tides flow at these times; when the Moon is in the North Part of her Orbit, and moves not over so much Sea, but over that vast Tract of Land which lies between *China*, and the western Shore of *Africa*. For since she presses not the Water directly when she moves over these *Mediterranean*

(*l*) The following Directions are of excellent use for observing the Tides, given by Sir *Robert Murray*, in *Philos. Trans.* Nº 17.

1. Observe the Situation of the Place of Observation, *viz* what Currents, Seas, Islands, Bays, Shores, Shelves, *&c.* are near it.

2. Observe in what proportion the Increases of the Tides from the Neap to the Spring Tides, and their Decreases, and the Risings and Fallings of the Ebbs, happen to be in regard of one another.

3. Observe the Increase and Decrease of the Velocity of the Currents.

4. Measure the Height of every utmost High Water and Low Water, from one Spring Tide to another.

5. Measure the exact Height of Spring Tides and Spring Ebbs.

6. Observe the Position and Strength of the Wind, the State of the Weather; the Height of the Barometer, &c.

7. Calculate the Moon's Age and Place in all Respects.

See Lowthorp's *Abridgment of* Philos. Transact. p. 260.

Places, I ſuppoſe this will cauſe a ſenſible Variation of the Motion of the Water. Likewiſe theſe Phænomena are to be obſerved when the Moon is in the South Part of her Orbit, and moves over *Braſil*, or South *America*. For without a perfect Notion of theſe Occurrences, we ſhall ſcarce be able to find out the true Reaſon or Cauſe of the Tide.

PROPOSITION XIX.

The Sea flows to moſt Shores in twelve Hours twelve Minutes, and ebbs back again in as many.

IN ſome few Places it takes more Time in flowing than in ebbing; and on the contrary, in others it flows in leſs Time than it ebbs: yet ſo that the Time of the Flux and Reflux (or the Time between the two full Seas) make together twelve Hours, 24⅛ Minutes, and two of theſe Times make twenty four Hours 48¼ Minutes, or almoſt twenty five Hours. So that High-Water happens every Day later by almoſt an Hour than the Day before, becauſe the Moon comes later to the Vertex, or Meridian of any Place, by almoſt an Hour (fifty Minutes) every Day.

WE have ſufficiently explained this Propoſition in our Demonſtration of the eleventh; tho' in that we accounted it to be full Sea, when the Moon is in the Meridian of any Place; but becauſe, as we ſhewed in the laſt Propoſition, it is found to be High-Water in ſeveral Places when the Moon is not in the Meridian, we do not, in this Propoſition, reckon the forementioned Hours from the Time the Moon is in the Meridian of theſe Places, but from the Time ſhe is found, by Experience, to be in that Vertex when it is high Water. Nevertheleſs this Period of of the Flux and Reflux is not performed exactly in twelve Hours, twenty four Minutes, (or in twenty four Hours, fifty Minutes) but some Times sooner or later, because the Moon constantly changing her Distance from the Zenith, returns at unequal Times to the same Vertex; but this Difference is small.

THEREFORE tho' the Flux and Reflux together be performed, in all Places, in about twelve Hours, twenty four Minutes (when there are no Storms); yet in some, the Time is equally divided between the Flood and Ebb; and in others, the Time of flowing is more or less than that of ebbing.

THE *Garonne*, a River in *France*, is seven Hours in rising, and but five in falling. And in the Port of *Maccao*, upon the Shore of *China*, the Tides flow nine Hours, and only ebb three, or less if the East Winds blow.

ON the contrary, in the River *Senegal*, in *Negroland*, the Sea flows four Hours, and ebbs eight.

IT is hard to assign Reasons for this Difference. Some attribute it to the strong and swift Current of certain Rivers, or to their ordinary Flux. Thus the River *Garonne* resists the Influx of the Sea with it's strong Current and hinders it; but helps the Reflux, and hastens it. Others will have the Flux to be prolonged another Hour, because the return of the Flood from the northern Seas, hinders it's Egress at the Mouth of the *Garonne*, and rather forces it further up the River. But it is my Opinion, that the River pours itself into the Sea, to a considerable Distance, with a rapid Motion, which is obstructed in part by the Tide, and made to stand, some Time before the Moon forces the Sea up into the very Chanel.

THE Reason why the Sea flows only four Hours into the River *Senegal*, is either because

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it's Chanel is extended from West to East, or because the swiftness of the Stream, may hinder the Flux for two Hours. There may be perhaps other Causes which we are ignorant of, for want of Observations; for we are not certain whether it really lessens all the eight Hours, or only six, and is stagnant the other two, by Reason of the Equality of the Current and the Tide,

WE are also to consider that low Places have apparently a longer Flux, and a shorter Ebb.

PROPOSITION XX.

Whether it be Flood in any Place at the Instant the Moon is in the Horizon of that Place?

THEY commonly say it is; tho' it be not true in those Places where it is full Sea when the Moon is in the Meridian. For when the Moon declines from the Equator southward, she approaches the Meridian in less than six Hours, and therefore the Flux must have begun when the Moon was depressed below the Horizon: on the contrary, when the Moon has a North Declination, she requires more than six Hours to move from the Horizon to the Meridian, and therefore it is Flood when she is elevated above the Horizon, or is in the Horary Circle of the sixth Hour; and so it is observed in most Places, tho' it be otherwise at *London*, as we observed above. It seems indeed reasonable that, tho' the Moon has a North Declination, the Flux should begin when she is horizontal, because she is then ninety Degrees distant from the Vertex of the Place, and therefore the Pressure of the Ocean ought first to touch here. But Observations are wanting to confirm this.

PRO-

PROPOSITION XXI.

Having the Time of High or Low-Water given, on the Day of the Change or Full, in any Place where the Sea ebbs and flows regularly, (viz. *in twelve Hours, forty eight Minutes*) *to find, at any Age of the Moon, the Time of High and Low-Water* (m).

WE

(*m*) The true Time of the Tides, at all Ages of the Moon is not well computed by Sea-Men and Astronomers; most of them reckoning, that the Moon being upon a set Point of the Compass, or so many Hours past the Meridian, makes High-Tide in such and such a Point at all Times of the Moon. As for instance, a South-west Moon makes a full Tide at *London*, that is, when the Moon is three Hours past the Meridian. Now this is true indeed at the New and Full Moon, but not at any other Times of the Moon, which few take any notice of.

But observing more narrowly, I find that at *London* the Tides fall out at least two Points that is, an Hour and a half sooner in the quarters than in the New and Full Moon, and the true Time of the Tides is found to be somewhat shorter and shorter from the New and Full Moon to the quarters, yet not in an equal manner, neither gradually decreasing from the New and Full Moon till the quarters; but rather that there was some little Difference of Alteration both at the New and Full Moons, and also at the quarters, and that the greatest Difference fell out in the midst between them, agreeing very well to a circular Proportion after this manner.

1. Divide a Circle into 12 equal Parts, or Hours, according to the Moon's Motion, or Distance from the Sun, from the New Moon to the Full.

2. Let the Diameter of the Circle be divided into 90 Parts, or Minutes, that is, according to the Time of the Difference between the New or Full Moon, and the quarters, which is one Hour and a half.

3. Make perpendicular Lines cross the Diameter of the Circle from Hour to Hour.

4. Reckon the Time of the Moon's coming to the South in the Circumference of the Circle, and observe the perpendicular Line that falls from that Point upon the Diameter; and the proportional Minute cut thereby, will shew how many Hours or Minutes are to be substracted from the Time of High Tides at the New and Full Moon, that so you may have the true Time of the Tides that present Day.

Example.

WE observed before, that the Time of High and Low-Water (if we reckon by the mean Motion of the Moon from the Sun) is every Day $48\frac{3}{4}$ Minutes, (or more accurately $48\frac{13}{16}$) and every half Day $24\frac{3}{8}$ Minutes later than the preceding.

IF therefore it be High-Water in any Place, on the Day of the New or Full Moon, at twelve o' Clock, it will be full Tide on the subsequent Days of the Lunation, as in the following Table:

Moon's Age.	Hours.	Minutes.
1	XII.	48
2	1	37
3	2	27
4	3	16
5	4	5
6	4	55
7	5	44
8	6	34
9	7	23
10	8	12
11	9	1
12	9	51
13	10	40
14	11	29
$14\frac{1}{2}$	12	Midnight.
15	12	Noon.

THAT

Example. At *London*, on the Day of New and Full Moon, it is high Tide at three of the Clock, that is when the Moon is three Hours past the Meridian, and so by the common Rule the Moon being about four Days old it will be South about three of the Clock, and it will be high Tide three Hours afterwards, that is at six of the Clock. But now by this Rule, if you count this Time of the Moon's coming to the South in the Circumference, the perpendicular Line which comes from three to nine, cuts the Diameter at 45 Min. which shews that so much is to be abated from the Time of High Tide in the New and Full

THAT is, at the end of the first Day of the Moon's Age it is High-Water later by forty eight Minutes, *&c.*

BUT

Full Moon; so that it is High Tide 45 Min. before six; that is, at five Hours 15 Min. and not at six, according to the common Rule.

The like you may do for any other Port, or Place, knowing the Time of High Water at the New and Full Moon in that Place: And you may do it the more readily, if you set down the Time of High Water at the New and Full Moon under the Diameter, as I have done for *London* where it is high Tide at three of the Clock: So when the Moon is south at three of the Clock or nine, the Perpendicular cuts the Diameter at two Hours 15 Min. which, added to the aforesaid three or nine, gives the Time of high Water as above.

Thus you may easily make a Table which by the Southing of the Moon shall readily tell you the Time of High Tide in any Place. The following is for *London.*

Moon South.	*Tide Lond.*	*Moon South.*	*Tide Lond.*	*Moon South*	*Tide Lond.*	*Moon South.*	*Tide Lond.*
H. M.	*H. M.*	*H. M.*	*H. M*	*H M*	*H. M.*	*H M*	*H. M.*
XII 0	3 0	III 0	5 15	VI 0	7 30	IX 0	11 15
10	3 9	10	5 21	10	7 40	10	11 29
20	3 18	20	5 27	20	7 52	20	11 43
30	3 27	30	5 33	30	8 4	30	11 57
40	3 36	40	5 40	40	8 15	40	12 10
50	3 40	50	5 46	50	8 25	50	12 24
I 0	3 54	IV 0	5 52	VII 0	8 36	X 0	12 37
10	4 2	10	5 59	10	8 48	10	12 50
20	4 9	20	6 6	20	9 0	20	1 3
30	4 16	30	6 13	30	9 13	30	1 16
40	4 23	40	6 20	40	9 26	40	1 29
50	4 30	50	6 28	50	9 39	50	1 42
II 0	4 37	V 0	6 36	VIII 0	9 53	XI 0	1 54
10	4 44	10	6 44	10	10 6	10	2 3
20	4 50	20	6 53	20	10 20	20	2 16
30	4 57	30	7 2	30	10 33	30	2 27
40	5 3	40	7 11	40	10 47	40	2 38
50	5 9	50	7 20	50	11 1	50	2 49

If

BUT for Practice, it is sufficient to add to the Time of High-Water at the New Moon.

For the first Day after the Change.	Hours	$0\frac{3}{4}$
For the second	———	$1\frac{2}{3}$
For the third	———	$2\frac{1}{2}$
For the fourth	———	$3\frac{1}{4}$
For the fifth	———	4
For the sixth	———	5
For the seventh	———	$5\frac{2}{3}$
For the eighth	———	$6\frac{1}{2}$
For the ninth	———	$7\frac{1}{3}$
For the tenth	———	$8\frac{1}{4}$
For the eleventh	———	9
For the twelfth	———	$9\frac{3}{4}$
For the thirteenth	———	$10\frac{1}{2}$
For the fourteenth	———	$11\frac{1}{3}$
For the fifteenth	———	$12\frac{1}{4}$

BUT this Calculation supposes the Motion of the Moon, from the Sun, to be equal, tho' it be not; for when she is in her Perigee she moves much swifter than when she is in her Apogee; and therefore in the former Case she prolongs the Time of the Tides, and in the later shortens them. Besides, some of the Lunar Months exceed thirty Days, and others are less than twenty nine, but the mean is twenty nine Days, twelve Hours, forty four Minutes.

BUT in those Places where it is High or Low-Water when the Moon approaches some certain

If you find the Difference not so much between the Neap Tides, and the Spring Tides, the Diameter must be divided into fewer Parts. *This is* Mr Henry Philips's *way, delivered in Philos. Trans.* N° 34. *which tho' it be found Fault with by* Mr Flamstead (*in the same Trans.* N° 143) *yet by many it is said to answer very well, and therefore we have transcribed it.*

Azimuth,

Azimuth, tho' the Times may be computed by this Method, yet they are not ſo accurately found.

NEITHER do the Conjunctions of the Sun and Moon happen at the ſame Time every Change.

WE ſhall ſhew in Chapter xxx. how this may be done by the terreſtrial Globe.

WE may uſe a Method ſomething like this, for thoſe Places where the Time of the Flux is more or leſs than the Time of the Reflux; ſuppoſing the Difference be conſtant. But the Conſideration of the Thing itſelf, and Experience, will ſooner teach theſe Particulars than Diſcourſe.

PROPOSITION XXII.

The Winds very often hinder, or promote, the Courſe of the Tides in all Places; and not only the Winds that blow in thoſe Places, but even thoſe in others may have the ſame Effect.

THE Truth of this Propoſition is ſo clear, that it needs no Demonſtration.

PROPOSITION XXIII.

When any Part of the Ocean hath a proper, or particular, Motion, it is called a Current. Currents are various and directed towards different Parts of the Ocean, of which ſome are conſtant and others periodical. To enumerate the moſt famous conſtant ones.

1. THE moſt extraordinary Current of the Sea is that by which Part of the *Atlantic* or *African* Ocean moves about *Guinea* from *Cape Verd* towards the Curvature or Bay of *Africa*, which they call *Fernando Poo*, *viz.* from Weſt to Eaſt, which is contrary to the general Motion. And

And ſuch is the Force of this Current, that when Ships approach too near the Shore it carries them violently toward that Bay, aad deceives the Mariners in their Reckoning. Hence it comes to paſs, that Ships which ſail in two Days Time from the Shore of *Mouree* to *Rio de Benin*, [or *Formoſa*] which is one hundred *Dutch* Miles, require ſometimes ſix or ſeven Weeks to return from *Benin* to *Mouree*, unleſs they run out into the main Ocean, which is not eaſily done, becauſe the Current ſets to the North-Eaſt, and runs ſwiftly from the Iſland of *St Thomas*, towards the Bay of *Fernando Poo*, carrying in with it the Ships tho' they have a fair North-Eaſt Wind; and they can ſcarcely get from the Shore, unleſs they be driven by theſe ſudden Storms which break from the Clouds (called Travados) which ſeldom happen, and in ſome Months not at all. This Current deſtroyed ſeveral Ships before Mariners were well aware of it; as being either unadviſedly driven upon the Rocks and Shoals, and periſhed by Shipwreck, or detained in the Bay 'till they died with Hunger.

BUT this Current affects not the whole *Ethiopic* Ocean, only that Part which is adjacent to the Shore of *Guinea*, to the end of the Bay, and to about one Degree of South Latitude. It is obſerved not to exceed the Diſtance of fourteen Miles from the Shore; therefore Ships are very careful leſt they ſhould approach ſo near, when they ſail along theſe Coaſts; which would hinder their intended Courſe, and drive them to a Place they would not care to viſit.

IT is no eaſy thing to find out the Cauſe of this Current ſo near the Shore, when the main Ocean thereabouts moves the contrary Way from Eaſt to Weſt. Two Things may be ſaid for it:

1. THE

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1. THE Ocean being repulsed by the *American* Shore moves slowly to the Eastward, but this Motion is not felt in the Main, because the other destroys it, and renders it less sensible, only near the Shore it runs swiftly towards *Fernando Poo*, which, being stretched a pretty way into the Land is fittest to receive it; and the Reason why it is not felt in other Places upon the Shore of *Africa* (as at *Congo*) is, because the Rapidity of the Rivers breaks and obstructs it.

2. THERE may be some subterraneous Receptacle in the Bay of *Fernando Poo*, into which the Sea perhaps may fall and draw the rest of the Ocean. But this may seem less probable; they that have opportunity of observing it better may give better Reasons.

PROPOSITION XXIV.

[*To point out the Place of the second perpetual Current*].

THE Ocean moves swiftly from about *Sumatra* into the Bay of *Bengal*, from South to North; so that it is probable this Bay was made by the Rapidity of the Current; by which also perhaps the Peninsula of *Malacca* was separated from *India*. I do not know whether the Cause may be owing to the many Islands, and to Cape *Mabo*, upon the South Continent, whereby the Ocean in it's Passage westward may be diverted northwards: or there may be a subterraneous Receptacle in the Bay itself.

BE it how it will, I suppose the Current doth not set directly to the North, but rather to the North-West. This same Current is felt between *Java* and the South Continent, and therefore when the *Dutch* sail to the *Indies*, they first make towards

wards the South Continent, and then direct their Course from South to North to come at *Java*.

PROPOSITION XXV.

[*To point out the Place of the third perpetual Current*].

BETWEEN *Madagascar* and the Cape of *Good-Hope*, and more especially between *Terra de Natal* and the Cape, there is a strong Current which sets from North-East to South-West (the same way as the Shore runs) and is carried with such a rapid and extraordinary Motion, that Ships, with a brisk Wind, can hardly weather it, or sail against it, to *Madagascar*; on the contrary, they that sail out of the Chanel, between *Madagascar* and *Africa*, towards the Cape of *Good-Hope*, are carried thither without the Help of the Winds, purely by the Force of the Current. I suppose this to be the Cause, that the *Indian* Ocean, being forced towards the *African* Shore, and thereby diverted from it's direct Course, naturally flows towards the Cape of *Good-Hope*; where it finds a Passage. For in the main Ocean, remote from the Shores, this Motion is not oblique but direct, from East to West.

PROPOSITION XXVI.

[*To point out the Place of the fourth perpetual Current*].

IN the *Pacific* Ocean, along the Shores of *Peru*, and the rest of *America*, the Sea flows from South to North; which, no doubt, is owing to the constant South Winds which blow upon these Coasts; for neither these Winds, nor the Currents are observed out at Sea.

PRO-

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PROPOSITION XXVII.

[*To observe the Place of the fifth perpetual Current*].

THIS is observed to flow from Cape *St Augustin*, in *Brasil*, along the Coast of *America*, among the *Antilles* in the Bay of *Mexico*, towards *Florida*, which is from South to North. For the Sea being driven by it's general Motion against the Shore of *Brasil*, is there repulsed, and carried northward, where the Chanel is broader and more open, which very likely causes this Current. The like Motion northwards is found at the Mouth of the Streights of *Manilha*, one of the *Philippines*. Likewise in *Japan* there is a very swift Current from the Port of *Xibuxia* towards *Arimia*.

PROPOSITION XXVIII.

[*To shew the Place of the sixth perpetual Current*].

THIS is in the Streights of *La Maire*, where the Sailors in the *Nassau* Ship observed the Current to set to the East; but this we cannot give so much Credit to, since *La Maire* himself writes to the contrary.

THERE are other Currents near the Shores of several Countries, but not yet accurately enough observed or described.

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PROPOSITION XXIX.

To these perpetual Currents may be referred such as are made by large Rivers, where they exonerate themselves into the Sea.

AT the Shore of *Loango*, ten or twelve *Dutch* Miles from *Congo* in *Africa*, there is a strong Current from the Land towards the West; because of the many vast Rivers, (of which the *Zaire* is the greatest) which fall headlong into the Sea, and repel the Water; being helped by the general Motion. Therefore it requires some Days before Ships can come up to these Shores, tho' but a *Dutch* Mile or two from them.

SO at the Island of *Lamton*, upon the Coast of *China*, the Sea moves from the Shore to the eastward, contrary to the general Motion, which is from the East to *China*. This Current is caused by the strong Efflux of the great River *Thoncoan* [or *Ta*] and is not observed out at Sea any further than the *Bashee* Islands.

THUS far concerning the constant Currents; we shall add somewhat about those that are stated or anniversary.

PROPOSITION XXX.

There is a great variety of shifting Currents which do not last, but return at certain Periods; and these do most of them depend upon, and follow, the anniversary Winds, or Monsoons, which by blowing in one Place may cause a Current in another.

AT *Java*, in the Streights of *Sunda*, when the Monsoons blow from the West, *viz.* in the Month

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of *May*, the Currents ſet to the eaſtward, contrary to the general Motion (*n*).

ALSO between the Iſland of *Celebes* and *Madura*, when the weſtern Monſoons ſet, *viz.* in *December*, *January*, and *February* (or when the Winds blow from the North-Weſt or between the North and Weſt), the Currents ſet to the South-Eaſt, or between the South and Eaſt.

AT *Ceylon* from the middle of *March* to *October* the Currents ſet to the ſouthward, and in the other Part of the Year to the northward; becauſe at this Time the ſouthern Monſoons ſet, and at the other the northern.

BETWEEN *Cochin-China* and *Malacca* when the weſtern Monſoons blow, *viz.* from *April* to *Auguſt*, the Currents ſet eaſtward, againſt the general Motion: but the reſt of the Year ſet weſtward; the Monſoon conſpiring with the general Motion. They run ſo ſtrongly in theſe Seas, that unexperienced Sailors here ſuppoſe the Waves to beat againſt ſome Rocks.

SO for ſome Months after the fifteenth of *February*, the Currents ſet from the *Maldivies* towards *India*, on the Eaſt, againſt the general Motion of the Sea.

ON the Shore of *China* and *Cambodia*, in the Months of *October*, *November*, and *December*, the Currents ſet to the North-Weſt, and from *January* to the South-Weſt, when they run with ſuch a ſwift Motion about the Shoals of *Parcel*, that it ſeems ſwifter than that of an Arrow.

(*n*) Theſe Currents conſtantly follow the Winds and ſet to the ſame point the *Monſoon* or Trade Wind does, out at Sea. See an accurate Hiſtory of theſe in Note (*a*) upon *Prop.* II. of *Chap.* xxi. below; from whence may be formed a better Judgment of the Time of the ſetting of theſe Currents than from what our Author delivers in this Propoſition.

AT *Pulo Condore* upon the Coast of [*Cambodia*] tho' the Monsoons are shifting, yet the Currents set strongly towards the East, even when they blow to a contrary Point.

ALONG the Coasts of the Bay of *Bengal*, as far as the Cape [*Romania*] at the extream Point of *Malacca*, the Current runs southward in *November* and *December*.

WHEN the Monsoons blow from *China* to *Malacca*, the Sea runs swiftly from *Pulo Cambi* to *Pulo Condore*, on the Coast of *Cambodia*.

THERE are several other Examples to be found in Sailors Journals; tho' less accurately given.

IN the Bay of *Sans Bras*, not far from the Cape of *Good-Hope*, there is a Current particularly remarkable, by which the Sea always runs from East to West to the Landward; and the more vehemently the more the Winds oppose it from the opposite Point. The Cause is no doubt owing to some adjacent Shore which is higher than this.

PROPOSITION XXXI.

The Gyrations of the Sea, which we call Vortexes, or Whirlpools, are of three Kinds.

SOME Whirlpools only turn the Water in a Round; others at Times absorb, and emit or vomit it up; and some again suck it in, but do not cast it out. And doubtless there is a fourth Kind somewhere in the Chanel of the Sea, which may throw out Water but takes none in. I do not remember any such to be recorded by Authors; only upon the dry Land there are several observed. The *Dutch* Mariners call these Whirlpools *Maelstroom*.

THERE

THERE are but very few of these, at least, that have been taken Notice of.

BETWEEN *Negropont* and *Greece* there is a famous Whirlpool; called the *Euripus*, much talked of because of the fabulous Story of *Aristotle*'s dying there (*o*). *Scaliger* endeavours to explain it thus. It is not much amiss (says he) to suppose the Water, received into the Caverns, in the Cliffs of the Rocks below, issueth from thence; for by the continual running in of the Water the little rocky Bays are filled, and being full, they emit what they received, thro' winding and subterraneous Passages; whose Capacity is such, that they pour out the Water for so many Hours, whereby the Tides are now obstructed or repelled, and a little after forwarded or helped. But any one may perceive the insufficiency of this Cause.

THE *Maelstroom* on the Coast of *Norway*, is the swiftest and largest known Vortex; for it is said to be thirteen *Dutch* Miles in Circuit; in the middle of which there is a Rock, which the People thereabouts call the *Mouske*. This Whirlpool, for six Hours, sucks in whatever approaches it, or comes nigh it; not only Water, but Whales, loaded Ships, and other Things; and in as many Hours disgorges them all again, with a hideous Noise,

(*o*) There are on each side the *Euripus* six or seven Gulphs, wherein the Water shuts it self up to issue from thence as often as it enters there; and the Situation of these Gulphs perhaps contributes to this sudden Flux and Reflux, of which the Moon seems to be the principal Cause.

There are twenty Days of each Moon in which the Course of the *Euripus* is regular, and ten in which it is irregular, *viz.* five Days before and after the New and Full Moon, in which there are nine or ten Changes of the Course of the Water every Day: and in each of these Changes the Water flows about a Foot, and ebbs back again. The Phænomenon is very wonderful, and it's Cause dubious. See *Philos. Trans.* N° 71. *Pag.* 215.

Violence, and whirling round of the Water. The Cause is latent.

BETWEEN *Normandy* in *France*, and *England*, there is a Whirlpit, towards which Ships are drawn with an incredible Celerity; but when they come near the middle of the Swallow, they are, with the same Force, thrown out again.

PROPOSITION XXXII.

The concussion or trembling of the Sea proceeds from a certain Spirit, which agitates not only the Earth, but also the very Water, and causes it to bubble.

IN the Bay of *Biscay*, not far from *Bayonne*, there is a Place, called by the Inhabitants *Cap-Breton*, where the Sea sometimes grows so turgid, without the least Wind, that the adjoining Shore seems to be in danger of being overflowed; and on a sudden grows calm again. There is the like raging in a Lake in *Scotland*, called *Loch Loumond*, which is also caused by a subterraneous Spirit.

THE *Portuguese*, about the Year 1523, observed a Percussion of the Water in the Sea of *Cambaya*. In the greatest Calm, when there was not the least Breath of Wind (as *Maffeus* relates) the Waves on a sudden began to swell up from the Bottom; and immediately the Ships seemed to nod as it were to one another; then their Joints cracked, and their Sides and Bottoms gave way. The Sailors, being struck with a sudden Fear, and thinking the Fleet had run upon Quicksands, were in the greatest Confusion: Some began to sound with the Lead, others to pump, but they that were more wary bethought themselves of escaping, and laid hold of Barrels to swim upon: but it was afterwards found to be an Earthquake, which had put them into that Consternation at Sea.

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PROPOSITION XXXIII.

Why the Pacific *Sea is more still and calm, and without high Waves; and why it is easily agitated by the Winds.*

THE Cause, no doubt, is, that it's Motion to the West, is not obstructed by the Lee-Shores; as it is in the *Atlantic.*

CHAP. XV.

Of Lakes, Ponds, and Moraſſes or Bogs.

PROPOSITION I.

Definition.

A LAKE is a Collection of Waters contained in ſome Cavity in an inland Place, of a large Extent, and every where ſurrounded with Land, having no Communication with the Ocean.

PONDS are little Lakes, which neither receive nor emit Rivers. Some Geographers, or learned Men, may perhaps define them otherwiſe, but it is no great Matter; we ſhall not ſtand to argue about Words: what we have done is to the beſt of our Judgment.

A Moraſs, or Bog, is an inland ſtanding Water, having Earth raiſed and appearing above it here and there, or even Earth, or Mud, mixed with it.

PROPOSITION II.

Lakes are of four Kinds.

1. SOME neither receive nor ſend forth Rivers; and if ſuch are ſmall, we call them Ponds; but if large, and of a vaſt Extent, they acquire the

the Name of Lakes. 2. Some again emit Rivers, but receive none. 3. Others receive Rivers, but have no Evacuation. 4. Others again, both receive and emit Rivers: of these some emit more Water than they receive, some less, and others an Equality. Again some send out their Rivers almost in a streight Line with those they receive, others discharge them other Ways, or towards other Points. Likewise some receive more Rivers than they send out, others not so many, and some an equal Number.

PROPOSITION III.

To explain the Origin, and Continuance, of those Lakes that neither receive nor emit Rivers.

SOME of these are large, others of a moderate bigness, and some but small. Of the two last some are always full of Water; others are dried up in Summer, and when it is constantly fair Weather; both these Sorts are called Ponds. As to those that are dried up, it is easy to shew their Origin, *viz.* abundance of Rain, which gathers and stagnates in some Cavity, or depressed Place. For if any Pit be situated in the middle of a descending Ground, the Rain-Water every way drains thither, and makes a Pond.

THERE are several such Ponds as these in *India*, made by the Industry of the Natives, of which some are a Mile, and some two in Circuit; they are surrounded with a stone-Wall, and are filled in the rainy Months, to supply the Inhabitants, in the dry Seasons, who live a great Way from Springs or Rivers.

IN like manner Pools or Ponds are made by the Inundation of the Sea, or the Overflowing of the Rivers.

THUS

THUS the *Nile* and the *Niger*, the one watering *Negroland*, the other *Egypt*, when they overflow their Banks and are decreased, they leave their Water in several Ponds; which the Inhabitants fence and fortify to preserve the Water 'till such times as they have occasion for it. By this means in *Muscovy*, *Finland*, and *Lapland*, in the Spring, Summer, and Autumn, they have many little Lakes, which are generated partly by the Rains, and partly by the melting of the Ice and Snow.

BUT tho' some of these Ponds may happen to be dried up in Summer, or when it hath not rained for a long Time; yet we are not thence to conclude, that they are wholly supplied with Rain-Water; for they may be dried up, tho' there are Sources, or Springs, in the Bottom, which perhaps, are so little that the Heat of the Sun, in Summer, dissipates the Water, and turns it into Vapour.

AS to those that admit no Rivers, and yet are not dried up, they may wholly proceed from Rain if their Chanels are deep and capacious, and in which so much Rain-Water may be contained, that the Heat of the Sun cannot consume the whole before more Rain fall to replenish them; tho' it is very likely, that many of these are supplied by Sources under Ground, which continually emit as much Water as is exhaled; especially those Lakes that are found upon the Summits of Mountains, as upon *Bructerus*, *Cenis*, &c. Some of them have perhaps been left, at first, by an Inundation, and are continually supplied and kept up by Rain-Water: And we need not doubt but that those Salt-Water Lakes, or Ponds, that are found near the Sea, were made at first by the Inundation, or Immission, of the Sea-Water, some way or other; as the Lake of *Harlem*, and others in *Holland*. There are also several salt Lakes in *Peru*.

THERE

THERE is but a small number of these Lakes to be found. Some little ones are observed in *Muscovy* and *Finland*, the Lake *Locasda* in [*Epirus*,] the Lake *Busaranda*, in *Amasia*; one in *Carniola*, called the *Zirchnitzer* Sea; a round one in *China*; another called *Hila* in *Cochin-China*; one in *Zanhaga* in *Africa*; two in *Mexico*, in *America*, the one of them seven Leagues long, and the other near as big. All these are but small ones, except that in *China*, which is of a moderate Bigness.

BUT the only one great Lake in the whole Earth of this sort is the Lake *Parime* in *America*, lying directly under the Equator. It is in length from East to West, about three hundred and five *German* Miles, and, in the broadest Place, one hundred Miles over, or thereabouts; so that it may be compared with, if it do not exceed, any Lake in the World for magnitude; yet it neither receives, nor emits any Rivers. It may reasonably be doubted how this Lake was produced, whether by some former Inundation of the Ocean, or by subterraneous Springs and Sources? And whether it is fed and kept up by Rain-Water, or the like? It seems probable that there are Springs in the Bottom which supply it with as much Water as is daily evaporated by the Heat of the Sun. For Lakes seem to have the same Origin as Rivers, only they differ in the Situation of their Springs, and the quantity of their springing Water. For if a Spring be surrounded with rising Ground, and run into a deep and broad Chanel, and also send forth but a small quantity of Water, it doth not run, but is evaporated as fast as it springs. There is no Difference therefore, in the main, between Springs, Lakes, and Rivers, only in some Circumstances; and there are found several Springs which do not emit Water; but such are more properly called Wells.

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PROPOSITION IV.

To explain the Origin and Supply of ſuch Lakes as emit Rivers but receive none.

THERE is an infinite Number of theſe Lakes, and very many Rivers flow from ſuch, as out of Ciſterns; eſpecially thoſe that have their Riſe in *Muſcovy*, *Finland*, *Lapland*, &c. where their Springs being ſituated low in the middle of a hollow Place, firſt fill the Cavity and make it a Lake, which being not capacious enough to hold all the Water, it overflows the adjacent Places and forms a River. And we need not doubt but ſuch Lakes have their Riſe and Maintenance from Springs at the Bottom, whether they be real Fountains, or apparent ones, *viz.* Water brought thither by ſubterraneous Paſſages from ſome other Places; which laſt is more likely in ſome Lakes that immediately produce vaſt Rivers.

OF ſuch ſmall Lakes as theſe there are, as I ſaid before, a great Number; as the *Wolga* at the Head of the River *Wolga*; the Lake *Odium*, at the Head of the *Tanais*; the *Adac*, from whence one of the Branches of the River *Tigris* flows; the *Ozero* [or *White* Lake] in *Muſcovy*, that gives Source to the River *Shackſna*, which is poured into the *Wolga*, and many more little ones; we ſhall here only reckon ſome of the larger ſort that are more remarkable.

1. THE great Lake *Chaamay* in the Latitude of thirty one Degrees North, not far from *India*, to the eaſtward of the River *Ganges*. Out of this Lake flow four very large Rivers, which water and fertilize the Countries of *Siam*, *Pegu*, &c. *viz.* the *Menan*, the *Aſa*, the *Caipoumo*, and the *Laquia*. Some

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Some Maps exhibit a small River that runs into this Lake.

2. THE Lake [*Singhay*] upon the East Border of *China*, sends out a great River [southward,] which being joined to another enters *China.*

3. THE Lake *Titicaca*, in [*Los Charcas*] a Province in South *America*, is eighty Leagues in Circuit, and emits a large River, which is terminated in another small Lake, and is no more seen. There are several Towns and Villages discovered about this Lake.

4. THE Lake *Nicaragua*, in a Province of the same Name, in *America*, is only four *German* Miles from the *Pacific*, or South Sea, and above one hundred from the *Atlantic*, into which it is discharged at broad Flood-Gates.

5. THE Lake *Frontena*, in *Canada*, out of which issues the River of *St Lawrence.*

6. THE Lake *Annibi*, in *Asia*, in the Latitude of Sixty one Degrees.

PROPOSITION V.

To explain the Rise and Maintenance of those Lakes which receive Rivers, but emit none.

IT is manifest that these Lakes were at first formed, and are still supplied and fed by the Rivers which they receive, or which disburden themselves into them. For when Rivers in their Course meet with a broad Plat of low Ground, they are there collected, and form a Lake; which (if the Soil be light, and porous to transmit the Water to the adjacent Fields, or if there be a subterraneous Receptacle, or, which is most likely, if the Water work it's way under Ground) never overflows but loses, insensibly, one way or another, as much Water as it receives.

THERE

THERE are not many of these Lakes taken Notice of.

1. IN the foregoing Proposition we observed that the Lake [*Titicaca*] discharges a River into a smaller called *Paria*, which therefore may be referred to this Class, *viz.* to such as receive Rivers but emit none.

2. THE Lake *Asphaltites*, which is also called the *Dead* Sea, receives the River *Jordan*, but emits none. It's length, from North to South, is seventy *German* Miles, and it's breadth five, as some make it.

3. THERE is one in the lesser *Asia.*

4. THERE is a small one in *Macedonia*, called *Janna*, which receives two little Rivers.

5. THE Lake of *Geneva.*

6. ONE in *Persia* near *Calgistan.*

7. THE Lake *Soran*, in *Muscovy*, receives two small Rivers.

8. THE River *Ghir*, in *Africa*, is reported, by *Leo Africanus*, to lose itself in a Lake, and some Maps so represent it; but others join it to *Nubia.*

PROPOSITION VI.

To explain the Origin of those Lakes that both receive and emit Rivers.

THEY are of three kinds, as was said before in Proposition 2. and either emit more Water than they receive, or an equal quantity, or less. If they emit more, it is evident they have some hidden Springs in the Bottom: If less, the Earth is either spongy, or there are subterraneous Aqueducts, whereby the Water is conveyed under Ground: If an equal quantity, it is a Sign that there are neither Springs nor Swallows at the Bottom.

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tom. Their Origins therefore are partly explained in Propoſition 4, that is, are owing to a low Ground where there happens to be Springs, and into which Plenty of Rain-Water is drained.

SUCH as are generated by the Influx of one River, and afford a Paſſage for it in at one Side, and out at another, are found in many Places. Thus the *Niger* makes three Lakes in it's Courſe, and runs upon the Side of another. The *Nile* makes ſeveral more Lakes than are ſhewed in our common Maps. The River *Duina* at leaſt runs thro' ſix, or ſeven, Lakes. And there are ſome Rivers in *Muſcovy* and *Finland*, that make, as may be ſeen in our large Maps, at leaſt ſixteen Lakes before they exonerate themſelves into the Sea. We ſhall only here enumerate ſuch as produce other Rivers than thoſe they receive.

1. THE *Zaire*, a Lake, or Moraſs, in the Foreland of *Africa*, lies between the ſecond and ninth Degree of South Latitude, and therefore is about one hundred and five *German* Miles long. In the middle of it there is an Iſland (beſides ſeveral ſmall ones) ſo large and populous, that the Inhabitants can raiſe an Army of Thirty thouſand Men. This Iſland almoſt divides the Lake into two Parts, which have each a peculiar Name; that to the ſouthward is called *Zambre*. Out of this Lake flow three large Rivers, the *Nile*, [or rather the *Zeebe*] the *Coanza*, and the *Zaire* (*a*). There are ſome ſmall Rivers that run into it;

(*a*) 'Our Author, according 'to the Opinion of the Geographers of his Time, maketh the '*Nile* to flow out of this Lake; 'but here (*and in other Places*) 'we have taken the Liberty to 'alter the Text (tho' as little as 'poſſible) that the Deſcription 'may be more agreeable to the 'modern Diſcoveries of the *Portugueſe Jeſuits*. A more juſt 'and modern account of the 'Riſe and Courſe of the *Nile* is 'given in the *Note* (*g*) upon '*Prop.* 20. *Chap.* xvi.

but

but these do not seem able to supply even the Lake itself with Water, and therefore doubtless there are Springs at the Bottom; tho' the Inundation of the Rivers is owing to the great quantities of Rain that fall in the wet Seasons.

2. THE Lake *Zaflan*, not far from *Zaire*, lies between the third and ninth Degree of South Latitude; and therefore is about ninety *German* Miles in length. It receives and emits some small Rivers.

3. THE Lake *Zachaf*, not far from *Zaire*, towards the Cape of *Good-Hope*, emits a River, which being joined to others, is called *St Esprit*, or *Delagoa*.

4. THE Lake *Aquilunda* receives a Branch of the *Zaire*, and pours many Rivers into the Kingdom of *Congo*.

5. THE Lake *Onega*, in *Finland*, lies between sixty two and sixty four Degrees of Latitude, and is about twenty five *German* Miles long, but scarce half so broad. It receives several considerable Rivers from other small Lakes, and discharges one, called the *Sueri*, into the Lake *Ladoga*.

6. THE Lake *Ladoga* is about thirty *German* Miles long, and fifteen broad; it receives the River *Sueri*, out of the Lake *Onega*, and other lesser ones from other Places; also a considerable one from the famous Lake *Ilmen* in *Muscovy*. It discharges one River into the Gulph of *Finland*.

7. [THE White Lake] or *Ozero*, receives some small Rivers, and discharges the River *Shacksna* which falls into the *Wolga*.

8. THE Lake or Morass called [*Enare Tresk*] in *Lapland*, is about forty *German* Miles long, and fifteen broad. It receives the River *Avila*, and sends one called [*Paesreka*] into the Sea of *Lapland*.

9. THE Lake *Ula* in [*Finland*] is thirty *German* Miles long, and half as broad. It hath an Island

Island in the middle like the *Zaire*, and receives a River which passeth thro' several Lakes, and discharges a large one into the *Bothnic* Bay. There are several other Lakes in *Muscovy*, *Finland*, and *Norway*.

10. IN *China* there are four remarkable Lakes that receive Rivers, and discharge others, various Ways.

11. IN *Brasil* there is a great Lake, with many Islands in it, called *Xarryes*, which discharges the *Rio de la Plata*, and the River *Miary*.

PROPOSITION VII.

Most Lakes are filled with fresh Water, only a few have salt or Sea-Water in them.

THOSE that are produced by Rain or Rivers, or such as are remote from the Sea, and are fed by their own proper Springs, for the most part contain sweet Water: but such as were formed by the Inundation of the Sea, or are supplied with Sea-Water, by some subterraneous Meatus, or have salt Springs at the Bottom, produce salt Water. Thus the Lake of *Harlem*, and others in *Holland*, are salt; and taste like Sea-Water. There is a salt Lake also in *Madagascar*, and another in *Peru*; there is one in *Cuba*, about two Leagues in Circuit, situated not far from the Sea, which tho' it receives some fresh Water Rivers, and breeds Fish and Tortoises, yet is salt. The Lake *Asphaltites*, tho' it swallows the sweet Water of the River *Jordan*, yet is not sweet itself, but exhales such a poisonous and stinking Vapour that the Fields thereabouts, for half a Mile round, are rendered barren.

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PROPOSITION VIII.

To determine whether the Caspian *Sea be a Lake or a Bay of the Ocean.*

SOME will have it to be properly called a Sea; as a Sea, properly speaking, is an extended Part of the Ocean, or is joined to it by a continued Tract of Waters. But they will have it to be joined to the Ocean by some subterraneous Intercourse. Some indeed of the Antients wrote, that it was joined by an open Streight, to the *Indian* Ocean; others, to the northern Ocean; but both were deceived, as we are well assured by Experience. Whether there be subterraneous Intercourses we do not know; only there seem to be such, because so many and so large Rivers exonerate themselves into it, and are constantly pouring in their Waters, whereby, in process of Time, the Chanel would be filled and run over, unless there were subterraneous Fissures and Meatus's, thro' which it might evacuate it's superfluous Waters into the Ocean *(b)*. But others think these Waters are distributed among the adjacent Mountains, and supply them with that vast number of Springs which is observed hereabouts. *Scaliger* and others were of Opinion, that this *Caspian* Sea runs under Ground into the *Euxine* Sea, but he gives no Reason for it; this may be said, that the *Euxine* Sea is continually disgorging a large quantity of Water thro' the *Bosphorus*, and some think this is more Water than the Rivers pour into it; therefore it may perhaps receive it

(*b*) By what means the *Caspian Sea* (and all others) lose as much Water daily, as they receive from the many Rivers flowing into it; is discussed in the *Note* (*k*) upon *Prop.* xiv. *Chap.* xiii. *which see.*

from

from the *Caspian* Sea. It seems to me to have no Communication any way with the Ocean, and therefore ought rather to be called a Lake, than a Sea. How it came at first is another Question. Some avouch that there are found several Mountains of Salt in the Bottom, whereby it hath acquired such a Degree of Saltness; and that it is replenished by the many Rivers that exonerate themselves into it. But it seems more feasible, (tho' these Rivers may contribute to it's Repletion) that this Sea hath, a great many Ages ago, been joined to the Ocean, and that it's Streights, by some means or other, were filled up and stopped, perhaps by interjacent Islands which gained upon the Shores, in a manner which we shall explain hereafter. And very likely, by the same Cause, the *Euxine* Sea may, some time or other, become a Lake; the *Bosphorus* being filled up or obstructed.

PROPOSITION IX.

To make a Lake in any Place, if it be possible.

THIS may be done if there be a River near, or a Spring upon the Place, and if the Place itself be depressed; tho' small Lakes may be made upon the very tops of the Mountains. First the Place is to be hallowed, and dug to such a Depth and Extent as we desire, and the Sides are to be fortify'd with Wood-Work, if we see occasion. Then a Chanel is to be made, by which the River is to be let in; but if there be a Spring upon the spot, there is no occasion for such a Chanel.

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PROPOSITION X.

To drain a Lake.

THIS may be done two Ways; 1. If the bottom of the Lake be a little higher, or almost of the same Altitude with the adjacent Places, dig a Chanel, and let out the Water; and by throwing in Heaps of Earth, together with the Heat of the Sun, it will in a short time be left dry.

2. IF the bottom of the Lake be lower than the adjacent Ground, it is to be first surrounded with a Ditch, leaving here and there some Canals, or Apertures, in it; to these apply Water-Engines and work out the Water; then cover the Ground with Dung, and sow in it such Seeds as are of a quick Growth, *viz.* Mustard-seed, Coleworts, and the like. The *Dutch* are very expert at draining Lakes by this Method; and often convert them into fruitful Meadow-Ground. At this time they are consulting how to drain the Lake of *Harlem*, and I do not doubt but it will be, some time or other, attempted; because this Lake covers much Ground which by draining would be of great Use to the Inhabitants.

PROPOSITION XI.

Morasses, or Leaches, are of two sorts; some are oozy and consist of Earth and Water mixed together, so as not to bear the Footsteps of Men: others are Ponds, or scanty Collections of Water, interspers'd here and there with small Spots of Land.

THOSE of the former kind neither receive nor emit Rivers, we call them *Sloughs* or *Bogs*; there are many in *Holland*. In *Brabant* there is a large

large one called *Peel-marsh.* There are also several in *Westphalia* of both Sorts. Those of the later kind are chiefly found at the Heads of Rivers, whence some call these Heads *Morasses*; as the Morasses of *Tanais* in *Muscovy*, and of the *Nile*. There are several of these in the Province of *Savolax* in *Finland*, which cover vast Tracts of Ground; also those [called *Enare-Tresk*] in *Lapland*; the Marshes of *Chelours* in *Africa*, the Morasses thro' which the *Euphrates* runs in *Chaldæa*, &c. such as these are also found in Woods and heathy Desarts, and are made by the Rain-water gathered into hollow Places, whereby the Earth is soaked and moistened, and the Rays of the Sun are hindered from drying it up, by the Leaves of the Trees and the Heath. These are found chiefly in *Germany* and *Muscovy*.

THE narrower small Lakes, like the larger Sort, do some of them both receive and emit Rivers; some only receive, others only emit, and the rest neither receive nor emit any.

THE first sort are formed and fed, partly by Springs under Ground, and partly by Rain-water which stagnates for want of a Chanel to carry it off. Of this sort there are many in *Muscovy* and *Finland*. The second sort are generated from small Springs, and are fed by them and Rain-water.

ARISTOTLE calls the Sea of *Mæotis* a Lake, which is truly so.

PROPOSITION XII.

Bogs contain a sulphureous, bituminous, and fat, Earth.

THIS is apparent from the black Colour of the Turf that is got out of them, which easily takes fire, (as in *Holland* and other Places) by reason this sort of Matter is contained both in the Rain

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and in the Ground, where theſe Lakes are ſituated. But all Bogs have not that ſort of Earth: and where the Ground is hard and rocky we ſeldom find any Lakes; and therefore moſt part of them contain a ſoft ſpongy and ſulphureous ſort of Earth.

PROPOSITION XIII.

To drain, or dry up, a Bog.

THO' ſome Bogs are of a great Depth, yet no more is required than to drain them to a certain level, which may be done ſeveral ways; 1. By making a Chanel to carry off the Water. 2. By throwing in plenty of dry Earth, when they are almoſt dried up by the Heat of the Sun. 3. By ſetting their Surfaces on Fire. 4. By turning the Water that feeds them, another way.

CHAP.

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CHAP. XVI.

Of RIVERS in general.

PROPOSITION I.

This Proposition contains some necessary Definitions.

1. A *RIVER* is a Flux of Water continued thro' a long narrow Chanel, from one part of the Earth to another. The *Chanel* is a Cavity, or hollow Place, made lower than the Banks, for the Water to run in.

2. A *Brook* is a little River, which is neither broad nor deep enough to carry a small Ship of Burden. A *Navigable River* is capable of carrying all sorts of Ships, great and small; but these and the other sort are generally called *great* and *small Rivers*, according as they are in bigness. A *Torrent* is a violent Flux of Water from the top of a Mountain.

3. A *Confluence*, *Concurrence*, or *Conflux*, is a Place where two Rivers meet.

4. *BRANCHES* of Rivers are the Brooks that run into them, and mix with them; or when a River is divided and runs in two Chanels, they are called it's *Arms* or Branches. Where the River is thus divided, it is called the Place of *Parting* or *Divarication*.

5. A *Spring* is the Place where running Water ſprings out of the Ground. A *Well* is where the Water riſes and runs not forward, but is kept upon the ſpot.

PROPOSITION II.

Torrents and Brooks are ſometimes generated from Plenty of Rain and melted Snow.

IN the elevated or mountainous Parts of the Earth, there are found many Receptacles, ſmall Lakes, and Ponds. And when the Rain is poured into theſe, or the melted Snow, in ſuch Quantity, that they are not large enough to contain it, they overflow and diſcharge the ſuperfluous Water into the under-land Places. This being done every Year, the Water in time makes itſelf a Chanel (tho' it ſometimes flows without any certain Chanel). Thus a great many Torrents and Brooks, being fed only by Rain, or Snow melted from off the Mountains, before they have run their Courſe, become moderate Rivers; eſpecially if they proceed from a long Range of Mountains; as thoſe in the Foreland of *Africa*, *India*, *Peru*, *Sumatra*, &c. And what is remarkable, ſuch Torrents flow in the Day-time only.

PROPOSITION III.

Moſt Rivers have their Riſe from Springs.

THE great as well as the middle ſized Rivers, proceed either from a Confluence or Collection of Brooks and Rivulets, or flow from Lakes and Moraſſes. But no River of conſiderable Magnitude (ſuch as the *Elbe*, the *Rhine*, &c.) flows from one Spring or one Lake, but is augmented by the accession of others, flowing from other Fountains and Lakes. The *Wolga* or *Rha* receives above two hundred Rivers and Brooks, before it exonerates itself into the *Caspian* Sea; and the *Danube* receives no less, before it enters the *Euxine* Sea.

AND tho' *Pliny* and *Cardan* tell us, that no Rivers flow into the *Nile*, yet Experience shews the contrary; as they that have travelled into *Abyssinia* assure us.

THIS Proposition may be proved by innumerable Examples.

THE Springs of Rivers are some of them found on the tops of Mountains, and some on the Planes; and those Rivers that proceed from Lakes, have their Fountains (as was said in the last Chapter) at the bottom, or in the Chanel, of those Lakes that produce them, which like Cisterns contain the effusion of Water, 'till in a greater Quantity it be poured into it's proper Chanel. Hence some Fountains are covered with Earth or Water, and others are open.

THE Springs of the Rivulets which begin the *Tanais* and the *Elbe*, are on Planes, to which others are afterwards joined. We might here add several Examples, but these are sufficient.

CARDAN is of Opinion, that these Fountains do not flow immediately from the Plane itself, but are conveyed by subterraneous Aqueducts from the adjacent Mountains; however, I believe they first make a Lake or a Morass; for the *Tanais* does not seem to flow immediately from a Spring, but from a Morass or shallow Lake.

THE Springs of most Rivers are upon Mountains, as those of the *Rhine*, the *Po*, the *Danube*, the *Niger*, &c.

SEVERAL flow from Lakes, as the *Nile*, the *Wolga*, and the great River of *St Lawrence* in *Canada*.

A great

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A great River may happen to flow from one Spring, if the Spring itself be situated high (as most are) and a great part of the Chanel low, or but a little higher than it's mouth; so that the Water flowing with a swift Course at first, and by degrees slower, is increased in the Chanel and becomes a large River, because it discharges not so much Water at it's mouth, as it received from it's Spring when it first began to flow.

PROPOSITION IV.

Rivers are much augmented by frequent Rains or melted Snow, and at particular Times of the Year.

IN the Country of *Peru* and *Chili* there are some Rivers so small, that they do not flow in the Night-time, but only in the Day; because they are fed by the Snow upon the Mountains of the *Andes*, which is then melted by the Heat of the Sun. There are also several Rivers upon both sides of the extream Parts of *Africa*, as in *Congo*, *Angola*, *&c.* which are greater by Day than by Night. The like are found both in *Malabar* and *Cormandel* in *India*. The Rivers also in these Places are almost dried up in Summer, but swell and overflow their Banks in Winter, or the wet Seasons. Thus the *Wolga* in *May* and *June* is filled with Water, and overflows it's Shelves and Islands; which at any other time of the Year is so shallow, that it scarcely affords a Passage for loaded Ships. For the Snows being melted at this time of the Year, on the Mountains, from whence the Rivulets (being more than an hundred) flow into the *Wolga*, cause this Inundation. The *Nile*, the *Ganges*, the *Indus*, &c. are so much swelled with Rain, or melted Snow, that, in like manner, they overflow their Banks. But these Deluges happen at divers times of the Year,

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Year, because they proceed from various Causes and different Places. Those that are swelled with Rains, are highest in Winter; because these are then more frequent than at other times of the Year; but if they proceed from Snow, which in some Places is melted in the Spring, in others in Summer, or between both; the Deluges of the Rivers happen accordingly, *viz.* in the Spring, Summer, *&c.* or at the time when the Snow is melted upon the Banks of the Rivulets that form these Rivers. Moreover some Rivers, especially the large ones, flow from Places at a great Distance, where it is Summer at the same time it is Winter in the Places where they pass through; and for this Cause they overflow their Banks at different times of the Year. But most of them cause an Inundation in the Spring, because the Snow is then melted in most Places. We shall explain the Cause of their different Properties in the particular Description of each River.

WE shall also in the next Chapter treat of that remarkable Spring in *Japan*, which only flows for two Hours every Day.

PROPOSITION V.

To explain the Origin of Springs (*a*).

THIS is easier to conceive than when it is proposed thus; *From whence are Rivers generated?* For

(*a*) Since by Dr *Halley*'s Calculation it appears, that the Vapours which are drawn up from the Sea exceed almost three times the Quantity of Water discharged into it by Rivers, [*as was shewn in the Note (k) upon Prop.* xiv. *Chap.* xiii.] it will be no hard matter, seeing there is such an overplus of Water, to find enough from thence to supply Fountains, according to the Opinion of the same learned Gentleman.

For these Vapours being carried every way by the Wind, necessarily

For when we see such great Rivers as the *Rhine*, the *Elbe*, &c. we more admire whence they proceed because

cessarily meet with the high Ridges of Mountains that are dispersed over various Tracts of the Earth: each of which far surpasses the usual Height to which the Aqueous Vapours of themselves ascend, and on the Tops of which the Air is so cold, and rarified, as to retain but a small part of those Vapours that shall be brought thither by the Winds. The Vapours meeting with these Ridges of Mountains are there compelled by the Stream of the Air to mount up with it to their Tops, where meeting with more rarified Air, they naturally fall down in Drops, pervading the Crannies and Fissures of the Earth, and gleeting into the Caverns of the Hills, the Water thereof gathers into the Basons of Stone, or Clay, it finds, which being once filled, all the overplus of Water runs over, and, where it can find a Passage, breaks out at the Sides of the Hills, and forms Fountains; many of these, running down the Vallies, or Guts, between the Ridges of the Hills, and coming to unite, from Rivulets or Brooks; many of these again being united into one common Chanel, form vast large Rivers, as the *Rhine*, or the *Danube*.

This Theory of the Cause of Springs the same excellent Person proves by Experience. For he says, that when he was in the Island of *St Helena*, taking Astronomical Observations in the Night-Time, on the Top of the Hills about 800 Yards above the Sea, he found such a Condensation of the Vapours, that in 7 or 8 Min. Time, tho' there was a clear Sky, the Glasses of the Telescopes he used were covered with little Drops, and the Paper on which he wrote his Observations would immediately be so wet with the Dew that it would not bear Ink.

This Hypothesis he thinks more reasonable than that of those who derive all Springs from the Rain-Waters, which yet are perpetual and without Diminution, even when no Rain falls for a long Space of Time: Or than that which derives them from a Filtration or Percolation of the Sea Waters, thro' certain imaginary Tubes or Passages within the Earth, wherein they lose their Saltness. This Opinion labours under this principal Absurdity, that the greatest Rivers have their most copious Fountains farthest from the Sea, and where so great quantities of fresh Water cannot reasonably be derived any other way than in Vapour. *See Philos. Trans.* No. 192. *Pag.* 468.

Notwithstanding it is very probable that all Fountains have not the same Origin; but that some proceed from Rain penetrating the Fissures of the Earth, and slowly gleeting thro' the Interstices to the Orifices of Springs; and others, especially those that are salt, and placed near the Sea Shore, take their Rise from the

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because of the Quantity of their Water, than when we look upon small Brooks. But we have shewed in the two last Propositions, that Rivers proceed partly from Rain and melted Snow, and partly from Lakes and Concurrences of Brooks and Rivulets; and therefore we do not enquire so much here about the Sources of Rivers, as about the Origin and Permanency of Springs.

THE Opinions of Naturalists and Geographers are various about this Matter.

1. SOME think that all Rivers and Springs receive their Water from Rain, or melted Snow; and this they bring for a Reason, that Rain and melted Snow sometimes augment Rivers to such a degree, that they overflow their Banks, and lay whole Countries under Water: But in the Summer Season, when no Rain has fallen for a long Time,

Sea Water percolating thro' the Sands; but the greatest part of Fountains, especially such as break from the sides of high Hills, derive their Waters from Vapours, as was said above.

The learned Dr *Woodward*, in his *Natural History of the Earth*, explains the Origin of Fountains otherwise. He imagines, that there is a great Abyss, or Promptuary, of Waters, inclosed in the Bowels of the Earth, which, communicating with that of the Ocean, is continually exhaled into Vapours, by the Force of a subterraneous Heat which he proves by many Arguments to be in the interior Parts of the Earth; and that as these make their way upwards, they pervade the Fissures, and Intervals of the *Strata* of the Earth, permeating also the very Interstices of the Particles of Sand, Earth and Stone, 'till they come near the Superficies of the Earth, where they are condensed with cold, and come together by Drops, which, being collected, break out at some Aperture or other, and form Fountains. But when the Heat above the Superficies of the Earth, is as intense as that in the interior Parts thereof, it takes the rising Vapour, where it penetrates the Superficies of the Earth, and bears it up into the Air, or at least diminishes greatly.

They who would see this Hypothesis more accurately explained, let them consult the learned Author in his Book: It is enough for us only to mention it, accounting Dr *Halley*'s Theory much more clear, and built upon a better Foundation.

Jurin's Appendix.

the

the great Rivers grow leſs, and the ſmall ones are moſtly dried up, becauſe the Chanels of the later are too ſhallow to contain any large quantity of Water; but the former, whoſe Chanels are deep, do not ceaſe running, nor are dried up, becauſe they have collected ſo much Water from the former Rain and melted Snow, that it cannot all be exhaled into Vapours, except it be by a laſting and conſtant Heat. 2. Becauſe there are the feweſt Rivers where it ſeldom raineth, as in the inland Parts of *Africa* there are but few Springs.

BUT theſe Allegations do not ſolve the Propoſition, which doth not enquire about the Origin of Rivers, but from whence the Water of Springs proceeds; therefore they that take this to be a Solution do not underſtand the Senſe of the Propoſition, as we obſerved before. And even the Property they propoſe to prove it by is not univerſal; for there are Rivers found in Places where they have ſeldom any Rain and no Snow, tho' what they ſay is true concerning the Rivers in *Egypt* and *Peru*. Beſide, Rain-Water doth not penetrate into the Ground beyond the depth of ten Foot; whereas ſeveral Fountains ſpring from a greater Depth.

2. OTHERS think, that we are not to enquire about the Origin of the Water of Springs, ſince it is an Element as well as the Earth, Air, and Fire, whoſe Origins are not enquired into. This is *Seneca*'s way of arguing. But theſe Authors cut the *Gordian-knot* when they cannot untie it; for we do not diſpute about the Principles of Water, but enquire how it flows to the Heads of Rivers, rather than to any other Place. Moreover, the Earth is not a Fluid as Water is; and to ſay, that the Air and Fire are not enquired into, is falſe.

3. THE Peripatetics follow the Opinion of their Maſter *Ariſtotle*, delivered in Chapter xi.

Book i. *de Meteor.* where he endeavours to prove, that the Water of Springs is generated from Air contained in the Bowels of the Earth. These are his Reasons; 1. The Air, surrounding the Earth, is turned into Water, *viz.* into Rain; and therefore since there is also Air in the Bowels of the Earth, and the same Cause to condense it, *viz.* Cold, it is contrary to Reason to think that Water is not produced from Air there. 2. Experience teaches us, that great Drops gather from small ones under Ground, and therefore the Heads of Rivers are only a great many Springs gathered into one Place. For this Reason, they that make Aqueducts, use to draw the Water thro' narrow Trenches and Pipes, which distils, as it were, from the moist Earth, Drop by Drop. 3. Because most Fountains, especially of great Rivers, are found on mountainous Places, and but few upon Planes, it is a Sign that their Water proceeds from condensed Air or Vapours, which naturally tend towards high Places; and Mountains are Sponges, as it were, lying upon the Planes. These are *Aristotle's* Reasons, to which this following may be added of no less Force than the rest, *viz.* that when the Air is clouded and filled with Vapours, acid Fountains taste sweeter, which is a Sign they are augmented by the Air.

4. *CARDAN* and others are of Opinion, that the Water of Fountains proceeds from little Drains or Guts collecting the condensed watery Vapours both above and under Ground; but these seldom become Rivers, without being increased with Rain and melted Snow. His Reasons are these; 1. If you observe the Mountains in the Morning you will find them full of Moisture. 2. Rivers in the Morning are found to swell, and the more the nearer they are to their Springs.

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BUT the perpetual bubbling and springing up of the Water from Fountains, without any intermission, does not seem to be produced by so weak and inconstant a Cause. Neither is there much Difference between *Aristotle's* Opinion and this of *Cardan*; only *Aristotle* says, Fountains proceed from Air condensed, and *Cardan*, from Vapours; and there is but little Difference between Air and Vapours.

5. SOME of the Antients were of Opinion, that Rain-Water is hoarded up in the internal Caverns of the Earth, from whence it issues, as out of a great Promptuary, and that all Rivers are supplied from one common Fund, or spring one from another; also that no Water is dispersed over the Earth but such as is collected in the Winter Season, and reserved in these Receptacles, to be poured in due Time into innumerable Rivers. For this Cause, say they, Rivers are greater in Winter than in Summer; and some are perennial, others not. Their Reasons are the same with those given for the first Hypothesis. But *Aristotle* and his followers reject this Opinion, because there is more Water poured out of the Mouth of one River in a Year, than the whole Bulk of the terraqueous Globe.

6. MANY of the modern Philosophers, with the Antients, suppose the Earth to suck in as much Water as it exonerates into the Sea, thro' the Mouths of Rivers; and that the Sea-Water, by draining thro' the hidden Recesses of the Earth, and by being strained thro' the Mazes and Fissures, and thro' the Interstices of the Sand and Gravel, loseth it's Saltness, and becomes pure Water.

I am also of this Opinion, and think it most reasonable, but do not exclude the Causes repeated in the first and third Place. The Reasons for it are:

1. BECAUSE

1. BECAUSE more than a thousand Rivers exonerate themselves into the Sea, and the larger sort produce such quantities of Water, that what each of them pours in a Year's Time into the Sea, exceeds the Bulk of the whole Earth; as what the *Wolga* pours into the *Caspian* Sea, and others. So that it is impossible but that the Water should be refunded out of the Sea into the Earth, and carried to the Heads of Rivers; else we could not conceive why the Sea is not increased to an immense Bulk, or why Springs do not cease to emit Water. Neither can any one object that there is as much Water exhaled from the Sea in Vapours, as it receives from the Rivers; for Rain alone returns these Vapours, and if the Water of Rivers were continually turned into Vapours, it would produce more than those exhaled from the Sea.

2. THIS Opinion is also thus proved, because that Springs near the Ocean are salt or brackish, and the nearer they are the Sea, the more they are sated with Salt; as on the Shore of *Africa*, and in *India*, chiefly on the Shore of *Cormandel*, where no Vines grow, and all their Wells taste salt. Near the Town of *Suez*, at the end of the *Red Sea*, their Springs are all salt and bitter; and even the Water which is fetched two *German* Miles from the Shore, tastes a little brackish. Also in several small Islands there are no fresh Water Springs, but all salt (tho' something less sated than the Ocean) as in the Island of *St Vincent*, and others. In the low Countries of *Peru*, that border upon the Ocean, their Lakes are saltest, because of the Vicinity of the Sea. And in the maritime Parts of some eastern Countries their Coco-nuts are observed to taste brackish. Not to mention the Salt Springs that are found in inland Countries, as in *Lorrain*, *Lunenburg*, &c.

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3. BECAUSE it is certain, that the Sea sends it's Water thro' subterraneous Conduits to the salt Springs of *Lunenburg*, *Hall*, &c. whose Feeders are observed to contain perfect Sea-Water under Ground.

4. BECAUSE if we dig to a great Depth, as is often done in Mines, we shall find plenty of Water, which can neither proceed from Rain nor Air.

BUT by what means the Water is carried from the Sea to the Fountain-Heads, and how, in the Passage, it becomes sweet, we have already explained; and shewed that the Bottom of the Sea not being in every Place rocky, but here and there sandy, gravelly, and oozy, imbibes the Sea-Water, and letteth it into the Earth (after the same manner as when we throw Water upon Sand, Beans, Peas, Wheat, or other sorts of Grain) thro' whose Interstices it is brought by degrees to a great Distance from the Sea, where at length the small Drops come together, especially in streight Places, as are Mountains, *&c.* and having found an Aqueduct they discharge themselves at a Spring. But if the Cavity, where they are collected, be covered and bound up with the Earth, then the Water will take another Course, where it can with greatest Ease insinuate itself, and spring up at an Aperture in another Place; which is not the real Fountain, but a Conveyance of the subterraneous River to a Place above Ground. And if the Water can find no Way out of the Receptacle, and hath not force enough to make itself one, it is not increased, but the subsequent Particles of Water are turned another Way. For it is the nature of all Liquids and Fluids, that their Parts or Particles flow towards that Place where the Flux is made. Thus if you fill a Vessel with Water 'till it rise above the Brim, tho' all the raised Parts

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of the Water equally press the Brim, and have an equal Tendency and Power to run over at the next Side, yet if on one Side of the Vessel any part of the incumbent Water be made to flow, the rest will forsake their respective Sides, and move (as if they were drawn) towards that Side where the Flux is begun (the Cause of which it belongs to *Physics* to explain) (*b*). Or if you put one end of a Piece of Bread into Water or Wine, you will see the Water move upwards and diffuse itself thro' the Part above Water. Moreover the Sea easily pervades the Fissures of the Earth, and therefore with the same ease may glide out of them; except we had rather ascribe this to Evaporation, whereby the Particles are carried upwards, and condensed into Drops, when they meet with narrow Places.

BUT because there are some Arguments, which may seem to render this Opinion less probable, we will discuss them here, lest they should seem like Blots upon our Hypothesis.

1. SPRING-Heads are more elevated than the Superficies of the Sea, and for the most part are seated in mountainous Places; therefore it is contrary to the Nature of Water to move from the Sea up to these Places; for Water always runs downwards, as is manifest from Rivers and Drains.

2. THO' the Bottom of the Sea be sandy, gravelly, and spongy, so that the Water may easily pervade the Interstices; yet for what Reason should it not rather moisten the subjacent Parts of the Earth, than ascend upwards, and glide to the Ducts of Fountains, when the Earth near the Sur-

(*b*) We gather from Sir *Isaac Newton's Principles*, that it is the Nature of Fluids (and of all the Matter in the Universe) mutually to attract themselves, and the Parts of one another; Thus Water attracteth Water, and the Particles that first begin to flow, draw the next Particles to them, and these the next, *&c.*

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face is commonly rocky and stoney, as in the Mountains of the Island of *St Helena?*

3. WE have no Reason assigned why the Water as it flows from the Sea to remote Fountains, does not break out in some intermediate Place. And we are as much in the dark, why there is none or very little Water found in deep Mines, as we are told by *Thurnbeuserus.*

4. *SPRING Water* must be salt, if it proceed from the Sea.

THESE are the chief Arguments which seem to invalidate our proposed Hypothesis; for I pass by those of less moment alledged by others, as that the Sea cannot supply so many Rivers: and then again, that Rivers would never lessen, if they proceed from whence we say they do. These two are soon answered; for first, the Sea receives the Water it emits into Fountains, from the Rivers; and the other, as we observed before, is not the Question, for we are not arguing, that all the Water of Rivers proceeds from the Sea, but only the Water of Fountains, which of themselves make Rivers, as we said before; where we also asserted, that Fountains are augmented by Rain and Dew, which sink down into the Earth and either soke and moisten it, or are drawn towards the Fountain-heads by the Efflux of the Water, as we shewed by other Examples. Let us therefore return to examine the other four Arguments which seem to be of some Weight.

THE first is thought to be the strongest, as being taken from Experience, and therefore the Learned have contrived several Answers to it. They come off easiest who assert that the Ocean is higher than the Earth, and consequently higher than the Fountain-heads; wherefore say they, Water naturally flows to the Fountains, because they are of a less Altitude than the Ocean. *Olea-*

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rius also in his Description of his Travels into *Persia* relates, that having ascended one of the Mountains which bordereth upon the *Caspian* Sea, he tried the Altitude of it above the Superficies of that Sea with an Astrolabe (or rather a Surveying Instrument) and found none; but observed, that the extream parts of the Sea seemed to be in the same horizontal Line, or even a little elevated above it; and therefore the bulging of the Sea made it as high, or even a little higher, than the top of the Mountain, where he took the Observation. But this Solution notwithstanding cannot be admitted, because we proved in Chap. xiii. that the Superficies of the Ocean is not higher than the Land, or than Mountains, but rather lower, as appears also from frequent Observations made by expert Mathematicians. As to *Olearius*'s Observation, it is not to be insisted upon here; for the *Caspian* Sea is not higher than it's Shores, much less than the Mountains, as appears from the many Rivers that exonerate themselves into it. We must therefore suppose, that Refraction obstructed *Olearius*'s Observation, and made the Surface of the Sea appear higher than it really is; and perhaps the fluctuating of the Waves might increase the Cause, or the Mountain which he ascended was of no great Height.

THE Weakness therefore of this Solution being exposed, others propose this; that the natural Place of the Waters is about the Earth, and therefore they ought to surround or cover it, because they are lighter; and because they are hindered from possessing their natural Place by the Mountains and Hills, and the Elevation of the inland Places, that part of the Ocean which should be where the Mountains and high Parts are, being thrust out of it's natural Place, violently presses the Water underneath it, which tho' it be in it's natural Posture, yet being squeezed and pressed towards the bottom,

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by the ſuperincumbent Water, it is forced to give way, and finding no place to flow to, it retires towards the Sides, and pervades the Foundations of the Mountains; where being collected, as in a Ciſtern, it is ſtill urged forwards towards the tops of the Mountains by the incumbent Water of the Ocean. As we may obſerve in a Tankard that has a Pipe on the ſide (reaching to the very bottom) made to pour Wine thro' into Glaſſes; if, I ſay, we drop a Stone into ſuch a Veſſel, whether it be full or half full of Liquors it will ſpout out at the Orifice of the Pipe. This is *Scaliger*'s Subtility, but it is too groſs to paſs. For the Water is not thus forced towards the tops of the Mountains, ſince Experience ſhews us the contrary in Mines; and if it were ſo, the Water of all Springs would be ſalt; beſides, it is falſe to ſay that the Water is not in it's natural Place, and therefore preſſes upon the Water underneath, for this is aſſumed without Proof, and is contrary to Experience. Water does not preſs upon the Parts below, unleſs it's Surface be of an unequal Altitude, but the Surface of the Ocean is ſpherical and conſequently at Reſt. Moreover, if the Waters were moved by any Preſſure, it would be towards the Shores, where the Paſſage is more open than the ſmall Fiſſures of the Earth. And tho' there be great outlets at the bottom of the Sea, for the Water to flow through, yet ſince it is ſalt, it cannot make freſh-water Fountains. I think the true Anſwer to this Argument is not far to fetch, if, we conſider how Water is conveyed to Fountains, not by any Chanel or Pipe from the bottom of the Sea, or the Root of the Mountain (by which means it would ſtill keep it's Saltneſs), but by a continual diſtilling, gleeting, and ſtraining of the watery Particles thro' the terreſtrial Matter, till they find a Receptacle fit to collect and condenſe them into Drops, where being continually ſucceeded by others,

others, they have recourse to some Conveyance, and through it break forth at a Fountain. And we observe this very thing in Mines dug to a vast Depth, how that Water on every Side is continually dropping, and collecting itself into small Guts, which they call Veins of Water; and if several such Guts or Runnels as these concur in one Receptacle, they form a Fountain, as they who make Drains, to bring Water into Wells, very well know. For in most Draw-Wells the Water is collected from the dropping of the Earth, round about into the bottom of the Well; and they that make Aqueducts dig small Furrows in Gutters to collect the Waters, and then convey it in a large one to the intended Place. If it be objected, that many Fountains are observed to spring up among Rocks, where it is likely the watery Particles can scarce be admitted; I answer, That this confirms our Opinion; for these Rocks are not continued to the foot of the Mountain (upon which such Springs are found) but only cover the Surface to a small Depth, and the Earth is lighter and less rocky within, or at least fit to give Admission to the Water, which, when it comes to the *Strata* of the Stones, can penerate no farther, but is there impeded and collected into Drops, and breaks out into a Fountain among the Rocks, if it can find any Aperture. Moreover, the rocky Mountains in the Island of *St Helena*, and in most other Islands, are not within so dense and obdurate, as appears from the Cinders, Ashes, and sulphureous Earth; which shews that these Mountains some time or other burnt or smoaked. And to this we may add, that the Fountain is not always in the Place where the Water breaks out, which is conveyed very often from a higher Place, by a Chanel under Ground, and this causes it to break forth with greater Violence, as is very often observed.

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We may be further convinced of the Truth of theſe Things, by conſidering that Fire will tend downwards thro' a Continuation of Matter, tho' of it's own Nature, when it is free from Matter, it tends upwards, Thus if you put one End of a Bar of Iron into the Fire, it will penetrate thro' the whole, and heat the other End, tho' it be turned downwards. And this is ſufficient to convince any one of the Invalidity of the firſt Argument.

TO the Second we anſwer, That the Reaſon why the Sea-Water doth not penetrate and ſink into the Earth towards the Center, ſo much as into the Mountains, is, becauſe the Earth there is denſer, and full of Metals, as we find by Experience; but where it is not ſo obdurate, the Water glides in, and therefore if there are Receptacles under the bottom of the Sea, we do not deny but that there may be ſome freſh and ſalt Water Lakes there. But becauſe there are few ſuch Receptacles, and the Earth every where is denſe and metalline, under the bottom of the Sea, it cannot conſtantly imbibe Water; but when it is ſaturated it receives no more, and then the overplus Water diſtils towards the higher Places. And the Sea conſtantly changing it's Altitude, and fluctuating backwards and forwards, may contribute much to elevate the Water; for where it is higher than ordinary, it muſt certainly preſs the Water into the Earth, and drive it to the Fountain-Heads. And ſince the Surface of the Ocean in every Place is conſtantly agitated, and made higher and lower, not only by Storms, but alſo by the Tides, therefore ſuch a Preſſure as this muſt happen every Day. But I queſtion whether this can do much.

TO the third Argument we ſay, That this is owing to the Diſpoſition or Situation of the *Strata* of the Earth, or of the Earth itſelf, and that it is the

the nature of all Fluids to gather to a Head, where there is a Flux. I think there is no need of saying any more to this.

BUT the fourth is not so easily answered, for we do not perceive Salt to be separated from Sea-Water only by Percolation or Straining. Beside, there are two kinds of Salt in Water (which the *Aristotelians* did not consider) the one of which is very well named, by Chymists, fixed, and the other volatile. The fixed Salts may indeed, by continual straining, or boiling, or distilling of the Sea-Water, be separated from it; but the volatile Salt is so full of Spirit, that it flies up with the Water, and cannot be separated from it, neither by frequent Distillations nor any other Art hitherto used. Therefore it is very difficult to shew how this volatile Spirit of Salt is separated from the Sea-Water, in it's Passage from the Ocean to Fountain-Heads. The following Accounts will serve our Turn. 1. Tho' we have not found out the Art of separating the volatile Spirit of Salt from Sea-Water, yet we cannot deny but that it may be done, since we see it separated by Nature, when it rains fresh Showers in the main Ocean, tho' they proceed from Vapours exhaled from the Sea. 2. The Particles of salt Water which pervade the Fissures of the Earth, before they come to their Fountain, are mixed with other fresh Water, which proceeds from Rain and Vapours condensed there, whereby the small Degree of volatile Salt that remains in them is rendered insensible. 3. It is not true that all Fountains are entirely deprived of Saltness, for there are some salt Springs, as we said before, about two Miles from *Suez*, and in several other Places not so far from the Sea. Therefore to separate the volatile Salt from the Water, a long Transcolation, and a gentle Evaporation is required, and thus it is to be separated by Art; and thus

thus also is Rain-Water generated and made fresh; tho' sometimes saltish Showers are observed to fall into the Sea.

THE Water of Springs therefore proceeds partly from the Sea, or subterraneous Water, and partly from Rain and Dew that moistens the Earth. But the Water of Rivers proceeds partly from Springs, and partly from Rain and Snow.

PROPOSITION VI.

Some Rivers in the middle of their Course, hide themselves under Ground, and rise up in another Place, as if they were new Rivers.

THE most famous are:

1. THE *Niger*, a River in *Africa*, which some antient Cosmographers would have to proceed from the *Nile*, by a subterraneous Chanel, because it overflows it's Banks at the same Time of the Year, and after the same manner that the *Nile* does: and they could not shew a better Cause for it's Inundation. This River meeting with the Mountains of *Nubia*, hideth itself under them, and emerges again on the West Side of the Mountains (*c*).

2. THE *Tigris* in *Mesopotamia*, after it has passed the Lake *Arethusa*, meets with Mount *Taurus*, and plunges itself into a Grotto, and flows out at the other Side of the Mountain; also after it

(*c*) This River hides itself no where under Ground that we know of; tho' perhaps we are not certain whether it do or no, because no *European* has traced it to it's Fountain: Only the *Zeebe*, a large Branch of it, (which proceeds from the Lake *Zaire*, and was some time since taken for the upper Part of the *Nile*) meeting with the Mountains of *Nimeamay*, is said to divide itself into several streams, and immerge under them, and to emerge again on the *North* side of the Mountains. But I do not write this as a Certainty.

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it has run thro' the Lake *Tospia* it again immerges, and being carried under Ground about six *German* Miles, it breaks out again. Our modern Maps seldom exhibit such Receptacles.

3. *ARISTOTLE* (in Book i. Chap. xi. *Meteor.*) writes, that there were several such Brooks in the *Peloponnesus* about *Arcadia*; some of which are mentioned by the Poets. The two following, *viz. Lycus* and *Erasinus*, are excellently described by *Ovid* in the following Verses.

> *So* Lycus *swallow'd by the yawning Earth,*
> *Takes in another Place it's second Birth:*
> *Great* Erasinus *now seems lost, but yields*
> *His rising Waters to th'* Arcadian *Fields.*
>
> MORRICE.

4. THE *Alpheus*, a River in *Greece*, is swallowed by the Earth, and, as the *Greek* Poets write, takes it's Course under both Sea and Land into *Sicily*, where it rises, as they say, on the *Syracusian* Shore, and is the same with the River called *Arethusa* in *Sicily* (*d*). This they were induced to think, because that this River, every fifth Summer, did cast up the Dung of Cattle, at the same Time that the *Olympic* Games were celebrated in *Achaia*, when the Dung of the slain Victims was thrown into the *Alpheus*, which was therefore carried with a direct Course into *Sicily*.

5. THE River *Guadiana*, between *Portugal* and *Andalusia*, (formerly called *Anas*) hideth itself

(*d*) This (and also the former) are thought to meer Poetical Fictions, for no such Rivers are found to exist at present. That which was anciently called *Alpheus* is now named *Carbon* or *Orfea*, which rises from the Mountain *Stymphalus*, and running all it's Course above Ground, receives a great Number of Rivers, and afterwards falls into the Gulph of *Castel di Tornese*.

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under Ground, near the Town of *Medelin*, and gushes out again about eight *German* Miles from that Place (*e*).

6. THE Brook *Dan* (which together with *Jor* makes the River *Jordan*) emerges some Miles below it's real Fountain the Lake *Phyala*; for Chaff being thrown in here is cast up at the other end of the Orifice, or where the Fountain seems to be.

PLINY and others have wrote that the *Nile*, in some Places, runs under Ground; but we know, by Experience, that it runs it's whole Course above Ground. *Aristotle* also tells us, that the *Po*, a famous River in *Italy*, hideth itself for some Space under Ground; but Experience shews the contrary.

THE Reason why these Rivers hide themselves under the Earth and appear again, is, because they meet with elevated Ground which they cannot overflow, and therefore are forced to glide into the next Grotto they meet with: or make themselves a subterraneous Chanel, if the Earth be soft and easy to penetrate.

THERE are also some Rivers that hide themselves under Ground, but do not appear any more; as we shall shall shew presently.

PROPOSITION VII.

Most of the small Rivers, many of the middling ones, and all the large ones, exonerate themselves into the Sea, or into a Lake; and the Place where they discharge their Water is called their Mouth. Some Rivers also have one Mouth, some two, some

(*e*) This River is at present said, not to bury itself under Ground (as was reported formerly) by all the *Spaniards* that have mentioned it.

three,

three, and others more. Several of the middling, and small Rivers discharge themselves into the great ones: the rest either stagnate, or are swallowed up by the Earth.

CONCERNING the great Rivers the thing is manifest, as the *Rhine*, the *Elbe*, the *Danube*, the *Wolga*, *&c.* The *Danube* discharges itself at five Mouths into the *Euxine* Sea; the *Wolga* is reckoned by some to have at least seventy Mouths; the *Nile* seven, and, when it overflows, more (*f*).

THE Reason why these great Rivers exonerate themselves into the Sea is their swift Course, and their Plenty of Water; and why at more than one Mouth is, 1. [The Situation of the Coast]. 2. The Shelves and Sand-Banks, which are gathered in their Mouths, and in Process of Time become Islands; and if there happen to be but one of these, the River is divided into two Branches, and is said to have two Mouths; if more, the Mouths are increased accordingly. By this means the Land often gains on the Sea; and few great Rivers are found without some Islands before their Mouths.

THE Ancients tell us, that the *Nile* formerly discharged it's Water at one Mouth only, which they called the *Canobian* Mouth. To these two Causes therefore a third may be added, *viz.* Human Industry. For People often draw Canals from Rivers, or turn them thro' a new Chanel, into the Sea, partly to water their Fields, and partly for the Use of Navigation, and in process of Time these are made larger by the Current. And therefore we may believe the Antients, when they tell us, that all the Mouths of the *Nile*, except that at *Canobus*, were made by Human Industry. But of

(*f*) See the next Note below.

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of this more fully in the next Proposition, where we shall explain how it comes to pass, that one River flows into the Chanel of another.

THE River *Wolcoff*, in *Muscovy*, (not *Wolga*) arises from one Lake, and runs into another.

RIVULETS, or Brooks, that neither run into the Sea, nor into other Rivers, are either peculiar Rivers, or Branches of others. They that are the Branches of other Rivers probably stagnate, and do not run under Ground; and the Reason why they do not reach the Sea is, 1. Because their Chanels lie low, and contain but little Water. 2. Because they meet with rocky Ground, which hinders their Progress. 3. Several of them are made by Art, to moisten the Ground, and for the Use of their Water. 4. Perhaps their Mouths are stopped or obstructed, by intervening Land, which is gained from the Sea, or by Shelves, which are increased to such a Bulk as to stop their Current; so that they are forced to retreat towards their Fountain, or to the Place where they divaricated. Thus a Branch of the *Rhine*, which formerly ran into the *German* Ocean, at the *Huys le Britain*, near *Catwick*, is now choaked up with Sand, and stagnates between *Catwick* and *Leyden*.

BUT such as are proper Rivers, and neither run into others, nor exonerate themselves into the Sea, but spring up in one Place, and are swallowed up in another, are few in Number, and very small; as those that flow from the Mountains of *Peru*, *India*, and *Africa*, are buried in the Gravel, or sucked up by the sandy Soil. Also at *Meten* (a Village near the *Arabian* Gulph) there is a small River whose Chanel is full of Gravel, under which the Water in Summer-Time hides itself, and glides along out of Sight. If these Rivers find no subterraneous Passage they run into small Lakes, or Bogs; but some of them spring so slowly, that they

they are exhaled into Vapours, almost as fast as they spring, and thus they are dried up, and neither make Lakes, nor run under Ground. There are several of these in *Muscovy*; as the *Conitra*, the *Salle*, the *Maresfa*, the *Jeleesa*, and others taken Notice of in larger Maps.

PROPOSITION VIII.

To determine whether the Chanels, in which Rivers flow, were originally made by Art or Nature.

IT is probable the Chanels of those Rivers, which are not of the same date with the Earth itself, were made by Industry, for these Reasons: 1. We are well assured that when new Fountains break forth, the running Water does not make itself a Chanel, but diffuses it's Streams over the adjacent Country, and therefore wants to be brought to a Chanel by Art. 2. Because there are several Canals even now cut by Hand. So the *Chinese* have cut a Canal for the Water to run out of the yellow River into another. There are several other well known Instances which I omit. 3. Because such Lakes and Marshes found about the Fountains of several Rivers, *viz.* of the *Nile*, the *Tanais*, the *Wolga*, *&c.* confirm this. For since these Lakes, without donbt, were made by the Effusion and spreading of the Fountain-Water, the Inhabitants, to drain it from their Fields, which were in danger of being overflowed, made a Chanel to contain it, and carry it off. The same is to be understood of Rivers, whose Heads are in Mountains.

THERE is a Question like this; *viz.* Whether the Rivers which exonerate themselves into others, have of themselves made their way thither, or have been brought thither by Chanels made with hands?

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The latter is more probable for the Reasons aforesaid. The same may be said of such Branches of Rivers as make and enclose Islands in the *Tanais*, the *Wolga*, and others. So one Branch of the *Euphrates*, gliding thro' the Marshes of *Chaldæa*, was formerly carried that way into the Sea, but afterwards it left it's Course, being choaked up with Sand, and partly dispersed it's Streams among the innumerable Canals which were made by the Inhabitants to water the Fields; and partly by a new Chanel mixed it's Waters with the *Tigris*. And this seems to be the Case of other Rivers which do not now reach the Sea, but stagnate; tho' perhaps they might have had a Passage into it formerly.

PROPOSITION IX.

To explain why there are no salt Rivers, tho' there are so many salt Springs.

THE Reason is, because Mankind have no occasion for salt Water, and therefore do not collect it into Chanels, since they can have Salt at an easier rate. But if Chanels were made as for other Rivers, we should have salt Rivulets, such as are in *Lunenburg*, and *Hall*, under Ground. And no doubt but there are several such subterraneous salt Rivers in other Parts of the World.

PROPOSITION X.

The Chanels of Rivers the nearer they are to their Fountains, are generally so much the higher; and most of them are depressed gradually towards their Mouths.

THO' it may sometimes happen, that the Parts of the Chanel which are more remote from the Fountain, are higher than the Places that are nearer

nearer it; for they are not always even throughout, but have here and there Hills and Vallies, as we may call them, interspersed. Notwithstanding no part of the Chanel is higher than the Fountain-head.

THE Proposition is plain from the Nature of Water, which never flows but from a higher to a lower Place, and therefore every Part of the Chanel (especially the Mouth of the River) must of Necessity be lower than the Fountain; else the Water would flow back again to it's Source. But it is true also, that the parts of the Chanel are elevated either way, because in many Places there are Whirlpools which draw the Water downwards; besides Shoals, Ridges, and Sand-banks, which increase the Altitude of the Chanel, and make it higher in some parts than in others nearer the Fountain; yet the River flows forward from the Fountain towards it's Mouths, and fills the hollow Places with a greater Quantity of Water, so that their Superficies are still higher than the Shoals, Sands, *&c.* which would otherwise obstruct it's Passage. And there are scarce any Rivers but what have such Inequalities in their Chanels, especially the *Nile* and the *Wolga*, which in some Places are almost choaked up with Sand.

WHEN the Water of a River falls from a high to a low Place, if the Fall be steep, and if it gushes down swiftly and with great Force, it is called the *Cataract* of the River. And there are several such *Cataracts* in great Rivers; especially in the *Nile*; two of which are extraordinary, where the Water gushes between the Mountains with such Rapidity and Noise, that the Inhabitants, within the sound of them, are said to be all deaf.

THE [*Wolcoff*] a small River in *Muscovy*, hath also two *Cataracts* near *Ladoga.*

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THE *Laire* alſo in *Congo* hath a *Cataract* about ſix *German* Miles from the Sea, where it wholly falls from a Mountain. The *Rhine* hath two dangerous ones at *Schaffhuyſen* and *Lauffenburg*, where the whole River falls with a dreadful Noiſe, from the tops of Rocks.

BUT they that are ſkilled in *Hydraulics* obſerve, that if the Chanel of any River be depreſſed one Pace in 500, it is ſcarcely navigable, by reaſon of it's Rapidity; and ſince all great Rivers are navigable, it ſhews that their Chanels in no Place are depreſſed ſo much as one Pace in 500; except where there are Cataracts and Whirlpools.

THE Depreſſion of one part of a River below another, is called it's *Level*; and the difference between the Altitude of the Fountain-head of a River and it's Mouth, is called the *Depth of the Level of a River*.

PROPOSITION XI.

To explain why Rivers are broader in one Part than another.

THE Cauſes are; 1. If the Bank, or Shore, be lower than ordinary. 2. If the Ground be ſoft and mouldering, and give way to the violent beating of the Waves, or to the Rapidity of the Water. 3. If the Chanel be ſhallow or full of Shelves and Sands. 4. If the Water flow from a Cataract, it ſpreads and makes the River broader.

PROPOSITION XII.

To explain why the Chanels of Rivers are more depreſſed in ſome Places than in others.

RIVERS

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RIVERS become shallow by these Accidents; 1. If Sands are gathered. 2. If the River run broad. 3. If it run slow.

ON the contrary they become deep, If the current runs strong, especially from a Cataract; or if the Chnael be narrow, or if the Bottom be soft and mouldering.

PROPOSITION XIII.

To explain why some Rivers run with a swift Current, and others slow: and why the same River (for example the *Rhine*) *acquires different Degrees of Rapidity in several Places.*

THE Causes are; 1. The Altitude of the Fountain. 2. The Declivity of the Chanel, or the Depression of the Mouth of the River; for if the Chanel be depressed one Pace in five hundred, the Current is so rapid that Navigation becomes dangerous (as was observed before); therefore Rivers flow with the greatest Rapidity where there are Cataracts; and those Torrents are most impetuous which fall from the highest and steepest Mountains. 3. The narrowness of the Chanel, and the abundance of Water; as where a River runs between two Mountains, or Forelands.

RIVERS famous for their swift Course are; the *Tigris*, the *Indus*, the *Danube*, the *Yrtisch* in *Siberia*, the *Malmistra* in *Cilicia*; which last makes such a dreadful Noise, that it may be heard a great way off.

PROPOSITION XIV.

[*When the Mouths of Rivers are broad and shallow, and discharge but a small quantity of Water, and that slowly, they are easily stopped or choaked up.*]

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FOR these Causes make it flow with less Force, so that it cannot disgorge the Sand and Earth into the Sea, but lets them settle in it's Mouth, whereby it is soon stopped.

PROPOSITION XV.

Few Rivers run in a direct Course from their Fountains to their Mouths, but turn various ways, and make innumerable Windings and Curvatures.

THE Cause is partly owing to the Industry of Man, and the Motion of the Water; and partly to the Rocks that impede and divert the direct Course.

THE winding Rivers are; 1. The [River of the *Amazons*] in South *America*, which makes innumerable Curvatures, so that it's Chanel is accounted above fifteen hundred *German* Miles long, tho' it be only seven hundred Miles from the Fountain to the Mouth in a direct Line.

2. THE River *Madre* in *Natolia* is said to have six hundred Curvatures.

3. THE River *Tara* in *Siberia* is interrupted by so many windings and turnings, that the *Russians* and *Siberians*, when they sail on it, often carry their Boats and their Burdens, by Land, from one Reach to another, to save Time and Labour.

PROPOSITION XVI.

To determine whether the Lakes that some Rivers seem to pass through, be made by the Rivers themselves, or are fed by their own proper Springs, and increase the Rivers: or whether the Rivers that flow from them, be the same that flow into them.

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THERE are but some few Rivers that pass thro' such Lakes; the *Nubia* in *Africa* hath five, the *Niger* four, and the *Rhone* has the Lake of *Geneva*, &c.

WE said of these Lakes in the foregoing Chapter, that the River which runs in, must be compared with that which runs out; and if this be larger than the other, there are certainly Springs in the Bottom which feed that Lake, and the River: but if it be less, or of the same bigness, then is the Lake made and fed by the River which runs into it; and the Cause of this Lake is the Breadth, Depression, and Concavity of the Chanel; and a Lake may be thus made in any River, as we said before.

AND if the River which runs out, be in a direct Line with that which runs in, it is to be accounted the same, or a Part of the same River, tho' perhaps it may be greater or even less, yet I think it is not to be doubted but that it is still a Part of the same.

YET the *Rhone* enters the Lake of *Geneva*, and flows thro' it, but doth not make or feed it; as appears from the different Colour of the Water of the Lake, and of the River, (and other things) neither doth the *Rhone* make any Lakes, but is wholly fed by Springs and Rivulets. Tho' I do not say this is certainly true.

PROPOSITION XVII.

The further Rivers have run from their Fountains, the more they increase in Breadth; and are broadest at their Mouths.

THE Reason is; 1. Because that other Rivers mix with them, and continually increase them. 2. Because the Declivity of the Chanel is not so

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great near the Mouth. 3. Becauſe that Sea-Breezes frequently blow the Water up into the River near the Mouth, but do not affect it in Places near the Fountain. 4. The Sea-Water alſo enters the Mouth of the River when ſuch Breezes blow, and makes it wider by it's violent Agitation.

THE fewer Mouths any River hath, the broader they are.

RIVERS remarkable for their broad Mouths are; the great River of the *Amazons* in South *America*, the River of *St Laurence* in *Canada*, the *Zaire* in *Africa*, and the *Rio de la Plata* in *Braſil*. This laſt is ſaid by ſome to be forty Leagues broad at the Mouth, tho' others ſay but twenty; perhaps the former take in the other Mouths of this River. They that have been in *Congo* relate that the Mouth of the *Zaire* is twenty eight *German* Miles broad. Such Rivers as theſe pour ſuch vaſt quantities of Water into the Ocean, that they take away the Saltneſs of the Sea near the Shore, and diſturb it's Motion, for twelve or ſixteen *German* Miles round them.

PROPOSITION XVIII.

Rivers often carry along with them Particles of various Metals and Minerals; as alſo of Sand, and of fat and oily Bodies.

THE following Rivers are auriferous, that is, have Grains of Gold mixed with their Sands, *viz.* 1. Some in *Japan*. 2. Some in the adjacent Iſlands to *Japan*. 3. A Brook called *Arroë*, which ſprings from the Foot of the Mountains of the Moon in *Monomotapa* (where there are Gold Mines), and falls into the River *Magnice*. 4. Some in *Guinea*, where the Negroes gather the Grains, and ſeparate them from the Sand to exchange with the

Europeans, who sail thither for that Purpose. If the Particles are very small they call it Gold-Dust, which is the best, and needs but little cleansing. 5. In all the Brooks about the City of *Mexico*, there are found Grains of Gold, especially after Showers of Rain; but there are seldom any found but in the rainy Seasons. 6. In *Peru*. 7. In *Sumatra*. 8. In *Cuba*. 9. In *Hispaniola*, and other adjacent Islands. 10. In *Guiana*, a Province of South *America*. 11. In the Rivulets of the *Caribbees*, there are found great Lumps of Gold after Showers of Rain. The Inhabitants cast Nets into the Rivers when these are out, and catch the Sand, from which they can easily separate the Gold. 12. There are several Rivers and Fountains in the Countries near the *Alps* in *Germany*, particularly in the County of *Tyrol*, from whose Waters they extract Gold and Silver, tho' there be no Grains of either Metal to be perceived in the Water, they lies in such small Particles or Atoms. The *Rhine* also, and the *Elbe* has golden Clay in several Places. The *Tagus*, or *Tago*, a most celebrated River in *Spain* was formerly famous for carrying Gold-Sands at the Bottom: but there are none now; nor do I hear of much Riches got that way out of any River in *Europe*, tho' some boast of a small Rivulet in *Hesse*, which has Gold mixed with it's Sand; but I have not read it in any Author of Credit.

NO Rivers, which in like manner produce Silver, are taken Notice of by Authors; yet it is not to be doubted but there are as many if not more of this Sort also; only because Silver is not so easily discerned from the Sand, and no great Profit is expected to requite the Pains of extracting it, no Body has thought it worth their while to take Notice of it. And for this Reason there hath been no mention made of those Rivers that carry Grains of Iron, Copper, Tin, &c. except

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of some few; tho' without doubt there are great Numbers of them in the World, at whose surprizing effects Men are amazed; and superficial Philosophers have here recourse to occult Qualities. If we observe the River in *High Germany* which turns Iron into Copper (as is commonly thought), we admire that a Horse-shoe of Iron should, by hanging in it for some Time, be turned into one of perfect Copper. But, in truth, the Iron is not changed into Copper (as is vulgarly supposed), but the Grains and Particles of Copper and Vitriol that are in this River, moving with the Water, corrode the Iron, whose Particles being removed, those of Copper succeed in their Places.

NEITHER is there much Notice taken of such Rivulets as are impregnated with various kinds of Earth, Salt, and other Fossils, but we shall treat largely of mineral and metallic Springs, in the following Chapter.

FROM this Mixture of different Particles proceeds a strange Diversity of Waters, in Rivers and Wells. Some Water if you boil Meat in it, makes it black, which is a Sign that it is impregnated with Iron; nor will Pease boil soft so soon in this, as in other Water that is something fat and oily. Neither can the same Beer be made of different Waters. That Water which hath Particles of Iron in it we call hard Water; but if it be mixed with fat and oily Particles, we call it soft Water. The *Elbe* is a soft Water River, as we may call it, which (as Experience shews) is owing to the clayey and fruitful Ground it washes. And every other variety of Water arises from the different sorts of Earth, thro' which the Spring or River is carried, whether it be clayey, rocky, or metallic, &c.

PRO-

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PROPOSITION XIX.

The Waters of most Rivers differ in Colour, Gravity, and other Qualities.

FOR some Waters are black and some dusky, some incline to a red Colour, and others to a white.

AND this difference is best observed when two Rivers meet, where we can discern the Water of each distinctly, after they have run some Paces in the same Chanel; also by this we may perceive their different Gravity, by Reason that one tends more to the Bottom of the Chanel than the other.

THE Water of the River *Ganges* is accounted very light and wholesome, and the Emperor of *Guzarat*, or the Great *Mogul*, in whatever place he is, takes care that this Water be carried along with him in Bottles, of which he alone drinketh. Others will have the *Nile* to produce the softest and most wholsome Water. Heavy Water is for the most Part impregnated with Iron or Mercury.

TO understand the Nature of great Rivers we must look into the Rivulets that compose them; (for the *Rhine* receives many mineral Rivers, and the *Danube* takes in such as carry Gold, Iron, Vitriol, *&c.*) from whence their different Qualities arise, tho' most Fountains have something of these in them.

PROPOSITION XX.

Some Rivers, at a set Time of the Year, rise beyond their Banks, and overflow the adjacent Countries.

THE first and most celebrated among these is the *Nile*, which swells to such a degree that it covers all

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all the Land of *Egypt*, except the Hills. The Deluge begins about the seventeenth of *June*, and increases forty Days, and decreases as many, so that at this Time, all the Cities, which are most of them built upon Hills, appear like so many Islands. Antiquity hath given a large Account of this Inundation, because in that Part of the Earth which was then known (before the eastern and western Parts were discovered) no River was found to be the same, except the *Niger*, which therefore was supposed to communicate with the *Nile* under Ground. *Seneca* has described the Inundation of the *Nile* the best of all the Antients, and therefore I cannot but give it in his Words.

'THE *Nile* (*says he*) is increased in the middle 'of Summer, from before the rising of the little 'Dog-Star, to beyond the Autumnal Equinox. 'Nature hath placed this most noble River in the 'Sight of all Mankind, and ordered it so, that 'it should overflow *Egypt* at a Time when the Earth, 'being driest with the Summer Heat, might suck 'in more of it's Water, and sufficiently quench 'it's annual Thirst. For in that part of *Egypt* 'which lies towards *Ethiopia* there are few or no 'Showers, and those that fall do not refresh the 'Earth, which is unaccustomed to Rain-Water. '*Egypt* builds her whole hope upon this, and 'is fertile, or barren, according as the River af'fords it more or less Water. The Husband'man never minds the Heavens, and the Poet '*Ovid* does not jest when he says.

The Herbs beseech not Jove *to pour*
Himself upon them in a Shower.

'If we knew where it begins to increase, we might 'perhaps find out the Cause of it's Increase. But 'after it hath wandered over vast Desarts, and

'made

'made it's way thro' Fens and Marshes, and un-'known Countries, it collects it's disorderly Wa-'ters about *Philas*. The Island of *Philas* being on 'every side rocky and rugged, is washed by two 'Rivers which there come together and surround 'the whole Island. These losing their former Names, 'mix together and are called the *Nile*, which being 'increased in breadth, glides gently from thence 'thro' *Ethiopia*, and the sandy Desarts that afford 'a Passage to the Commerce of the *Indian* Sea. 'The Cararacts afterward receive it, which fill the 'Eye with something great and amazing; there the '*Nile* rushes against the broken Mountains in it's 'way, and is forced in to the narrow Passages 'and Hollows that are made in the hard Rocks, 'dashing against the Stones that obstruct it's Cur-'rent, and overflowing sometimes all the Obstacles 'that interrupt it. Here it's Course is obstructed, 'which makes it rise in waves and surges: and 'there it is confined between two Rocks, and frets 'and foams to be enlarged; so that it's Waters, 'which before glided gently, along, being now put 'into a violent Agitation, rush from one Rock 'to another, and make it appear more like a 'Torrent than a River. Now it looks thick, mud-'dy and troubled, and half covered with Froth, 'which is not it's natural Colour, but owing to the 'Injury of the Places it flowed thro'. At length 'having freed itself from all Obstacles, it falls on 'a sudden from a prodigious Height, and with 'a Noise dreadful to the Country thereabouts; 'which a Colony that were placed there, by the '*Persians*, could not endure; their Ears being 'so stunned with the continual Noise, that they 'were forced to transport themselves to more 'quiet Habitations. The incredible Boldness of 'the Inhabitants is reported among the Miracles 'of this River. They get into their Boats by

'pairs

'pairs, the one guides it, and the other throws
'out the Water, and after they have tumbled
'some Time among the raging Waves of the
'*Nile*, they get into the narrowest Chanels, and
'avoid as much as possible the dangerous Creeks
'in the Rocks; then guiding the Boat with their
'Hands, they are carried headlong down the
'middle of the Current, by the force of the
'whole River, and when the Spectators are in
'great Fear, and begin to lament, believing they
'are overset and drowned by the great Weight of
'the Water, yet they are in an instant seen sailing
'a great way from the Place where they fell down,
'being carried as swift as a Stone out of an Engine.
'Nor does the Boat in it's Fall overset, but is
'carried safe into the smooth Water. The first
'rising of the *Nile* is perceived about the fore-
'mentioned Isle of *Philas*, a little way from whence
'it is divided by a Rock (called, by the *Greeks*,
'*Abaton*) which none ever ascend but their Ru-
'lers: there the rising of the River is observed
'and marked upon the Sides of the Rock. A
'great way below this there are two eminent
'Rocks, called, by the Inhabitants, the *Veins of
'the Nile*, from which a great Force of Water
'floweth; yet not so much as to do any harm to
'*Egypt*. The Priests throw Offerings in at these
'Mouths, and the Governours Gifts of Gold,
'while the holy Rites are performing. From this
'Place the *Nile* seems as if it had got new Strength,
'and is rolled along a narrow and deep Chanel,
'being hemmed in by the Mountains on each
'Side, and hindered from enlarging it's Breadth.
'When it comes to *Memphis*, it is again at Li-
'berty, and wanders over the Country, dividing
'itself into Rivulets, and diffusing it's Streams
'over all *Egypt*, thro' innumerable Canals, made
'by Art as commodious as possible. At first it
'is

'is divided, but the Waters being continued, it 'stagnates and appears like a large troubled Sea. 'The Breadth of the Country thro' which it is 'extended, breaks the Violence of it's Current, 'being no less than the whole Land of *Egypt*. 'As much as the *Nile* increases, so much do their 'Hopes for that Year; and the Husbandman is 'not deceived who computes his product by the 'Measure of the River. It brings troubled Wa-'ter and mud upon the sandy and dry Soil, and 'leaves it's Dregs and Filth upon the Ground 'that is most chapped with Drought, and what-'ever clammy Fatness it brings along with it, 'is sprinkled upon the driest Places; so that it 'manures the Ground two ways, by watering it, 'and covering it with Mud; but the Places it doth 'not reach are bare and unfruiful. If it increase 'above such a height it does not so well. The 'Nature of this River is also wonderful; for when 'other small Rivers waste and wash out the Fat-'ness of the Earth, the *Nile*, by how much it ex-'cels others in Greatness is so far from wasting 'and eating out any Thing, that is rather adds 'new Vigour to the pining Ground, and at least 'puts it into a better Temper, by saturating 'the sandy Places with Slime and Mud; so that '*Egypt* does not only owe the Fertility of it's 'Soil to the *Nile*, but even also the Soil itself. 'When it overflows the Fields, it makes a plea-'sant appearance, for the Plains and Vallies lie 'hid under the Water, and the Towns, appearing 'like Islands, are only to be seen; and they have 'no Commerce one with another in the inland 'Places but by Boats; the less also the People 'see of their Lands, the more they rejoice. When 'the *Nile* is confined within it's Banks, it is poured 'into the Sea thro' seven Mouths, and every one 'of them hath the appearance of a Sea, besides

'several

' several other small Branches and Canals that are
' cut from one Shore to another. Moreover it
' breeds living Creatures, equal in Bulk and
' Noxiousness to any at Sea, from whence one may
' judge of it's greatness, by it's affording Room
' to play in, and Sustenance sufficient for such
' vast Animals. *Babillus*, the best of Men, and
' skilled in all kinds of Learning, relates, that
' when he went Governour into *Egypt* he saw
' at the *Heracleotic* Mouth of the *Nile* (which is
' the greatest) a Company of Dolphins coming
' from the Sea, that were met by a Troop of
' Crocodiles from the River, as it were to give
' one another Battle. The Dolphins, tho' they
' are harmless Animals, and do not bite, yet
' they were too powerful for the Crocodiles,
' whose Backs are hard and impenetrable even
' to the Teeth of larger Animals than themselves,
' but their Bellies and lower Parts are soft and
' tender; into these the Dolphins, swimming un-
' der Water, thrust their long Spikes, or prickly
' Fins, which they carry upon their Backs, and
' wounded them so that they let out their Bowels,
' by which several of them being killed, the rest
' turned their Tails and fled. They are Crea-
' tures that fly from the bold, and pursue the timo-
' rous; nor do the Inhabitants of *Tentyra* over-
' come them so much by their natural or supe-
' rior Valour, as by their Rashness and Contempt
' of them; for they follow them of their own
' Accord, and drive them into the Snares of Nets
' that are spread for them; tho' a great many of
' them, that have not Courage enough to pursue
' like the rest, are destroyed. *Theophrastus* relates,
' that the *Nile* once brought down Sea-Water;
' and it is certain that when *Cleopatra* reigned it
' did not rise for two Years, *viz.* in the eleventh
' and twelfth Years of her Reign; which they say
' portended

'portended bad Fortune to two great Persons, 'viz. to *Antony* and *Cleopatra*, who soon after 'lost their Empires. *Callimachus* relates, that the '*Nile* in former Ages did not overflow for nine 'Years.

'NOW I come to enquire into the Cause of 'the *Nile*'s overflowing in Summer, and I shall 'first begin with the Opinions of the Antients. '*Anaxagoras* was of Opinion, that the melted 'Snow is poured down, from the Mountains of '*Ethiopia* into the *Nile*, and makes it overflow; 'and all the Antients believed this to be the 'Cause; *Æschylus*, *Sophocles*, and *Euripides*, have 'taught the same. But this is evidently false 'for several Reasons: First, *Ethiopia* is the 'hottest Country upon Earth, as appears from 'the tawny or Sun-burnt Colour of the Inhabi-'tants, and the *Troglodytes* who build their Houses 'under Ground: the Rocks also are as hot as 'Fire, not only at Noon but even at the close 'of the Day; the Dust under foot is so hot that 'Men cannot walk upon it; Silver is unsoldered; 'the Joints of Images are disjoined, and what-'ever is laid on them for Ornament dissolves or 'is peeled off; the South Wind, which blows 'from these Places, is immoderately hot, and 'those Creatures, as Serpents, &c. that elsewhere 'use to hide themselves in the Winter, never 'withdraw there, but are found in the open Field 'all the Year. There is no Snow nor heavy 'Rain falls at *Alexandria*, which is a great way 'removed from these immoderate Heats. How 'therefore should a Country subject to so much 'Heat, be covered with Snow all the Winter? 'Some Mountains indeed may have Snow on them 'there, but not more than the Ridges of *Thracia* 'or *Caucasus*; and the Rivers that flow from these 'last, swell in the Spring, and the beginning of

'Summer,

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'Summer, and are less again in Winter; because 'that in the Spring the Snow is washed down 'by the Rain, and if any is left it is melted by 'the first Heat of the Sun. Neither the *Rhine*, '*Rhone*, *Ister*, nor *Cayster*, are subject to this; they 'only are out a little in Summer, tho' the Snows 'are very deep on the northern Mountains. The '*Phasis* and the *Borysthenes* would also rise at that 'time, if the Snow could produce great Rivers 'against Summer. Moreover, if this were the 'Cause of the Increase of the *Nile*, it would flow 'most at the beginning of Summer; for then 'the Snow, being large and entire, is melted in 'greater Quantities. But the *Nile* is in it's Gran-'dure four Months, and is then always the same. 'If we may believe *Thales*, the anniversary North 'Winds resist the Descent of the *Nile*, and hinder 'it's Course, by driving the Sea in at the Mouths 'of it's Chanels, so that being repulsed it runs 'back upon itself; and is not increased, but be-'cause it cannot find a Passage, it overflows and 'breaks out in every Place where it can make 'it's Way. *Euthymenes*, of *Marseilles*, sides 'with him, and gives this Testimony: I have 'sailed, says he, in the *Atlantic* Sea; whence the '*Nile* flows larger as long as the anniversary 'North Winds blow, because that then the Sea, 'being urged by the Winds, replenish it's Stream; 'but when they cease, the Sea grows calm, 'and the *Nile* returns with less Force. Besides, 'the Sea-Water is also sweet, and the Monsters 'in it resemble those of the *Nile*. But where-'fore then, (say I) if these Winds make the *Nile* 'swell, doth it rise before they begin to blow, 'and continue after they are over? also why 'doth it not grow greater when they blow strong-'er? for it is not increased or lessened, when 'they blow more or less, which it should be, if

'it

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'it depended upon their Force. Moreover, these 'Winds blow against the Shores of *Egypt*, and 'the *Nile* descends the contrary Way against them, 'but why should it not flow from whence they 'blow, if it hath it's Origin from them? Besides, 'it would flow from the Sea pure and green, 'not troubled and muddy as it doth now. Add 'to this, that innumerable Witnesses contradict 'this Testimony, and tho' Men might lie safely 'and put any Fables upon us, as long as the 'Coasts were unknown; but now the foreign 'Coasts are frequented by Merchant-Ships, yet 'none of them mention the green Colour of the '*Nile*, or that the Sea hath any other Taste than 'usual; which is also disagreeable to Nature, for 'the Sun evaporates the lightest and freshest 'Particles. Besides, why doth it not increase in 'Winter, when the Sea is sometimes raised with 'greater Winds than these annual ones, which 'are commonly moderate; and further, if it pro-'ceeded from the *Atlantic* Sea it would cover '*Egypt* at once, and not by Degrees as it does. '*Oenopides* of *Chios* says, that in Winter the Heat 'is kept under Ground, and therefore Dens and 'Caverns are then hot, and Fountain-Water is 'warm also, that the Veins of the Earth are dried up 'by the internal Heat; but in other Countries the 'Rivers are replenished with Rain: only the '*Nile*, which is not supplied with Rain, is lessened 'in Winter, and increases in Summer, when the 'interior Parts of the Earth are cold, and the 'Fountains are fresh and cool. But if this were 'true, all the Fountains would increase, and run 'over in Summer. Besides, the subterraneous 'Heat is not greater in Winter, tho' Water, Caves, 'and Wells, are then warm, because they do not 'admit the external cold Air; so that they are not 'absolutely hot, but only exclude the cold: for 'this Reason they are cold in Summer, because 'the hot Air is kept from them. *Diogenes Apollo*-'*niates* says, that as the Sun draws Moisture to it, 'so the dry and parched Earth draws it from the 'Sea and other Waters; for it is impossible that 'one Part of the Earth should be dry, when ano-'ther is moist, because it is all over perforated and 'full of Intercourses, thro' which the dry Places 'draw Moisture from the wet, otherwise they 'would long since have been burnt up. For this 'Reason, the Sun draws the Waters to it, and the 'meridian Places that have most need of it; also 'where the Earth is most dried, it draws most 'Moisture to it. As in Lamps, the Oil runs to-'wards the Place where it is consumed, so the Wa-'ter runs towards that Place where the Earth is 'parched up with Heat. From whence therefore 'should it come but from the cold northern 'Parts? Does not the *Propontis* for this Reason 'constantly flow into the lower Seas, not as o-'thers do by a Flux and Reflux, but by a con-'stant and rapid Course towards the same Point? 'And unless by these Intercourses, Places that 'wanted were replenished from those that abound-'ed, the Earth would be soon dried to Dust, or 'laid under Water. I would willingly ask *Dio*-'*genes*, why, since the Sea and all Rivers meet 'together, they are not larger in all Countries 'in the Summer? The Sun scorches *Egypt* more 'than other Countries, and therefore the *Nile* in-'creases more: and in other Parts of the Earth 'there is also some increase of the Rivers. But 'I ask him, why then is there any Part of the 'Earth without Moisture, since the hotter it is in 'any Place the more Moisture it draws from o-'ther Countries? And lastly, why is the *Nile* so 'sweet, if it receives it's Water from the Sea? For 'no Water is so sweet as the Water of the *Nile*.'

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FROM this Passage of *Seneca* we gather the Opinions of the Antients (especially of the *Greek* Philosophers) about the Cause of the Inundation of the *Nile*. But none of them are true, because in those times no Body had travelled out of *Europe*, so far as the Springs of the *Nile*, or had visited the Nations that border on them, which are very remote from *Egypt*. But the Matter is now well searched into, and the true Cause is found out, since the *Portuguese*, and also the *English* and *Dutch*, trade with the Nations that border upon these Springs, in the Kingdoms of *Congo*, *Angola*, *Sofala*, *Mozambique*, &c. (*g*). From these

(*g*) Since we seem to have a better Account of the *Nile* than our Author had in his Time, it will not be amiss to transcribe a New Description of it from Mr *Salmon's Present State of all Nations*, Vol. 5. Pag. 10, 11.

'The River *Nile*, or *Abanes*, 'which in the *Abyssine* Language signifies the *Father of Rivers*, hath it's Sources as is 'generally held, in 11 or 12 'Degr. of northern Latitude in 'the Empire of *Abyssinia*: but 'whether the *Portuguese* Jesuits, 'as is pretended, or any other 'Persons have discovered the 'very Fountains it issues from, 'is very much questioned. I 'perceive, the Country where 'it rises, as some of the Natives 'relate, is covered with vast 'impenetrable Woods. This 'River runs a Course of about 'Fifteen hundred Miles from 'South to North for the most 'Part, and a little below *Cairo*, 'dividing itself into two Branches, one inclining to the East 'and the other to the West, fall 'into the *Mediterranean*; the 'two Mouths being about a 'Hundred Miles asunder. As 'for any other Branches of this 'River our Modern Travellers 'take no Notice of them, and 'probably those that have been 'mentioned by antient Writers 'were only *Canals* cut from one 'of these, particularly the *Canal* 'which was made to convey the 'Water from the River to *Alexandria* seems in our Maps to be 'laid out for one: However certain it is, that there are no other Branches navigable at this 'Day than those of *Damietta*, 'and *Rossetto*. While the River 'is contained within the Bounds 'of the ordinary Chanel, I do 'not find it is broader at *Old Cairo* than the *Thames* at *London*, and in the dryest Season 'of the Year is fordable in many 'Places. In the upper Parts of 'the Stream there are seven '*Cataracts*, where the Water 'falls in sheets from a very great

 'Height,

these we understand that the Fountains of the *Nile* are in the great Lake *Zaire*, situated in the Foreland of *Africa*, in the middle between the eastern and western Shore, as was said in the former Chapter. Near to this Lake are several Ridges of Mountains, particularly those called the *Mountains of the Moon*, and of *Seth*, between which the Lake lieth as in a Valley among the Mountains. And because these Places lie on the South Side of the Equator, the Motion of the Sun requires that it should be Winter with them when it is Summer with us; but by Reason of their small Distance from the Equator, they have little or no cold Weather, but Rain (instead of Snow) for two Hours before and after Noon, every Day, in the Kingdom of *Congo*. And the Clouds (scarcely ever permitting them to see the Sun) seem to cover the Tops of the Mountains, and pour down continual Showers of Rain upon those mountainous Places; which flow from thence like Torrents, and have their Confluence in the Lake *Zaire*; from whence they are discharged into the Chanel of the *Nile*, *Coanza*, *Zaire*, and other Rivers, which have their Rise from this Lake; but they do not overflow so much (tho' the *Zaire* makes an Inundation every Year in the same manner) as the *Nile*, because their Chanels are deeper, and after a short Course they exonerate themselves into the Sea; yet all of them increase at the same time, and disgorge a vast quantity of Water into the Ocean. Therefore it

'Height, causing a prodigious 'Noise, but thro' *Lower Egypt* 'it slides along with a very gentle 'Stream, and Passengers are sel-'dom surprized by Tempests on 'it 'Tis observed, the Water 'is very thick and muddy, espe-'cially when it is swelled by 'those heavy Rains which con-'stantly fall within the Tropics 'in the beginning of the *Sum-'mer*; and these are the Occa-'sion of it's overflowing the low 'Lands of *Egypt* annually.'

appears

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appears that the Inundation of the *Nile* is caused by the vast quantities of Water it receives from these continual Rains; but the Cause of these Rains is unknown, tho' it be likely they proceed from the same that generates Rain and Snow with us in Winter, which make Inundations not only in the *Nile* but in our Rivers, when they fall in a greater quantity than ordinary, as every one knows from his own Observations.

THE Time when the *Nile* begins to overflow, and also when it ends, agrees with this Cause; for the Winter, or rainy Season, in *Congo* and the mountainous Places, begins in our Spring, about the middle of *March* or *April* (which is the Time of Autumn to them, *viz.* from *May* the Twenty first to *June* the Twenty first) but is not so vehement as in *May*, *June*, and *July*: in *August* and *September* it is also moderate, and ends in the middle of *September*. The rising of the *Nile*, as was said before, begins about the seventeenth of *June* in this Age. But *Herodotus* testifies that the *Nile*, in his Time, was a hundred Days in rising, and as many in falling; therefore it began to increase some Weeks sooner, *viz.* about the first of *June*, or in *May*, and before that it must have rained some Time upon the Mountains, bordering upon the Lake, that is, from *March* to *May* or *June*. But the Reason why it begins to overflow not so soon now as formerly (*viz.* in the Time of *Herodotus*, when it seems to have begun in *April*) is because the *Nile*, by bringing down Mud and terrestrial Matter, hath made the Ground, which it overflows, higher, and therefore the Chanel is lower and deeper (as well by this as by being scoured by the rapid Current) and contains more Water than formerly, which is the Reason that it doth not so soon overflow it's Banks. And no doubt but the *Nile*, in a great many Ages, may not

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overflow it's Banks at all; for, by a continual washing down of the Earth, the Country is raised and the Banks and Shores grow higher, and in Time may make a Chanel big enough to contain all the Water of the River when it is at it's Height.

BUT we have said too much of the *Nile*, and more than we intended.

THE second of these Rivers, that overflow the adjacent Countries at a certain Time of the Year, is the *Niger*, a River in *Africa*, of no less Course than the *Nile*, tho' not so famous. It overflows at the same Time that the *Nile* does. *Leo Africanus* says, it begins to rise on the fifteenth of *June*, and increases forty Days, and decreases as many. When it is at the Height, People may sail in Boats all over *Negroland*, tho' not without great Danger.

THE third River that overflows is the *Zaire* in *Congo*, as was said before; and to this may be referred other Rivers in the same Country.

THE fourth overflowing River, is the *Rio de la Plata* in *Brasil*, which waters the adjacent Fields at the same Time with the *Nile*, as *Maffeus* observes.

THE fifth is the *Ganges*.

THE sixth is the River *Indus*. These two last pour out their Waters upon the Earth in the rainy Season *viz.* in *June*, *July*, and *August*, when the Inhabitants gather the Water into Ponds, and preserve it, that they may be supplied at other Times of the Year, when there is almost no Rain. This Inundation makes the Land very fruitful.

THE seventh includes a great many, *viz.* four or five that flow from about the Lake *Caamay* in moderate large Chanels, and exonerate themselves into the Bay of *Bengal*, flowing thro' *Pegu*, *Siam*, and other Places. That River which waters the Royal

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Royal City of *Siam* is called *Menam*, and overflows in *September*, *October*, and *November*, at which Time the Fields and Streets in the City are all covered with Water, so that the People are forced to make use of Boats to sail from one House to another. This also causes an exceeding Fertility.

THE eighth is the River [*Mecon*] in *Cambodia*, which overflows in Summer; but is not right placed in Maps.

THE ninth is the River [*Paraguay*, which is a Part of the *Rio de la Plata*] and overflows at the same Time with it, and the *Nile*.

THE tenth includes those in *Cormandel* in *India*, which overflow in the rainy Months, and are fed by the Rain that is poured from mount *Gaté*.

THE eleventh is the *Euphrates*, which overflows *Mesopotamia* on some particular Days of the Year.

THE twelfth is the River *Sus*, or *Azus*, in *Susa*; which overflows in Winter.

I do not remember to have read of any other Rivers, besides these, that overflow annually at a stated Period, tho' there are several that do it most Years, as the *Oby*, the [*Hoambo*] or *Yellow River* in *China*, &c.

THERE are many Rivers that overflow without keeping a set Time, and indeed scarce any of the larger Sort but what break over the Banks, at one Time or other, as the *Elbe*, the *Rhine*, the *Weser*, &c. And if it were not for the Depth and Capacity of the Chanel, all great Rivers would annually overflow; for most of them are vastly increased in the Spring. And it may so happen, that a River which did not use to overflow may begin to do it yearly, if any Part of the Chanel be raised higher by Sands, or otherwise, so as almost

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to equal the Height of the Banks. But to prevent this, Men commonly raiſe the Banks in proportion.

THE ſole Cauſe of theſe Deluges is the great quantity of Water which in ſome Places is drained from the melted Snow, and in moſt others, proceeds from frequent Rains and violent Showers. Yet it is to be admired why the *Indus* and the *Ganges* ſhould not overflow at the ſame Time that the neighbouring Rivers do, which proceed from the Lake *Chaamay*; tho' it may be thought perhaps that this difference of Time, is partly owing to the anniverſary Rains in the adjacent Places, and partly to the Mountains that ſurround the Sources or Spring-Heads, as we ſaid of the *Nile*; but to avoid Prolixity, we ſhall forbear examining every Particular. The River [*Aiſne*] near *Paris*, in *France*, ſometimes ſwells ſo much, without any more Rain than ordinary, as to overflow the Suburbs of *St Marcellus*, and do a great deal of Damage.

THE Reaſon why almoſt all theſe Deluges make the Fields fertile, is becauſe the Water that overflows them is either melted Snow or Rain, which being light and ſpirituous, and containing ſulphureous Matter mixed with it in the Air, is more prevalent to make the Ground fruitful, and alſo more wholeſome than mineral Water; and that Rain-Water contains ſuch Sulphur and Spirit, appears, 1. From the Worms that are bred in it. 2. From it's quick Putrefaction. 3. From the chymical Diſtillation of it. Yet there are ſome Rivers that do not make the Land fruitful by their Inundation but rather barren, as the *Loire* in *France*; whilſt the *Seyne*, with it's fat and ſoft Waters, makes the Land fertile.

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PROPOSITION XXI.

To explain how Springs break out of the Earth.

WE have shew'd in the fourth Proposition, whence the Water proceeds that flows out at Fountains; we now come to enquire how the Collections of Waters are made to spring out of the Earth, which one would think could not be done withont a violent Perforation of the Ground. But there are various Causes that make way for a Spring: 1. If there be a Cavity, or Receptacle, in any Place, the Water, of it's own Nature, and without any other Cause, will distil and drain into it, and, in process of Time, by constantly pervading the Crannies and Passages, will make them larger, 'till at last the Cavity be full, and overflow into a Rivulet; and the same may happen if there is no Receptacle, if the Spring be upon the Side of a Mountain, or even upon the Top of it. For this Cause there are several Springs found in Woods, and shady Places, where the Rain-Water moistens the Earth; and because it is not so soon evaporated by the Heat of the Sun, or a free Air, it draws to it by degrees the secret Water of a future Fountain. 2. The Spirits that are mixed with the Waters yet in the Earth, and the Rarefaction of them whereby they take up a larger Space, often remove the Earth, and make way for Fountains; for Water is more spirituous while it is hid under Ground: subterraneous Fires also contribute much to it's Rarefaction. 3. Fountains are brought to Light by Showers of Rain, which pervade the Pores of the Earth, and enlarge them, and by mixing with the subterraneous Water, draws it to a Head, by a mutual Coherence or Attraction. 4. Sometimes Fountains

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tains are opened by Earthquakes; as the River *Ladon* which run formerly between *Helis* and *Megalopolis* was disclosed by an Earthquake. 5. Sometimes they are discovered, by chance, as the Ground is digging. 6. Several have been discovered by Animals rooting up the Earth with their Snouts. Thus the first of the Salt-Springs in *Lunenburg* was discovered by a Hog's rooting up the Ground, and making a Gutter, into which the Water spouted up, and filled it, and he (according to the nature of them) laid himself down in the Water; when he had got up again, and the Sun had sufficiently dried his Back, some body discovered a certain whiteness upon him, which, being more narrowly observed, they found to be white Salt; then they sought for the Place where he had laid down, and found it to be a Spring, producing Salt; which made them begin to seek for more, and they soon discovered several others. From this the Town acquired all it's Riches and Splendor, and to this very Day there is kept in the *Stadt-house* of *Lunenburg* the same Hog quartered and smoaked hanging upon a Beam, whose Parts are grown so thin, by length of Time, that they seem to be only Pieces of Leather.

PROPOSITION XXII.

A Place being given in the Earth, to know if a Fountain or Well may be made in it.

VITRUVIUS in his Architecture (*Book* viii. *cap.* 1. learnedly assigns the Marks by which we may know this, from whom *Pliny* and *Palladio* have borrowed what they wrote upon this Subject. *Besonus* hath added to it in his Book published the same Year 1569. We shall here give *Vitruvius*'s own Words.

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'IF (ſays he) your Fountains do not flow, you 'are to ſeek out their ſubterraneous Feeders, and 'collect their Waters together, which are thus to 'be found. A little before Sun-riſing, lie with 'your Face cloſe to the Earth, in thoſe Places where 'the Water is ſought for, and ſupporting your Face 'with your Chin upon the Ground, look round the 'Country; for by this means the Sight, being no 'higher than it ought to be, will not miſtake, but 'ſee as much of the Country as is upon the ſame 'level; then where you obſerve the Vapours to 'vibrate backwards and forwards, and to riſe up 'into the Air, there you may dig; for this Sign is 'never obſerved in a dry Place. Moreover, they 'that ſearch after Water, ought to conſider the 'Soil, for there are different Sorts of Water in 'different Soils. In chalky Ground the Water is 'ſmall and weak, of no great Depth; and not of 'the ſweeteſt Taſte; in looſe gravelly Ground it 'is alſo weak, and if it be drawn from a great 'Way under Ground, it is muddy and bitter; in 'black Ground, there are found ſeveral ſmall 'Drains and Runnels, the Water of which, being 'collected into Ponds, made in firm and ſolid 'Ground, has an excellent Taſte; in ſandy Ground, 'or among Grit, there is moderate Water, but no 'Veins of it found, yet what there is in it is very 'good; in hard gravelly Ground, mixed with Par-'ticles of Coal, you are ſure to find excellent, 'well taſted, Water; in red ſtony Ground there is 'plenty of good Water, if it do not ſink into 'the Interſtices and waſte away the Stones; at the 'roots of Mountains, and among Flint Stones, 'there is the coldeſt and moſt wholſome Water, 'and the greateſt Plenty of it; but Springs that 'are found in low champain Ground, are ſalt, 'heavy, warm, and unwholſome; unleſs they 'come in ſubterraneous Paſſages from the Moun-

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'tains, and break out in a part of the Plain 'that is well ſhaded with Trees, for then they 'excel the Mountain Springs in ſweetneſs. There 'are ſeveral other Signs to find Water by, beſides 'thoſe already mentioned; as if there be found 'growing in any Place, ſlender Bull-ruſhes, wild 'Willows, Alder Trees, *Agnus caſtus*, Reeds, Ivy, 'or the like, which cannot grow or be nouriſhed 'without moiſture (tho' theſe alſo uſe to ſpring 'up in Ditches, into which the Rain-Water is 'drained from the adjacent Fields in Winter, and 'is there preſerved longer than ordinary, but you 'muſt not truſt to ſuch Places) only in thoſe 'Countries or Places which have no Ditches, and 'where theſe Signs appear growing naturally, 'Water may be ſought for. And in thoſe Coun-'tries where there are no ſuch Signs; to find the 'Water, let there be dug a Place about three 'Foot broad every way, and no leſs than five 'Foot deep, and let there be placed in it, about 'Sun-ſet, a braſs or pewter Diſh or Baſon (which 'is at hand) upſide downwards, beſmeared all o-'ver on the inſide with Oil; let alſo the top of 'the Place be covered with Leaves or Reeds 'caſt upon the Earth; the next Day let it be o-'pened, and if there be Drops, or a Sweating, 'in the Veſſel, there is certainly Water there. 'Alſo if there be put in the ſame Place a Veſſel 'made of Chalk not boiled, the Veſſel will be diſ-'ſolved or at leaſt very moiſt if there be Water 'there; if a Fleece of Wool be placed there 'over Night, and if the next Morning Water 'may be wrung out of it, it is a Sign that there 'is plenty of Water in that Place. If a trimmed 'Lamp, full of Oil and kindled, be put cover-'ed into that Place, and the Oil is not ſpent the 'next Day, but ſome Relicks both of the Oil and 'the Wick ſomething moiſt is left, it ſhews that

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'there is Water there; because all Heat draws 'moisture to it. If a Fire be made there, and 'the Earth be throughly warmed and burnt, and 'a Cloud of Vapours arise, that Place affords 'Water. When these Things are tried, and the 'forementionꞌd Signs appear, a Well may be sunk 'there, and as soon as Water is found, Chanels 'may be dug round about to bring it to a Head. 'But these are to be sought for chiefly in Moun'tains and northern Countries, where the Water 'is more pleasant, wholesome, and plentiful; for 'they are turned from the Course of the Sun, 'and are frequently covered with Woods and 'Trees, and the Mountains themselves afford cool 'Shades, so that the direct Rays of the Sun do 'not reach the Earth to draw out it's moisture. 'The Vallies between the Mountains also receive 'a greater share of the Showers, and the Snow is 'longer preserved under the shade of Woods and 'Mountains; which being melted, pervades the 'Pores and Veins of the Earth, and is carried to 'the very Roots of the Mountains; where it 'feeds some Fountain or other with Water. But, 'on the contrary, in plain champain Countries, 'they have seldom plenty of Water, and if they 'have, their Springs cannot be sweet, because the 'vehement Heat of the Sun, being uninterrupted 'by any Shade, sucks up the moisture; and if 'there be any fine, light, and wholesome, Water 'above Ground it is evaporated by the Heat 'of the Air, and the hard, heavy, and unwhole'some Particles are only left in these Fountains.'

BUT at this Day, without regarding any Signs, they dig up the Ground sometimes to a great Depth, where there are, for the most part, found Veins of Water, or Spring-heads, or Receptacles of Water, or subterraneous Rivers.

OTHERS superstitiously take the Branch of a Hazle-Tree, cut down at certain Aspects of the Planets, and pretend to know thereby where Water lies concealed.

PROPOSITION XXIII.

To make a Well or Fountain in a given Place, if it be possible.

LET us again use the Words of *Vitruvius*, because he was a Person well versed in these Affairs; and I myself never practised any such Business.

'REASON (says he in Chapter vii.) must not 'be despised in digging of Wells; and the na'ture of Things is to be diligently searched into, 'because the Earth hath several Sorts of Matter 'in it, and is (as all other Things are) compo'sed of four Principles, of which the Earthy Part 'itself is one; and Moisture, from whence Foun'tains proceed, is another: also Fire and Heat, 'from whence proceed Sulphur, Alum, and 'Bitumen, and the thick Spirits of Air, which 'pervading the Pores, Interstices, and Fissures 'of the Earth, gather to the Place where the Well 'is sunk, and send the natural Vapour they bring 'along with them into the Nostrils, and stop the 'Motion of the animal Spirits, so that unless 'they can quickly get out they immediately 'perish. But to prevent this, they should let 'down a lighted Candle, which if it continue 'burning, there is no danger in going down; 'but if it be put out, by the strength of the 'Vapour, then they must dig in other Places 'near this Shaft, and make Tubes (that the Earth 'may have Nostrils as it were) to discharge the 'noxious Vapours out of it's Bowels. When these

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'are finished, and you are come to Water, let 'the Well be built round within, but not so as 'to stop the Veins from running; but if the Earth 'be hard, and the Veins not quite at the Bottom, 'then must Plaister-work be made to receive the 'Water from the Ledges and upper Places. To 'make your Plaister durable, let the finest and 'hardest Sand be got, and a certain Weight of 'Flint broken to powder; mix the Sand with the 'best quick Lime, two Parts of the one to five 'of the other, and add to this the Cement or 'Powder; with which plaister the Sides of the 'Well to the intended Depth, and fasten it with 'Beams of Wood nailed into it, lest it should 'fall in. This being done let the Earth in the 'Bottom be clean taken out as far as the Plaister-'work goes, and when it is levelled, ram the 'same sort of Plaister upon it, to what thick-'ness you please. If this Work be repeated o-'ver and over, and the Plaister laid on thick, 'the Water, by being strained thro' it, will 'be more refined and made more wholesome; 'for the Mud by it's subsiding will make the Wa-'ter clearer; and it will keep it's Taste without 'any noisome Smell; otherwise it may be needful 'to add Salt to refine it.

PROPOSITION XXIV.

To know whether Fountain-Water be wholesome.

OF this *Vitruvius* writes thus (Book viii. Chap. v.) 'The Proof or Trial of Fountains is to be made 'in this manner. If they bubble out of the Earth 'and flow, let the Inhabitants that live near the 'Fountain-Heads be observed, and if they have 'strong Constitutions and healthy Bodies, are well 'coloured, without distorted Limbs or blear

'Eyes,

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'Eyes, the Waters are certainly good. In like 'manner if a Well be new ſunk, take ſome of 'the Water and ſprinkle it upon a Veſſel made 'of the beſt Braſs, and if it leave no Spots or 'Stains, it is the beſt of Water. Let it alſo be 'boiled in a brazen Kettle, and if, after it is 'ſettled and poured out, there be no Sediment 'of Sand or Slime at the Bottom, the Water 'is certainly good. If Peaſe or Beans be 'quickly boiled ſoft in it, it is a Sign the Water 'is good and wholeſome. Likewiſe if it appear 'clear and tranſparent in the Fountain, and no 'Moſs or Bull-ruſhes grow in any Place where it 'flows, alſo if the Places be no way corrupted 'with Filth, but are of a fine ſort of Earth; 'theſe are all Signs that it is light and whole-'ſome Water.'

PROPOSITION XXV.

To make an artificial Fountain in any Place if it be poſſible.

A Fountain is ſaid to be artificial or only apparent, when it is fed by a ſubterraneous Chanel conveying Water from a higher Place; as we ſhewed in Propoſition 5. Such an one as this may be made, if there is any Lake, River, or Fountain near, *viz.* by cutting a Chanel under Ground from the Place propoſed to one of theſe, whereby to convey the Water; as we ſhall ſhew in the next Propoſition.

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PROPOSITION XXVI.

To bring a River from a given Fountain, or River, to a place appointed.

IF the Fountain or River is higher than the proposed Place, it will be easily done by those Instruments that are used for levelling Places, to convey Water from a certain Height to such or such a Level. Let there be therefore a Chanel cut from the Fountain or River to the Place proposed, and let it incline, or be more or less levelled, according as you would have the Water to run slow or swift, for you are not stinted by this Problem. To make Aqueducts that will convey Water with a moderate Celerity, they commonly depress the Chanel no less than half a Foot in five hundred, otherwise the Water will run too slow, or not at all. *Vitruvius* requires no less than half a Foot in one hundred and no more than a Foot, or at most a Foot and a half, otherwise the Course will be too swift and rapid: But if the Fountain be not higher than the given Place, you must use Engines for raising the Water, for the making of which you must consult Mechanics: and other things are to be considered in this Affair. Some of the *French* write, that the River *Seine*, in running from the *Arsenal* at *Paris* to the royal Gardens of the *Tuilleries*, which is five hundred Fathoms, falls scarce one Foot; but it is to be considered that in some Parts of the Chanel there is no need of so great an Inclination, the Water having acquired some Force already. By this Problem Rivers are also joined, and Canals cut from one to another for the Use of Navigation; as from the *Tanais* [or *Don*] into the *Wolga*, and from the *Hoambo*, or Yellow River, to the [*Kiam* or] Blue River in *China*, *&c.*

PROPOSITION XXVII.

Some Rivers are remarkable for their long Courses, others for their Breadth, some are famous for their Swiftness; and others for the peculiar Nature of the Water they carry, and some again for two or more of these Properties.

THIS Proposition requires no Proof. We need only enumerate those of the larger sort, *viz.* that have a long Course, and are famous for their Breadth: of such there are but sixteen hitherto discovered. The *Nile*, *Oby*, *Jenisa*, [the River of the *Amazons*], *Rio de la Plata*, *Parana*, *Miary*, *Oroonoque*, *Ganges*, *Danube* (*b*), *St Lawrence* in *Canada*, *Niger* in *Africa*, *Nubia*, *Wolga*, the blue and the yellow River in *China*.

THOSE famous for Breadth, tho' not of so long a Course, are about twenty. The *Indus*, *Zaire*, *Coanza*, these from the Lake *Chaamay*, the *Euphrates*, *Tanais*, *Petzora*, [*Maia*] *Tobol*, and *Yrtisch* in *Siberia*, *St Esprit* in *Africa*, *Amana* in the *American Castile*, *Magdalen*, *Julian* in *Chica*, *St Jaques* in *Peru*, the *Rhine*, *Elbe*, *Maes*, *Borysthenes*, and *Totonteac* in *New-Britain*.

WE shall here only trace the Course of ten of the largest Rivers, leaving the more accurate Explication of them and others to special Geography.

THE *Nile*, *Niger*, and *Ganges*, run almost in a strait Course, the rest have many and large Curvatures.

1. THE *Nile* has it's Fountain in the Lake *Zaire*, in six Degrees of South Latitude, and it's

(*b*) The *Danube* is said to perform a Course of above 1500 Miles in a strait Line, from it's Rise to it's Fall.

Mouth

Mouth in thirty one Degrees of North. It flows from South to North, and is in some Places very broad; but in others narrow, and hath two great Cataracts. The length of it's Course is about six hundred and thirty *German* Miles, or Two thousand five hundred and twenty *Italian*; which we may reckon to be Three thousand for it's Curvatures. It overflows every Year.

2. THE *Niger* (*i*), a River in *Africa*, (sometimes called *Senegal*) arises from a Lake of the same Name, in 5 Degr. of North Latitude. Some have formerly thought it to proceed from the *Nile* by a subterraneous Passage, because it annually overflows at the same Time with the *Nile*. One of it's Mouths is in 11 Degr. of Latitude, but the furthest is 15 Degr. distant from the Equator. It flows from East to West, and in one Place hides itself under Ground, and again emerges. It's Course is about 600 *German* Miles, but less if you neglect it's greatest Curvatures, and more if you include them.

3. THE *Ganges*, in *Asia*, has it's remote, and not well known, Fountain a great way up in *Tartary*; some place it in 35 Degr. of North Latitude, and others further North. It has it's Mouth in the

(*i*) *De l'Isle* in his Maps makes the River *Niger* to lose it's name at the Lake *de Guarde*, and from thence to the Sea which in a strait Line is 700 *British* Miles, is called *Senegal*; and makes the River *Gambia* to have no Communication with the *Niger*; but we have no sufficient Proof that there is any such River as the *Niger*: But Mr *Snow*, late Governour of *James Fort* on *Gambia* River, informs me, that the *Senegal* hath not so long Course as it is represented in those *Maps*; and that it is a barr'd River, and capable of admitting nothing larger than Barks up to the *French* Settlements, above which, only flat-bottom'd Boats can float so high as *Gallam*: Whereas the *Gambia* is navigable for Ships of any Bur, then about 50 Leagues above the *English* Settlements, and for Vessels of 100 Ton up to *Barraconda*, and something higher, (for so far the Tide prevails) and is near 150 Leagues above *James Fort*. *Templeman's Survey*.

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Latitude of 22 Degr. and flows from North to South. It's Courſe is about 300 *German* Miles, and every Year it overflows it's Banks.

4. THE *Oby*, a great and every where broad River in *Aſia*, has it's Fountain in the Lake *Kan Kiſan*, among the Mountains of *Tartary*, in the Latitude of forty eight Degrees North. It has it's Mouth in ſixty nine Degrees of Latitude, and runs a Courſe of about four hundred *German* Miles, without it's Curvatures. It divides itſelf in *Siberia*, into two Branches, or rather ſends forth an Arm which makes a Curvature, and returns to it again, and ſo forms an Iſland, in which there is a City built by the *Muſcovites* and *Siberians*, called *Jorgoet*.

5. THE *Jeniſa*, a River in *Aſia*, hitherto unknown to our Geographers, but taken Notice of by the *Muſcovites*. It is ſaid to be much greater than the *Oby*, from which it is diſtant eaſtward, about ten Week's Journey, towards *Tartary*. There is a Range of Mountains runs for a great Way along it's eaſtern Banks; and the weſtern Shore is inhabited by the [*Ton-Guiſins*]. It overflows the weſtern Shore ſeventy *German* Miles every Year in the Spring, when the Inhabitants are forced to betake themſelves, with their Cattle and Tents, into the Mountains on the eaſtern Shore. Where it begins and ends is not known, but it is thought to run as long a Courſe as the *Oby*.

6. [THE *Maia* or *Lena*] is far diſtant from the *Jeniſa* eaſtward. The eaſtern Branches are ſaid to proceed from the Borders of *China*, and the Kingdom of *Cathaia*; if there be ſuch a Place. It's Fountain and Mouth are unknown; and it is not reckoned one of the largeſt ſort of Rivers; only we are willing to mention it here, becauſe it has not been taken notice of by any Geographer, no more than the *Jeniſa* and *Yrtiſch*.

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7. THE River of the *Amazons*, (or *Rio de Orellana* from *Francisco Orelli*) in *America*, is thought to be one of the greatest Rivers upon Earth. It's Fountain is in the Province of *Quito* in the Kingdom of *Peru*, near the Equator, and it's Mouth, being 15 Leagues broad, is in 2 Degr. of South Latitude. It is said to run a Course of 1500 *Spanish* Leagues, by reason of it's great number of Windings, tho' it extends not above 700 in a strait Line. Some confound this with, or will have it to be, a Branch of the *Miary*. It is in some Places four or five Leagues broad, but it receives it's Water not so much from Fountains, as from the Rains that fall upon the Mountains of *Peru*; and therefore is nothing nigh so broad in the dry Seasons. This makes Travellers disagree in their Descriptions of it.

8. THE River of *Plate*, *Argyropotamus*, or *Rio de la Plata*, in *Brasil*, hath it's Fountain in the Lake *Xarayes*, and receives a Branch from about *Potosi*, and it's Mouth in 37 Degr. of South Latitude, which is said to be twenty Leagues broad; but when it overflows, it has a great many Mouths, which are accounted but as one; for at other times it hath not much Water in it. The Inhabitants call it *Paranaguasa*, i. e. *The River like a Sea*, as some observe.

9. THE *Omarânan* is likewise a River of *Brasil*, flowing thro' a long Tract from the Mountains of *Peru*. These three great Rivers of *Brasil*, *viz.* the *Orellana*, the *Rio de la Plata*, and the *Omarânan*, meet in certain mediterranean Parts of *Brasil*, so as to form Lakes, from which they again rise separate.

10. THE River of *St Laurence* flows between *Canada* and *New-Holland*, in *North America*, and hath it's Fountain in the Lake [*Frontenac* or] *Iro-*

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quois. It's Course is no less than 600 *German* Miles.

PROPOSITION XXVIII.

There are Whirlpools and deep Pits found in some Rivers.

THUS in the River *Soame* in *Picardy*, between *Amiens* and *Abbeville*, there is a *blind Whirlpool*, into which the Water rushes with such Violence, that it's clashing may be heard several Miles off. There are many others of this kind.

PROPOSITION XXIX.

River Water is lighter than Sea-Water.

THE Reason is, because Sea Water hath much Salt in it. From whence it happens, that some things sink to the bottom in Rivers that floated upon the Sea; as very often heavy loaded Vessels, which were born up at Sea, sink in the Harbour. However, the Proportion between them is various, and they both differ in Weight in divers Places. We commonly say, they are as 46 to 45, *i. e.* 46 measured Ounces of River Water equiponderate 45 of Sea Water.

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CHAP. XVII.

Of Mineral Waters, hot Baths, and Spaws.

SINCE there are ſeveral Species of liquid Bodies, or Waters, whoſe peculiar Properties ſeem ſurprizing, it has given Occaſion to Geographers to treat thereof; but all of them hitherto, except a bare Recital of their Names, and a ſhort Account of ſome of the moſt extraordinary Fountains, have added nothing to give us an Inſight into their Cauſe. But we ſhall here treat of them more fully, and explain their *Cauſes*, and alſo ſet them in a clearer Light.

PROPOSITION I.

No Water is pure and elementary; but contains other Particles mixed with it, ſuch as are found in terreſtrial Bodies; and theſe are not only earthy, but alſo of various other kinds, as Oil, Spirits, *&c. But that is called* Mineral Water *which contains ſo many of theſe Particles different from the Nature of Water itſelf, that from them it acquires ſuch remarkable Properties, as affect our Senſes and makes us take notice of it.*

THE Truth of this Propoſition is apparent from Experience, and is proved as well from the different Taſtes of the Waters as from Diſtillation; and all Naturaliſts agree that there is no ſuch thing in Nature as pure or ſimple Water, or any other Element ſeparated from others, becauſe of the conſtant and various Agitation of the Particles of Bodies. But in mineral Waters (that we may come cloſer to our Subject) the cauſe of this Mixture is their receiving the ſpirituous Particles of heterogeneous Bodies; for Rain and the very Air itſelf that covers the Water, is impregnated with many different ſorts of Particles.

ALL Waters therefore have a Mixture of Particles of another Nature, tho' all have not the ſame Quantity of them; and tho' there flow into the *Rhine*, the *Danube*, and the *Elbe*, and into all great Rivers, ſeveral Rivulets impregnated with mineral Particles in ſuch Quantities as to affect the Senſes; yet becauſe, beſides theſe, there are many other Brooks that flow into the ſame Rivers which are not impregnated with a ſenſible Quantity of heterogeneous Particles; and becauſe moſt of their Water proceeds from Rain and Dew, therefore theſe heterogeneous Particles are not eaſily diſcovered in ſuch great Rivers, tho' they are received by them; but require to be ſeparated by Art, if we would know their Taſte and Qualities. We therefore call that mineral Water which hath ſome remarkable Property more than what is obſerved in common Water, or hath ſo large a Mixture of heterogeneous Particles as ſenſibly to alter it's Taſte.

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PROPOSITION II.

Mineral Waters are of three kinds.

SOME are corporeal, (we want a better Word for it) others ſpirituous, and the reſt both corporeal and ſpirituous. Thoſe we call corporeal mineral Waters do contain fixed and ſolid Particles of Minerals and Foſſils, which can be ſeparated from the Water, and ſeen with the naked Eye; and ſuch as theſe are of two ſorts: Some carry large Particles of Minerals and Foſſils, which may be perceived with little or no trouble in the Water itſelf; nor are they properly ſpeaking mixed with the Water: Such as theſe we treated of in the foregoing Chapter, and have in them Grains of Gold, Silver, *&c.* and therefore are called auriferous, argentiferous, *&c.* But ſuch are not properly called mineral Waters, becauſe they have not theſe Particles mixed with them, but ſeparate; neither do they receive any Property or Quality from them: yet becauſe Men admire ſuch Rivers and their Explication hath a great Affinity with the Deſcription of mineral Waters properly ſo called, we thought fit to mention them under the ſame Head; to which may be added bituminous Fountains, *&c.*

BUT corporeal mineral Waters are more properly ſuch as indeed contain ſolid Particles of Foſſils, but ſo ſmall and minute that they are entirely mixed, and cannot quickly be diſtinguiſhed by the Sight, unleſs they are made to ſubſide by Art, or a long ſpace of Time; or by Concretion are brought to a viſible Maſs, ſuch as Salt and ſulphureous Fountains, *&c.* and chymical Waters in which Metals are diſſolved.

SPIRITUOUS

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SPIRITUOUS Waters are those that contain only a volatile Spirit, such as is found in Minerals; but have no fixed Particles in them; and therefore their Composition can never be made visible.

WE call those Waters both corporeal and spirituous, which contain not only fixed and solid Particles of Minerals, but also volatile and spirituous: Of all which we shall give Examples in the following Propositions.

PROPOSITION III.

To explain how mineral Waters are generated.

1. IF the Water be carried under Ground with a rapid Course among metalline and mineral Earth, which is easily loosened, it is evident that it washes Particles from it, and may carry along with it Grains of these Minerals; and this is the generation of these corporeal mineral Waters that hold Grains in them.

2. IF the Minerals are imperfect and not so closely joined, as Vitriol, Sulphur, *&c.* or even Salt, which of their own Nature easily mix with Water; and if a Rivulet, or Gut of Water, runs thro' Beds or Mines of such Minerals, or be strained thro' them (without a Chanel or Duct in such a Manner as we explained in Proposition 5. of the preceding Chapter) the Water when it breaks out at the Fountain will have small Particles of these Minerals mixed with it, and will be corporeal mineral Water, of a subtile Composition, according to the smallness of the Atoms. Now whether the Water can in like manner dissolve or unite with itself the Particles of Metals, is to be questioned, because they are hard and solid, and therefore are not easily blended with Water. I acknowledge

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acknowledge this may be done, but not with simple or common Water, but by a vitriolic and salt spirituous Water, like the *Aqua Fortis* of the Chymists; for as *Aqua Fortis* dissolves Metals into Atoms, and easily unites them with itself, so that they do not subside at the Bottom, unless they be separated by Art: in like manner when such Water runs thro' a metallic Earth, it may dissolve the metalline Particles and unite them with itself; and thus are the corporeal mineral Waters of the second Sort, accounted for and explained.

3. BEFORE Metals are formed in the Bowels of the Earth, Steams and Vapours are condensed about the extant Corners of the Rocks, to which they stick fast; being at first but of a soft Substance, though they are afterwards hardened by degrees; if therefore the Water should run or gleet thro' the Places where such Vapours are in Commotion, it is impregnated with them; and thus spirituous mineral, and metalline, Waters are produced. Imperfect Minerals also make mineral Waters of their own Nature, after another Method; *viz.* when, being heated by a subterraneous, or their own proper, heat, they send forth Spirits and Vapours, as Sulphur, Vitriol, Salt, Coal, *&c.* And such Fumes and Exhalations are always stirred up where there are such Minerals; among which the permeating Water is impregnated with that Spirit. Some think these spirituous Waters may be generated by being only carried thro' a metallic Earth, or by having their Receptacles in it, or in their Mines; but it is found to the contrary by Experience, that Water receives no Quality from Metals and Minerals, tho' they should be immersed in it a great many Years. Therefore, rejecting this Opinion, it is most reasonable to suppose, that these Waters receive a certain Spirit, from the Seeds of Metals, or first Principles,

as

as we may call them; or we may ſay that ſuch Waters are impregnated with the ſubtile Spirits of Vitriol, Salt, *&c.* by the help of which a Spirit is extracted from hard Metals; but I do not lay ſo great Streſs upon this latter cauſe; for a Queſtion will ariſe again about the Generation of this ſpirituous, mineral, vitriolic, and ſalt Water.

FROM theſe together it appears, how mineral Waters, both corporeal and ſpirituous, are generated.

PROPOSITION IV.

There are innumerable Kinds of mineral Waters, according to the Variety and Diverſity of the Particles, they receive from different Minerals.

WE have ſhewed and explained in the former Propoſition, how mineral Waters receive theſe Particles (from which their extraordinary Qualities ariſe) from Minerals, or Foſſils. Now becauſe there are divers Kinds of Minerals, it hence follows, that mineral Waters are various, and almoſt infinitely different in their Qualities; not conſiſting of one kind of Water impregnated with only one ſort of Mineral, but of various Kinds, mixed with various Sorts. Wherefore mineral Waters are either ſimple or mixed; and the Mixed have two, three, four, or more, ſorts of Foſſils in them.

HENCE are, 1. Metallic Waters, as of Gold, Silver, Copper, Tin, Lead, Iron, *&c.*

2. SALT Waters, as of common Salt, Nitre, Alum, Vitriol, *&c.*

3. BITUMINOUS Waters, ſulphureous, antimonial, as of Coal, Ambergris, *&c.*

4. WATERS proceeding from various kinds of Earth and Stones, *viz.* Limeſtone Waters, (which receive

receive Particles of Lime-Stones) Chalk, Oker, Cinnabar, Marble, Alabaster, *&c.*

5. MERCURIAL Waters, *&c.*

ALL these kinds of Waters are to be understood three Ways, as was said in the second Proposition (as all other mineral Waters are), *viz.* 1. Some of them are corporeal, either sensibly so, or by a refined and subtile Commixture. 2. Others are spirituous. 3. Others are both corporeal and spirituous. These Differences may be applied to the several Kinds of mineral Waters. For Example: There are Golden Waters which are, 1. Corporeal, that carry Grains of Gold, of such Magnitude, that with small Trouble they are discernable, by reason of their gross or course Mixture. 2. Corporeal, that carry very minute Particles of Gold, well mixed with them; and tho' the smallest Particles of Gold, do of their own Nature sink to the bottom in Water, yet that there are such, appears from the *Aqua Regia* of the Chymists, in which Gold is dissolved into Atoms; but this *Aqua Regia* is not a Simple Water, neither does any Water carry Atoms of Gold in it, unless it be before impregnated with other mineral Particles. 3. Spirituous golden Waters, that have ingendered a Spirit and Vapour in the Earth from which Gold is produced. 4. Golden Waters that are both corporeal and spirituous, *viz.* that have both Atoms of Gold, and the Spirit that produces it.

THUS we are to apply this four-fold Variety to all sorts of mineral Waters, whether simple or mix'd (from whence innumerable Species are produced; for either the Bodies of Fossils, or their Spirits, or the Body of one Fossil with the Spirit of another, are mixed or ingendered in the Water): so Leaden Waters are of four kinds, *viz.* 1 Visibly corporeal. 2. Corporeal by a subtile Mixture. 3. Tinctured by the spirit of Lead. 4. Impregnated both with

with the Body and Spirit of Lead. And these four Participations of Minerals are to be applied to mercurial Waters, &c. and more especially to salt, vitriolic, and sulphureous Waters, because in these, Nature itself displays a four-fold Variety; tho' it is to be doubted, whether there be corporeal Particles of a subtile Grain in metalline Waters. Spirituous metallic Waters are also very rare; but the Water of Salt, Sulphur, &c. both corporeal and spirituous is very common, because these Fossils are found in more Places of the Earth, and in greater Plenty, and their Particles are also sooner dashed to Atoms, and dissolved by the Water; beside they frequently emit Steams and Vapours.

LET us explain this four-fold Variety of Participation by one Example of Gold.

1. IN the preceding Chapter, Proposition 16, we enumerated those Rivers that carry Grains of Gold, and with this Treasure glad the Hearts of the Natives upon their Banks; as in the County of *Tyrol*, and the neighbouring Places, there are several such; and as we said before, the *Rhine*, the *Elbe*, the *Danube*, and several other great Rivers, carry Grains of Gold in several Places (and also other Metals and Minerals) which they receive from auriferous Rivulets. The *Rhine* carries Grains of Gold, mixed with Clay and Sand, in many Places, but especially at these, *viz.* 1. Near *Coire*, in the *Grisons* Country. 2. At *Mayenfield*. 3. At *Eglisau*. 4. At *Sokinge*. 5. At the Town of *Augst*, not far from *Basil*. 6. At *Newburg*. 7. At *Seltz*. 8. At *Worms*. 9. At *Mentz*. 10. At *Bacherach*, 11. At *Bon*, &c. The auriferous Rivulets, which the *Rhine* receives, the Reader may see in *Thurnheuserus*; and also those that run into the *Danube*, and *Elbe*. Small Grains of Gold are found in the *Elbe* in these Places: 1. At *Lotomeritz* in *Bohemia*. 2. At *Purn*. 3. At *Dresden* in *Meisen*. 4. At *Torgaw*.

5. At

5. At *Magdenburg*. 6. At *Lavenburgh* Tower, five Miles from *Hamburg*. Several other auriferous Rivers are given an Account of in the forecited Book of *Thurnheuserus*; and such as carry other Metals and Minerals. And these are auriferous corporeal Waters, of the first kind, carrying visible Grains, which are not so properly called Mineral or Golden Waters, because the Gold Grains are not mixed with the Water, but only carried in it by it's rapid Motion; the Water itself being uncompounded with it.

2. CORPOREAL Golden Waters of fine Mixture, whose Atoms are united with the Atoms of Gold, like the *Aqua Regia* of the Chymists, which dissolves Gold, and unites it by Atoms to itself. For since it is possible that there may be in Nature such Water as this of the Chymists, which may run thro' Golden Earth, or Gold Mines, it is reasonable to suppose, that it eats out Particles and dissolves them into Atoms, and unites them to itself; and from this Cause proceed those (or such like) Golden Rivulets as are described by *Thurnheuserus*, in his Account of the *Danube*, *Rhine*, *&c.*

3. SPIRITUOUS Golden Waters are but very few, some of which perhaps are enumerated among the rest by *Thurnheuserus*; but these are not so much known or regarded, because Golden Earth and Gold Mines are very scarce; besides where there are such Mines, there is such a Mixture of other Minerals, that they are not perceptible. Nevertheless there are some Rivulets in the high *Alps* of *Bohemia*, that are said to participate of these Golden Spirits, as in the *Fiechtelberg* Mountains in *Silesia*. The *Hot Baths* also in the Bishopric of *Coire*, are believed to be impregnated with this kind of Spirit, yet because of the Mixture of other Minerals

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rals in a greater Quantity, this quality is rendered leſs perceptible.

4. GOLDEN Waters that carry both the Atoms, and Spirit of Gold, are ſome of thoſe Rivulets mentioned by the above-named *Thurnbeuſerus.*

LET us alſo give an example of ſalt Waters.

1. CORPOREAL ſalt Water, which carry groſs and undigeſted Particles of Salt, are found in many Places, and ſufficiently known; as Fountains, whoſe Waters produce Salt; and Sea-Water from which Salt is extracted by boiling.

2. SUBTLE corporeal ſalt Waters, which contain Salt diſſolved into the minuteſt Atoms, are ſuch as are very ſalt, and yet very clear, as many ſalt Fountains are, and Sea-Water that is thin and fine; tho' there is a great Difference in this ſubtile Mixture. Hereto may be referred the Urine of all Animals.

3. SPIRITUOUS ſalt Waters, which do not contain the Particles of Salt, but only the Spirit of it, are of ſuch a Nature, that if ſeveral Tuns be ever ſo much boiled, they will not yield any Salt. There are a great many of theſe in *Germany*, and other Places, but they are ſeldom without Mixture.

4. CORPOREAL and ſpirituous ſalt Waters, which contain the Particles and Spirit of Salt. Almoſt all corporeal Waters have ſome ſmall Portion of ſaline Spirits in them, but few of them any Quantity. Thus the Fountains about the City *Saltzinge*, near the *Rhine*, are ſalter than other ſalt Springs, and yet yield leſs Salt, becauſe their ſharp and brackiſh Taſte is heightened by a Spirit or volatile Salt, which flies away in the boiling.

HENCE it appears how this four-fold Variety of Participation is to be applied to the ſeve-

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ral kinds of mineral Waters, *viz.* to vitriolic, Alum, and Lead Waters, *&c.*

PROPOSITION V.

To enumerate the most remarkable Varieties of mineral Waters.

IN the foregoing Propositions, we have explained the Kinds and Differences of mineral Waters, taken from their Nature, which consist in having mineral Particles in them, which they carry or with which they are impregnated; but because these Varieties are not so perceptible to the Senses, and there are several Mixtures of Minerals that cause various, and almost unaccountable, Properties in the Waters, therefore they are not so easily known and distinguished by the Vulgar; for Waters (and other Bodies) become famous among Mankind, and receive their Names from their manifest Qualities which strike and affect the Senses, whose Cause and Explication is to be deduced from their Composition and Participation. There are therefore ten Species of Waters, or Liquids, that flow out of the Ground, which are commonly taken Notice of by the Vulgar. 1. Acid Waters. 2. Bitter. 3. Hot. 4. Very cold. 5. Fat and oily. 6. Poisonous or deadly. 7. Coloured. 8. Boiling. 9. Waters that harden Bodies, change their Colour, or otherwise alter them. 10. Saline. 11. To these may be added, such as are invested with other uncommon Properties. All kinds of Waters described by Authors, may be referred to one or other of these Heads. We shall here briefly explain their Generation and Differences; and give some Examples.

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PROPOSITION VI.

To explain the Origin, or Composition, of acid Waters, their Difference and real Species.

THESE four Waters, called by the *Germans Saur-Brunnen*, are celebrated in most Countries. They proceed from a Mixture of the Spirit of Vitriol, Salt, and Alum; which Minerals are found partly simple, and partly mixed, with others more or less, in the Bowels of the Earth, especially with Steel and Iron. We prove this to be the true Cause of *Acidulæ*. 1. Because almost wherever these acid Fountains break out, there are found Mines of Vitriol, Salt, and Sulphur. 2. Because the Spirits of Vitriol and Salt are acid, and also the Spirit of Sulphur, as appears from Chymistry, 3. Because no acid Body can be drawn from these *Acidulæ*, but only a Spirit which is no way unlike the Spirit of Vitriol, Salt, *&c.*

THERE is plenty of *Acidulæ* in most Countries, especially those that abound in Mines. In *Germany* alone, their Number amounts to almost one thousand. Their Cause is an acid Spirit which is found in most Bodies, and in all Herbs and Fruits.

THE difference of *Acidulæ* is remarkable: Some are so acid, that Men use them instead of Vinegar; such a Fountain as this is found in the Province of *Nota*, in *Sicily*; and another of a remarkable sourness at *Elbogen* in *Germany*. Other Fountains are called vinous because they come near the grateful Relish of Wine; of which kind there is a famous one at *Schwalbach*, in the County of *Catzenelkebogen* in *Germany* (*a*). There is a Spring near *St Baldomar*,

(*a*) Such like *Chalybeates* or *Spaws* are not so properly called *Acidulæ* or *Sour Waters*; for they do not contain any rough, vitriolic *domar*, in the Province of *Lionnois* in *France*, called *la Fontaine forte*, which supplies the want of Wine; for if one fourth Part of it be mixed with Wine, it will want nothing of it's right Taste and Relish; if it be poured on Flower, it will immediately ferment; they can boil no Meat in it, because through the Subtility of it's Spirit, it soon evaporates; *it is so exraordinary wholesome, that the Inhabitants thereabouts seldom stand in need of a Physician.*

NOT far from the Town of *Bazas* in *Guienne*, there is such a Fountain, of a sharp vinous Taste, whose Waters, if they are mixed with a sixth Part of Wine only, will drink like neat Wine, without the least mixture of Water. Near *Rome* there is a sharp tasted Alum-Fountain, whose Waters being mixed with Wine, make a very agreeable Liquor. There is a great Number of such *Acidulæ* in *High Germany*; some Part of which flow into the *Danube* and some into the *Rhine*. There are several of these in the fore-mentioned County of *Catzenellebogen*, in the Electorate of *Triers*, in *Tyrol*, in the *Grisons*

vitriolic, or acid Salts to make them taste sharp or sour, but rather leave a sweetish Flavour or Farewel behind; and tho' at the first thought one would ascribe a sharp or sour Taste to the *Pyrmont*, *Spaw*, or *Tunbridge*, Waters, yet if they be rightly considered it is their smart brisk Taste that misleads us to think them acid or truly sour. Thus Cyder and soft Ale when bottled will give the like Pungency to the Tongue, and such an acute Affection to the Palate, when it is far from being sour. *This is proved from several Experiments by Dr Slare.* See more to this purpose in a late Book entitled *New Experiments and Observations upon Mineral Waters* by Dr *Shaw*. See also Philos. Trans. No 137. Pag. 247. and No 351 Pag. 564.

The most celebrated *Spaws*, *Mineral*, or *Medicinal Waters* in *England*, are at these Places; viz. at *Bath*, and *Tunbridge*; at *Farington* in *Dorsetshire*; at *Islington*, *Hampsted*, and *Pancras* in *Middlesex*; at *Scarborough*, *Harrowgate* and *Cockgrave* in *Yorkshire*; *St Winifred's Well* in *Flintshire*; at *Dulwich* in *Surry*; at *Butterby* in the Bishoprick of *Durham*, &c.

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Country, in *Bavaria*; and a famous one called *Heilburn*, near *Anderna*. Near the Village *Valentiola*, in the Territories of *Toledo* in *Spain*, there are Fountains that are acid, and have a vinous Taste, near the Bottom, but are sweet at the Surface; which *Baccius* thinks proceeds from the subsiding of the acid and nitrous Particles; but I believe (if the Relation be true) that it proceeds rather from a subtile Spirit, which by coming to the Surface, quickly expires.

OTHER acid Fountains are astringent, and contract the Palate, which is a Sign of a Mixture of the Particles of Iron, or of Vitriol and Alum, *&c.*

THE Water of these Fountains, is observed to be not so sour in cloudy and rainy Weather, which is a sign that condensed Air is mixed with it. Also if it be exposed to the Sun, or stand for some Hours in an open Vessel, or be carried in the cold from one Place to another in Bottles not well corked, it loses it's Acidity; which is a certain sign that this Acidity proceeds from a subtile Spirit.

THEY have also the very Atoms of Vitriol, Alum, Iron, Salt, Ink, *&c.* and of Clay and Gravel, *&c.* as appears from the Matter that sticks to the Canals thro' which they flow.

THE Studious may collect a great many Examples from Authors. There are no less than two hundred acid Fountains or Rivulets, that flow into the *Rhine*; but because of the Subtility of their Spirits, the *Rhine* does not taste acid in the least.

IF any should enquire, Why there are no acid Fountains in the northern Countries? I suppose the Cause is owing to the want of subterraneous Heat, and to the great Density of the Earth; and for this same Cause there is little or no Gold found in those Countries.

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PROPOSITION VII.

To explain the Cause of hot Baths, and to enumerate the most famous ones.

THERE is a Fountain in *Iceland*, which is thought to be hotter than any of the rest, so that it's Waters differ not from those that are heated to the highest Degree by Fire (*b*); but *Caronius* writes, that in *Japan* there is a Spring so hot, that no Water can be brought to the same Degree of Heat, by the most vehement Fire; it also retains it's Heat three times longer that our common Water heated. It flows not constantly, but twice a Day for an Hour, with a great Force of Spirits, and makes a Lake, which (as another Author tells us) is called by the Inhabitants *Singacko*, *i. e.* Hell.

NEXT after these, the Baths at *Baden* in *Switzerland* are famous for their Heat. To these succeed the *Aponensian* Baths in *Italy*. There are a great Number of common ones in *High-Germany* and other Places (*c*). In *Scotland* there is a Lake called

(*b*) 'Dr *Paulus Biornonius* 'tells (in *Philos. Trans.* No '111. *Pag.* 238.) that some 'Fountains in *Iceland* are so hot 'that in a quarter of an hour 'they will sufficiently boil great 'Pieces of Beef, which is thus 'ordered: they hang the Kettles 'with cold Water, over them 'in which they put the Meat to 'be boiled; for fear of either 'burning or throwing up the 'Meat by the fervent, and ve-'hement Ebullition of the Hot 'Waters,

(*c*) There is a very hot Spring of *Mineral Waters* in *Jamaica* which comes out of a Rock in a fresh Current, near to a fine Rivulet, of good cool Water, but is so hot that it soon boils Eggs, Crawfish, Chickens, &c. The Baths at *Baden* in *Austria* are tolerab'y warm, and tinge Metals with other Colours. 'Those at the Town of *Bath* in '*Somersetshire* are not so very 'hot (even the hottest of them) 'as to harden an Egg; yet there 'is a Spring in the King's Bath 'so hot that it is scarce suffer-'able, so that they are fain to 'turn much of it away, for fear 'of inflaming the Bath. The

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called *Ness* that discharges itself into a River of that Name; which tho' they be neither of them hot yet they never freeze, but still smoke in frosty Weather.

THE Cause and Generation of hot Baths is, 1. A Mixture of sulphureous Particles which are gleaned by the Water as it is carried thro' the subterraneous Passages, or rather as it gleets thro' the Sulphur Mines to the Receptacles about the Fountains. 2. Fumes, Vapours, and Exhalations in the Bowels of the Earth, where there is pure or impure Sulphur, Fossil-Coals, Amber, &c. For these

'Queen's *Bath* is not so hot, 'having no Springs of it's own, 'but receives it's Water from 'the *King's*. The *Cross-Bath* 'is something colder than the 'others, and eats out Silver ex'ceedingly; a Shilling in a 'Week's time has been so eaten 'by it that it might be wound 'about one's Finger. In Sum'mer they purge up a green 'scum on the Top, and in Win'ter leave a *Yellow* one on the 'Walls. The Walls that keep 'in the hot Springs are very 'deep set, and large; ten Foot 'thick, and fourteen deep from 'the Level of the Street. The 'Cement of the Wall is yellow 'Clay, Lime, and beaten Bricks. 'In the Year 1659, the *Hot* '*Bath* (one particularly so cal'led of equal Heat with the '*King's Bath*) was much im'paired with the breaking 'out of a Spring which the 'Workmen at last found, and 'restored. In digging they 'came to a firm Foundation of 'factitious Matter which had 'Holes in it like a *Pumicestone*, 'thro' which the *Water* plaid; 'so that it is likely the Springs 'are brought thither by Art: 'Whence probably was the *Ne*'*cromancy* which the People of 'antient times believed, and re'ported to have contrived, and 'made these Baths; as in a very 'antient Manuscript Chronicle 'I find these Words: *When Lud* '*Hidibras* was dead, *Bladud* a 'great *Nigromancer* was made 'King; he made the Wonder 'of the *Hot Bath* by his *Nigro*'*mancy*, and he reigned twenty 'one Years, and after he died, 'and lies at the *New Troy*. And 'in another old Chronicle 'tis 'said: *That King* Bladud *sent* '*for the Necromancers* to A'thens *to effect this great Busi*'*ness*; who, 'tis likely were 'no other than cunning Arti'ficers well skilled in *Architec*'*ture* and *Mechanics*.' *This from* Mr *Joseph Glanvil's Description of* Bath *in Philosoph. Transf.* No 49. Dr *Brown* says, the natural Baths at *Buda* are the noblest in *Europe*, not only for their variety of hot springs but also for the Magnificence of their Buildings.

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Bodies conſtantly emit hot Smoke, which warms the Water as it paſſes ſuch Places (*d*). Nevertheleſs in moſt Baths there is a Mixture of the Particles of Alum, Iron, or Nitre, which give them an aſtringent and tartiſh Taſte. Moſt Baths that we know of, flow without ceaſing, except the famous Pepper-Baths not far from *Coire* in the *Griſons* Country in *Germany*, whoſe Waters contain, beſide Sulphur, ſome Gold, and not a little Nitre. They begin to ſpring yearly about the third of *May*, and ceaſe to flow about the fourteenth of *September*. The moſt celebrated Baths in *Germany* are, the leaden ones in *Louvain*; the *Emſenbades* above *Conſtance*; thoſe near *Geberſweil* in *Alſatia*; thoſe in the Marquiſate of *Baden*; thoſe in the Dukedom of *Wirtemberg*, called *Wildbad*; the *Cellenſian* Baths; the *Blaſianian* Baths, near *Tubingen*, *&c.* There are many in *Japan* and the *Indian* Iſlands: and ſome in the *Azores* ſo hot that Eggs may be boiled hard in them.

PROPOSITION VIII.

To explain the Cauſe and Generatoin of oily and fat Liquids that flow out of the Earth, and to enumerate the Places in which the chief of them are found.

SOME Fountains pour out a bituminous Liquor, others a fat Water, or Water in which Drops of Oil ſwim about. Two Miles from *E-*

(*d*) They beſt account for the Heat of theſe Fountains, who ſuppoſe, that two Streams having run thro', and imbibed certain Sorts of different Minerals, meet at laſt, and mingle their Liquors; from which Commixture ariſes a great Fermentation that cauſes Heat, as we ſee in *Vitriol* and *Tartar*, which when mingled cauſe an intenſe Heat and Ebullition. *See the laſt mentioned* Philoſ. Tranſact.

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dinburgh in *Scotland* there flows a Fountain upon the Superficies of which ſwim Drops of black Oil, which the Inhabitants uſe o ſoften their Skins, and to remove Scabbineſs (*e*). Among the Antients a River in *Cilicia* called *Liparis* was famous, in which they that waſhed themſelves, were thereby anointed as if they had been in Oil; but I doubt whether there be any ſuch River now. So likewiſe there was a Lake in *Ethiopia* which anointed thoſe that ſwam in it. In *India* alſo there was a Fountain which, in a clear Sky, ſent out abundance of Oil. At *Carthage* there was a Fountain upon which floated an Oil that ſmelled like the Saw-duſt of a Citron-Tree: this they made uſe of to anoint their Cattle with. *Vitruvius* tells us, that there were Fountains in the Iſland of *Zant*, and about *Dyrrhachium*, now *Durazzo*, and *Apollonia*, that vomited out a great deal of Pitch with the Water. Near *Babylon* there was a vaſtly

(*e*) *Pliny* ſaith, that the *Salonian* Fountain, and *Andrian* Spring flow with Oil and Wine. ' *Polyclytus* relates, that ' near *Soli* a City of *Cilicia* ' there was a Spring that ſup- ' plied the Place of Oil. *Theo-* ' *phraſtus* ſays, that there was ' a Spring in *Ethiopia* which ' had the ſame Faculty; that ' the Water of the Spring *Lycos* ' would burn by putting a Can- ' dle to it; and the ſame is re- ' ported of *Ecbatana*.' *Clarke upon Rohault's Phyſ* Vol. 2. Pag. 201. Many ſuch Fountains of *Petroleum*, and oily Subſtances, are now to be met with up and down; as at *Pitchford* in *Shropſhire*, and in the Iſland of *Zant*, very plentifully; in the *Valtaline*, ſubject to the *Griſons*; at the Foot of Mount *Zebia* in the Duchy of *Modena*; at *Gabian* in the Road from *Montpellier* to *Beziers* in *Languedoc*. The Inhabitants living near theſe fat oily Springs, take Care to gather and ſeparate the Bituminous ſubſtance from the Water; They gather it with Ladles, and putting it into a Barrel, ſeparate the Water from the Oil by letting out the firſt at a Tap towards the Bottom of the Veſſel. In the Iſland of *Barbadoes* there is a Rivulet, called *Tugh River*, which hath upon it's Surface in many Places a certain oily Subſtance, which being carefully taken off, and kept a little Time, is fit to burn in Lamps like ordinary Oil. Near Cape *Helene* in *Peru* there are Fountains of Roſin (or ſomething like it) which flow in Abundance.

broad

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broad Lake, called *Asphaltites Limne*, that had a liquid Bitumen swimming upon it, with which *Semiramis* cemented the large Brick-Walls which surrounded *Babylon*. At this Day there is a Fountain near *Degemsce*, a Monastery in *Bavaria*, whose Surface is covered with Oil, which is daily carried away by the Natives. There are also great Lakes in *Syria* and *Africa* which send forth Heaps of Bitumen. The *Acidulæ* at *Schwalbach* if they be kept quiet in a Vessel for some Hours, there will be small Drops of Oil swimming on the Top of them. A greater quantity of such Drops are found in a Fountain called *Oelbrunn* near the Village *Lamperschloch* not far from *Hagenaw*. And in most Baths there are found bituminous Particles, after they have stood to settle for some Time; as in the *Petrolean* Baths in the Kingdom of *Naples*.

THERE are also great Numbers of Fountains which do not produce Oil on their Surfaces, but pour out a meer fat or bituminous Liquor. Near *Gersbach* in the Valley called *Leberstbal*, there flows from an old exhausted Mine a thick Oil or Bitumen which the Country People use instead of Grease to the Axle-Trees of their Wheels, but they are ignorant of it's superior Virtues; for *Thernbeuserus* tells us, that an excellent Balsam may be prepared from it. In the Island *Sumatra* there is a Fountain which pours out a kind of liquid *Petroleum*: some say it is a kind of Balsam; there are said to be also Fountains of Ambergris there. They find a bituminous Fountain in *Peru* near the Sea, which emits a small Rivulet into it, and is used by the Inhabitants instead of Pitch; neither have they any other sort of Matter so like it. Not far from *Schimachian* in *Persia*, at the Foot of the high Mountain *Barmach*, there are about thirty Fountains that send out a *Naphtha* or bituminous Substance; but they lie low, and spring with great Violence

into

into Wells about two Ells deep, which are made with wooden Steps for the Conveniency of descending. They emit a strong sulphureous Spirit, which is of two Colours; in some places red, and in others white; the later is of a more pleasant Smell.

THE Cause of these bituminous Fountains is a sulphureous and bituminous Matter melted in the Bowels of the Earth, and pressed upwards by a hot Spirit. Their Differences arise from the different fat Minerals that supply them; as Ambergris, Amber, the Oil of Petrol, Pitch, *Naphtha*, Bitumen, *&c.*

PROPOSITION IX.

To explain the Origin of Waters that taste bitter; and to enumerate the Places of the Earth in which they are found.

ON the Shore of *Cormandel* in *India* there are several Springs and Wells whose Waters are bitter tho' they spring up among the Rocks. In *Pontus*, a Province of *Asia minor*, there is a small Rivulet at the Town of *Callipade*, called *Exampean*, whose Water is bitter; this makes the River *Hypanis* also bitter, into which it flows. The Reader may collect several more Examples.

THEY come from an impure Sulphur, Bitumen, Nitre, Copperas, Copper; as Water by long standing in a Copper Vessel, acquires a bitter taste. But I cannot credit what *Molina* delivers in his Description of *Gallicia*, *viz.* that there is a Lake in *Ireland* whose Waters are one half of the Day sweet, and the other half bitter.

THE Lake *Asphaltites*, which is also called the *Dead* Sea, in *Palestine*, hath bitter Waters, because of an impure Bitumen mixed with them, so that by right it belongs to the fat Waters in the

the last Proposition. It sends forth a nauseous stinking Vapour. Every thing without Life is there drawn to the Bottom: but it suffers no living Creature to sink; neither does it grow sweeter tho' it absorbs the whole River *Jordan* that constantly flows into it. It's Waters are poisonous by reason of it's containing Arsenic (*f*).

PROPOSITION X.

To explain the Cause of very cold Springs, and to enumerate the Places of the Earth in which they are chiefly found.

NOT far from *Vienne* in the Province of *Dauphiné* in *France* there is a Fountain so cold, that it swells the Mouth of those that drink it; nor can any one endure his Hands in it. It is not diminished when Water is drawn out of it, nor augmented by pouring it in. On the Coast of *Abex* in *Ethiopia* (formerly inhabited by the *Troglodytes*) there are extream cold Fountains, tho' the Sun be excessive hot there. Four Miles from *Gratz* in *Stiria*, are Fountains boiling up in a low Place, so cold that none can drink the Water running or drawn from thence. About a Mile from *Culma* there is a Fountain that pours out Water with a strong Spirit as if it were boiling, tho' it be very cold, which makes them call it the Mad-Water.

(*f*) Our Countryman Mr *Maundrel* observed this Lake narrowly upon the Spot; but could not perceive any Smoak or Vapour ascending above the Surface of the Water, as is described in the Writings of Geographers. He also went into it, and it bore his Body in swimming with an uncommon Force; but as to the Report of a Man wading into it as high as his Navel, will be buoyed up by it, this he found not to be true. *Salmon.*

THE

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THE Cause of their Coldness is, 1. A Mixture of Nitre and Alum, also of Mercury and Iron, &c. 2. The great Depth from whence they spring, so that they want the Rays of the Sun, and the sulphureous Heat under Ground.

THERE are also Fountains that are cold and hot by turns. In *Catalonia* there is a salt Fountain and Lake, which are extream hot in the Winter and as cold in Summer. This is common to several others. I suppose the Cause of it is, that the Pores of the Earth, being open in Summer, let out the subterranean hot Spirit thro' them: which being shut in during Winter, keep it as in a Furnace or Oven, to warm the Water. Thus some Fountains are hotter in the Night than in the Day.

PROPOSITION XI.

To explain the Origin of those Waters that seem to turn Bodies into other Species; and to enumerate the Places of the Earth in which they are found.

THERE are some Waters which petrify Wood or turn it into hard Stone. A little above the City of *Armagh* in *Ireland*, there is a small Lough, in which if a stick of Wood be fixed, and continue for some Months, the Part that is fast in the Mud becomes Iron, and that in the Water turns to a Whetstone, and that above Water continues to be Wood. This is reported by *Giraldus* and *Maginus*: but *Brietius*, by what authority I know not, says that it is a Fable throughout (*g*). In

(*g*) There is certainly no such *Lough* as this in *Ireland*; their famous *Lough Neagh* was formerly thought to have a petrifying quality; but upon due examination it is found, that the said quality is to be ascribed to the Soil of the Ground adjacent to

In the North Part of *Ulster* (a Province in *Ireland*) there is a Fountain, in which if Wood be immersed seven Years it will be petrified. There are Loches of Water in the Province of *Beausse* in *France*, that petrify every thing thrown into them. At the Town of *Sens* in [*Champagne*] near

to the Lake, rather than to the Water of the Lake itself. There are some Waters in *Scotland* that petrify: As in *Glevely*, at a Place called *Achigniglium*, there is a Rivulet which so turns Holly into a greenish Stone, that they ordinarily make Moulds of it for casting of Balls for Fuzees; and Tinkers that work in Brass, make both their Moulds, and melting Pots of it, and Women their round *Wharls* for spinning. Also upon the north Side of the *Firth* of *Forth* there is a Cave, from the Top of which drops Water that in falling makes long Columns resembling the Pipes of a Church Organ, and some of different Figures. *See Philos. Trans.* abridged by *Lowthorp*. Vol. 2. Page 321, 325. 'There is a 'River in *Thrace* which if you 'drink of it, will turn your 'Bowels into Stone, and cases 'with Marble whatever is put 'into it. Concerning which *Seneca* thus speaks in his *Natural. Quest. Book* 3. *Chap.* 20. the 'Mud of it is of that Nature that 'it glues Bodies together, and 'hardens them. As the Dust of '*Puteoli*, if it touches the Water, it becomes Stone, so on 'the contrary, this Water, if it 'touches any thing solid, sticks, 'and cleaves to it. Hence it is 'that Things thrown into this 'Lake are afterwards taken out 'and converted into Stones. 'The same Thing happens in 'some Parts of *Italy*, if you put 'in a Rod or a green Leaf, in a 'few Days after, you take out a 'Stone. And *Pliny Book* 2. '*Chap.* 103. says, 'In the '*Cicous* River, and in the Lake 'of *Velinus*, in the Country of '*Marca di Ancona*, Wood cast 'in is covered over with a stony 'Bark, and also in *Surius* a 'River in *Colchis*; so that a 'hard Bark commonly covers 'over the Stone still. So likewise in the River *Silarius*, beyond *Sarrentum*, not only Rods 'put in, but also Leaves turn into Stone; the Water is otherwise very wholesome to drink. *Clarke upon Rohault's Phys.* Vol. 2. Pag. 202. In the Island of *Haynan* near *China* there is a Water of such a strange quality that it petrifies some sort of Fishes when they unfortunately chance to enter into it. Among the *Quicksilver Mines* in *Guianavilica* in *Peru*, is a Fountain of hot Water whose Current having run a considerable way, turns at last into a soft kind of Rock, which being easily cut, and yet very lasting, is usually employed for building of Houses thereabouts. There are several petrifying, and incrustating Waters in *Virginia*, &c.

a Lake,

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a Lake, there flows a petrifying Fountain. *Vitruvius* tells us that there is a broad Lake, between *Mazaca* and *Tuana* in *Cappadocia*, which changes a Reed or a stick of Wood, in one Day, into Stone. There is a Fountain near *Charles*'s Baths in *Bohemia*, in which if Wood lie long it is turned into Stone. Such as these are found in divers other Places. Other Waters are thought to change Iron into Copper, which in fact they do not, only because these Waters carry the Spirit and Particles of Vitriol and Copper, they eat out, and by little and little dissolve, the Particles of Copper as they flow along with the Water.

THE Cause why these Waters turn Wood into Stone is, 1. Some do not change the Wood itself into Stone; but the earthy, stoney, saline Particles contained in the Water stick to the Wood, and only incrustate it with a stony Crust. 2. Others do not change the Wood into Stone, but give it a hardness equal to that of Stone. 3. If any Water have a true petrifying Quality, I suppose it may be accounted for thus (*b*). The chief Difference

(*b*) '[In the Summer of the 'year 1729, I happened to see 'the famous petrifying Spring 'called *Dropping Well* at *Knaresborough* in *Yorkshire*. It arises 'some yards from the Top of a 'Break of hard marly Earth (I 'cannot call it a Rock, it being 'several Degrees more soft, and 'crumbling than our common '*Rygate* Stone) made, I suppose, 'some time or other by the River *Nild* which flows very 'near to it. The Current, 'which is but small, runs to 'the Breakwards, where being interrupted with Sticks, 'Twigs, and Moss laid for that 'Purpose on the Edge of it, it 'is diffused all over the Stone, 'and partly gleets down the 'sides, and partly falls perpendicularly in Drops upon some 'Pebbles, where there is a 'small Matter of Water below.

'This Well doth by no means 'petrify Wood, Moss, &c. put 'into it, but only incrusts them 'all over with a stony Crust; 'Neither hath it this incrusting 'quality (at the Spring Head) 'before it comes to the Break, 'and runs down, or drop, from 'the soft marly Stone.

I am

Difference that can be perceived by the Eye between Wood and Stone is, that in the Wood there are as it were long Fibres in which it's Parts cohere, tho' not very close. But in Stone the Particles, being as it were Sands or Atoms, are not joined by any extended Fibres. If therefore it be the Nature of any Water to dissolve, and, as it were, grind the long fibrous Particles of Wood, that they do no more cohere after this Manner, but are still more condensed, the Difference between it and Stone will not be so great as to be discerned by the Eye; yet it is probable that these

'I am the larger upon this, 'because it seems to point out 'the true Reason of Petrifaction; 'for is it not hence reasonable 'to suppose? that the Water 'gleeting down the sides of the 'soft Stone, corrodes the minutest of it's Particles, and is impregnated with them; which 'are again separated from the 'Water, by putting sticks of 'Wood into it, (by the Power 'of Attracting) as we see some 'kinds of Salt separated from 'Water by the like Means, and 'other Bodies separated from 'those that are compounded 'with them, by such as are 'found by Experience to attract 'their Particles. Now when 'these Particles are so minute 'and subtile, as to intrude with 'the Water into the Pores of 'the Wood, in process of Time, 'when it is throughly soaked, 'the Interstices will be quite 'filled with stony Particles; and 'if any thing ligneous remain, 'it is so well guarded and incrustated by these Particles 'that it is not perceptible, nor 'to be acted upon by Fire: but 'if (as in the present Case) the 'Particles are not so minute as 'to penetrate the Pores of the 'Wood, they only stick close 'to the outside of it, and parget 'it over (as it were) by degrees 'to a considerable thickness.

'What strengthens this Opinion very much is; that the 'Particles of the Case or Crust, 'when ground to powder, are, 'to all appearance, like the Particles of the Stone from 'whence the Water drops, only 'the later is something whiter 'and rounder.

'Is not therefore such subterraneous Earth as this, thro' 'which the Water, of such like 'Qualities, runs, the Cause of 'Petrifaction?

'Because we may gather 'from hence the Reasons why 'Fountains petrify some sorts 'of Wood throughout, but not 'others; also why some petrify only the Bark, Sap, or 'softest Part, and others only 'incase it, &c.

mineral

mineral Waters communicate some Substance even to Wood itself.

PROPOSITION XII.

To explain the Cause of poisonous or lethiferous Waters; and to enumerate the Places of the Earth in which they are found.

THE Lake *Asphaltites* is one of these, having Arsenic mixed with Bitumen in it (*i*). The Fountain of *Neptune*, near *Terracina* in the Country of the *Volscians* was famous of old, because all that drunk of it immediately lost their Lives; and therefore it was filled up with Stones by the Inhabitants. At *Chycros* in *Thracia* there was a Lake that killed not only those who drunk of it, but even those that washed in it. There is a Fountain in *Thessaly* which Cattle are not suffered to taste, nor any kind of Beast to come near it. *Vitruvius* relates, that there is such deadly Water as this near the Sepulchre of *Euripides* in *Macedonia*. As to the Spring and River *Styx* in the

(*i*) Near *Esperies* in *Upper Hungary* are two deadly Fountains whose Waters send forth such an infectious Steam that it kills either Beast or Bird approaching the same; for the preventing of which they are walled round and kept always covered. In *Ireland* there is a Lake which commonly sends up such a pestilentious Vapour, as frequently kills Birds that endeavour to fly over it. 'Near '*Dantzic* there is an inland 'Sea made by the Confluence of 'three Rivers, whose Waters 'are sweet and wholesome, 'and well stored with delicate 'Fish; yet in the three Summer Months, *June*, *July*, 'and *August*, it becomes every 'Year green in the middle 'with an hairy Efflorescence; 'which green Substance being 'by some violent Wind forced 'ashore, and with the Water 'drunk by any Cattle, Dog, or 'Poultry, causeth certain and 'sudden Death'. See Mr *Kirkby*'s Observations upon it in *Philos. Trans.* No 83. Beyond the Falls of *Rapabanac* in *Virginia* there are said to be poisonous Waters, &c.

Mountain

Mountain *Nonacris* in *Arcadia*; the Antients write that it ſprings out of the Rocks, and is ſo cold and venomous that it is called a *River of Hell*, alſo that it can be contained in no ſort of Veſſel made of Silver, Braſs, or Iron, but only in the Hoof of a Mule. Some Hiſtorians write, that *Alexander* the Great was poiſoned with this Water, by *Jolla* the Son of *Antipater*, not without a Suſpicion of *Ariſtotle's* being concerned in it. *Vitruvius* writes, that there was a Water, in the Kingdom of *Cottus* on the *Alps*, which whoever taſted immediately fell down dead. At this Day there are ſeveral poiſonous Springs found on or about the *Alps*, but the greateſt Part of them are ſtopped up with Stones; ſo that they are not ſo much as taken Notice of.

THE Cauſe of ſuch Waters is their running or gleeting thro' arſenical, mercurial, and antimonial Earths, whereby they are impregnated with their Fumes; for as the Smoke, or Fume, of Arſenic kills living Creatures, ſo Waters impregnated with ſuch a Fume do the ſame.

PROPOSITION XIII.

To explain the Cauſe and Differences of coloured Waters; and to enumerate the Places of the Earth in which they are found.

AT the Town of *Chinon* in *Touraine* (a Province in *France*) there is a yellowiſh Spring guſhes out of a Cave, and as it flows is concreted into a Stone. In the Kingdom of *Congo* in *Africa* there is a River of a red Colour that flows into the Sea. In the Valley of *St George* near *Sultzmat* in *Alſatia* there is a Fountain of red Water, called *Rothwaſſer*. The *Rubicon*, (ſo called from it's redneſs) now *Piſatello*, in *Italy*, flows from the top of the highest *Alps*. There are some Fountains of black, greenish, and other colour'd Waters, but these are very rare (*k*).

THE Cause of the Colour of these Waters, is the Colour of the Earth thro' which they run, before they come to the Fountain-Head.

PROPOSITION XIV.

To explain the Origin of salt Waters; and to enumerate the Places in which they are found.

THEY are owing to two Causes. 1. Some proceed from the Sea in subterraneous Passages, to the Superficies of the Earth, where they spring up. 2. Others are generated from the Salt contained in the Bowels of the Earth, by pervading the Places where it lies, and mixing with it's Particles and Spirits, before they come to the Fountain. Salt Fountains are very common, and known to every one. In *Germany* there are those at *Hall*, in the County of *Tyrol*, at *Hall* in *Upper Saxony*, at *Hall* in *Swabia*, and at *Hallen* in *Bavaria*; likewise those in the Archbishopric of *Saltzburg*, in the Duchy of *Magdeburg*, at *Saltzburg* in *Lorrain*; and several others in other Places, which make up almost one hundred. We need not say any more to them here, since we also treated of them in the last Chapter; and every one knows whence they pro-

(*k*) In the Province of *Los Carcas* in *Peru*, there is a Fountain, out of which issues a considerable Current, of a Colour almost as red as Blood. Near *Yeoville* in *Somersetshire*, there is a Pool which contains a greenish sort of vitriolic Water. At *Basil*, there is a Spring of a blueish Colour. At *Eglingham*, in *Northumberland*, there is Water comes from an old Drift, formerly made to drain Coal-Pits, which has an atramentous Quality, and is turned as black as Ink, by an Infusion of Galls. There are several of these atramentous Springs in other Countries.

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ceed, *viz.* from hidden Quantities of Salt, lying here and there under Ground; it being itself an Element.

PROPOSITION XV.

To explain the Cause of boiling Fountains, and those that break out of the Ground with great Force; and to enumerate the Places of the Earth, in which they are found.

THE Cause is partly a sulphureous, and partly a nitrous Spirit, mixed with the Waters under Ground; if it be sulphureous, the Waters are hot; if nitrous, they are cold; but all that boil and bubble up like hot Fountains are not so, but several of them are cold; as that near *Culma*, called the *Mad Water*, which we mentioned in Proposition 10. The River *Tamaga*, in *Gallicia*, rises from a Lake, and at it's breaking out, makes an odd kind of bellowing Noise, for some Months of the Year (*l*). The strange hot Fountain in *Japan*, which

(*l*) There is a boiling Fountain at *Peroul*, not far from *Montpellier*, that heaves and rises in small Bubbles; which manifestly proceeds from a Vapour, breaking out of the Earth; for upon digging any where near the Ditch, and pouring other Water upon the dry Place newly dug, it produces the same boiling. The like bubbling of Water is found round about *Peroul*, upon the Sea-Shore; and in the *Etang* itself. There is a famous boiling or flaming Well near *Wigan* in *Lancashire*, with which you may boil an Egg, and upon the approaching of a lighted Candle, it takes Fire. One like this was discovered in the Year 1711, at *Broseley*, near *Wenlock*, in the County of *Salop*: It was first found out by a terrible uncommon Noise in the Night; the Noise was so great, that it awakened several People in their Beds, that lived hard by, who got up to see what it was, and found the Earth to rumble and shake in a Place near the *Severn*, and a little boiling up of Water through the Grass. They took a Spade, and digging up some part of the Earth, immediately the Water flew up a great

 Height,

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which (as we observed in Proposition 7.) only flows twice daily, and at each time about an Hour. When it begins to flow, it is cast out with such Force and Vehemency of Spirits, as to heave up great Stones laid on it's Mouth, and flies three or four Yards high, with a Noise resembling the Report of a great Gun. In *Westphalia*, there is a Fountain called *Bolderborn*, because of the great Noise it makes in springing.

ACIDULÆ, and most hot Baths, break out also with a great Force of Spirits, and boil up as if they were boiling hot; in Baths it is caused by a sulphureous Spirit, and in Spaws and *Acidulæ*, by the Spirit of Vitriol and Nitre, &c.

Height, and a Candle that was in their Hand set it on Fire. To prevent the Spring being destroyed, there is an Iron Cistern placed about it, with a Cover upon it to be locked, and a Hole in the Middle thereof, that any who come may see the Water through. If you put a lighted Candle, or any thing of fire to this Hole, the Water takes Fire, and burns like Spirit of Wine or Brandy. Some People out of Curiosity, after they have set the Water on Fire, have put a Kettle of Water over the Cistern, and in it a Joint of Meat, and boiled it much sooner than over any artificial Fire that can be made. Yet what is most strange, the Water of itself is as cold as any Water can be, even just when the Fire is put out. Of the same sort is that near *Grenoble* in *Dauphiné*; that near *Hermanstadt* in *Transylvania*; that near *Chermay*, a Village in *Switzerland*; that in the Canton of *Friburg*, and that not far from *Cracow*, in *Poland*. There are many hissing Springs, bubbling at the top, in *Switzerland*, and in other Places near the *Rhine*. There are some boiling Waters that are hot to several Degrees, so as to boil Eggs, and other things put into them; as those near the *Solfatera*, not far from *Naples*; as also upon the top of Mount *Zebio*, in the Duke of *Modena*'s Territories, not far from this *Villa*, near *Saffalo*; in the Source of the Emperor's Bath at *Aken*, in the County of *Juliers*, &c. This in part from Dr *Tancred Robinson*'s Observations upon boiling Fountains, in *Lowthorp's Abridgment*, *Vol.* II. *Pag.* 329.

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PROPOSITION XVI.

To enumerate the Waters that have other strange Properties, and to enquire into the Causes of them.

HITHER ought all such to be referred, as cannot be conveniently reduced to the former Class. There is a Fountain at *Cadima* (eight Leagues from *Coimbra*) in *Portugal*, which swallows up whatever is thrown into it; and there was formerly near to this, one that vomited up whatever was thrown into it, but it is now stopped. *Eusebius Nierembergius* relates, that there is a Lake not far from *Guadaiana* in *Andalusia*, which fortels a Storm, for when a Storm is approaching, it breaks out with horrible Roarings and Howlings, which may be heard at eighteen or twenty Miles distance *. There is a Well near *Calais*, in [*Picardie*,] into which if you throw a Stone, you'll hear a Noise in the Cavity, like a prolonged Thunder-Clap. There are some Wells on the *Alps*, whose Waters cause those that drink of them, to have great Swellings about their Necks. There is a Fountain near the Town of *Anteque* in the Province of *Granada*, which is of such a Nature, as to dissolve Rocks.

NEAR *Tours*, a Town in *France*, People visit the dropping Caves, (called *les Caves gouttieres*) from whose Concavity Drops of Water fall in several Figures, as that of Nuts, Almonds, *&c.*

THE hot Fountain in *Japan*, schorches and consumes every thing put into it, Iron, Flesh, Cloth, *&c.*

THERE was formerly a Fountain at *Clitor*, a Town in *Arcadia*, whose Water, being drunk

* There is said to be one like this near *Guadalaxara* in *New Castile.*

by any Person, made him have an Aversion to Wine.

THERE was a Spring in the Island of *Chios*, made those that tasted thereof stupid; and at *Susa* in *Persia*, there was a little Well, which made their Teeth fall out that drank thereof. The Studious may collect several other strange Properties of Fountains, in reading of Authors. Their Causes proceed from the Situation, or peculiar Properties of the Places where they are found (*m*).

PROPOSITION XVII.

To enumerate those Fountains that flow only at certain Times, or that ebb and flow; and to explain their Cause.

THIS Proposition belongs to the preceding Chapter, because it is about marvellous Waters, and being then omitted, it shall be explained here.

(*m*) *Josephus*, the Historian, tells us of a River, which for six Days runs violently swift, and resteth on the seventh always; wherefore it is called *the River of the Sabbath*. *Tavernier* tells of a Well at *Schiras* in *Persia*, which is fifteen Years rising to the top, and fifteen Years sinking to the bottom. 'About two Leagues from *Paderborn*, is a treble Spring called *Methorn*, which has three Streams two whereof are not above a Foot and a half distant from one another, and yet of so different Qualities, that whereas one of them is limpid, blueish, lukewarm, and bubbling; the other is Ice-cold, turbid, whitish, and heavier than the former, and also killeth all Poultry that drink of it. As to the third Stream that lies lower than the other two, about twenty Paces distant from them, is of a greenish Colour, very clear, and of a sour sweet Taste, pleasing enough.' *Philos. Trans.* N° 7. Pag. 133. At the City of *Toledo* in *Spain*, there is a Fountain, whose Waters near the bottom, are of an acid Taste, but towards the Surface extreamly sweet. Near to *Sanyenga* (a Village not far from *Rio de la Grace*, in *Negroland*) is a Well of ten Fathom deep, whose Water is naturally so very sweet, that in Taste it comes nothing short of ordinary Sugar. *Gordon*.

IN

IN *Wales*, not far from *Dinevowr* Castle [near *Carmarthen*,] there is a Fountain which ebbs and flows every day with the Sea, and observes it's Hours.

THE like Flux and Reflux, is observed in another on the top of a high Hill, in the Province of *Connaught* in *Ireland*, and yet the Water is sweet; the same is observed in the Fountain *Lou-Zara*, upon the *Chabretian* Mountains in *Gallicia*, twenty Leagues from the Sea; also in the Village *Marsace* in *Guienne*, there is a Fountain that follows the Tides at Sea, and flows at the same Time with the *Garonne* at *Bourdeaux*. There are other Fountains that are said to increase and decrease contrary to the Tides, such as *Strabo* and *Mela* report to have been in the Island of *Gades* (*Cadiz*) (*n*).

IN *Wales*, near the Mouth of the River *Severn*, there is a Pool called *Linliguna*, which swallows up the Water of the Flood Tides, as long as they flow (but is not increased thereby): but when they begin to ebb, then it begins to rise, and to vomit out the Water with great Vehemence all round it's Banks.

IN *Cantabria* (*Biscay*) there are the *Tamarician* Fountains, of which three out of the four, are dried up twelve times every day, so that there seems

(*n*) At a small Village called *Newton*, in *Glamorganshire*, is a remarkable Spring nigh the Sea, which ebbs and flows contrary to the Tides. '*Lay-Well*, 'near *Torbay*, ebbs and flows 'very often every Hour, visibly enough; sometimes sixteen, sometimes twenty times. 'The Distance between high 'and low Water Mark, is about five or six Inches. It is 'very pleasant to drink, and 'seems to have no Communication with the Sea'. *Philos. Trans.* N° 104. Pag. 909. [*There are two Fountains in* Craven *in* Yorkshire, *which ebb and flow; one at* Gigglesweek, *called* Ebbs and Flows, *which does so regularly every Day; the other at* Hebden, *called* Thruskil, *which sometimes (even in a great Drought, when there has been no Rain for a Month) breaks out with a great Force, of whitish, muddy, troubled Water; though at other times it runs very clear, and affords excellent sweet Water.*

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to be no Water in them. *Pliny* relates this, but I question whether such are to be found now.

IN the Dukedom of *Anjou*, above *Saumur*, there is a Village called *Varuas*, from whence a Rivulet flows twice daily, and twice ceases or stagnates.

IN *Savoy*, there is a large Spring called the *Wonderful Fountain*, which ebbs twice every Hour and flows twice, making a great Noise before it begins to flow. It runs into the Lake *Bourget*.

ON the Mountains of *Foix* (in *Languedoc*, a Province of *France*) near the Village *Bellestade*, is the source of the River *Lers*, which in *June*, *July*, and *August*, ebbs and flows twenty four times every Day. *Bertius* relates this from *Papyrius*.

IN the part of *Westphalia*, called *Paderborn*, there is a Fountain that ebbs and flows twice every Day, tho' it emits as much Water as, a little below the Fountain, turns three Mill-wheels. It breaks out with a great Noise, and therefore (as we said before) is called *Bolderborn* [*i. e. the boistrous Spring*].

IN the Town of *Villanova* in *Portugal*, there is a Fountain, commonly visited, that flows only from the beginning of *May*, to the beginning of *November*, and then leaves off; as *Eusebius Nierembergius* relates.

IN the County of *Valais*, in *Germany*, not far from the Baths called *Leuckerbad*, there is a Fountain called *St Mary's Well*; it ceases to spring on *St Mary*'s Day in *Autumn*, and returns in *May*.

IN [*Carniola*,] not far from *Laubach*, there is a Lake that is so dry in *Summer*, that it is sowed and mowed (*o*). The Water returns in *Autumn*, and

(*o*) This Lake is so very remarkable, that it will deserve a Description here, which we shall give from *Philos. Transact.* No 54.

and brings Fish with it. Not far from hence, there is a Fountain that hath the same Property.

SO

54, 109, 191. It is called the *ZirtbnitzerSea*, from*Zirtbnitz*, a Town upon it's Banks, of about three hundred Houses. The Lake is near two *German* Miles long, and one broad. It is surrounded every where with mountains, and no where runs over. In *June*, *July*, and sometimes not till *August*, the Water runs away, and sinks under Ground, not only by Percolation, or falling through the Pores of the Earth, but by retiring under Ground, thro' many great Holes at the bottom; the little, if any, that remains in the hilly or rocky Part, is evaporated; and in *October* or *Novemb.* it most commonly returns again (though not at any certain Time) and soon covers the Tract of Earth again. This Return and Ascent is so speedy, and it mounts at the Holes with such Violence, that it springs out of the Ground, to the height of a Pike.

The Holes are in the shape of Basons or Cauldrons, which are not of the same Depth or Breadth, being from twenty to sixty Cubits more or less broad, and from eight to twenty Cubits deep. In the Bottom of these are several Holes, at which the Water and Fishes enter, when the Lake ebbs away. These are not in soft or loose Earth, but commonly made in the solid Rock.

The Lake being thus every Year wet and dry, serves the Inhabitants for many purposes. For first, while it is full of Water, it draws to it several sorts of wild Geese and Ducks, and other Water-Fowl, which may be shot, and are very good Meat. 2. As soon as the Lake is emptied, they pluck up the Rushes and Weeds, which make Litter for Cattle. 3. Twenty Days after it is fully dry, they cut a great Quantity of Hay upon it. 4. After the Hay is in, they plow it, and sow Millet, which generally comes to Maturity. 5. There is great Variety of Hunting; there coming out of the neighbouring Woods and Mountains, plenty of Hares, Foxes, Deer, Swine, Bears, &c. so soon as the Water is gone. 6. When it is full, one may Fish in it. 7. All the Time when the Water goes away, it yields great abundance of Fish, which they catch in the Pits and Places, where the Holes are nor big enough to admit them under Ground. Lastly, when the Water returns, it brings a sort of Ducks with it, which are bred under Ground, and when they first come out can swim well enough, but are stark Blind, and have few or no Feathers on them. They soon see after they come into the Light, and in a small time get their Feathers, being much like Wild-Duks, and are of a good Taste, and easily caught.

The Cause, or rather *Modus*, of all these wonderful Phænomena in this Lake, is supposed to be, a Lake (*viz.* a subterraneous one) under the Bottom of this, with

SO the Pool or Lake of *Maron*, between the Sea of *Galilee*, and the City *Belena*, is ſo dry in *Summer*, that it brings forth tall Herbs and Shrubs, yielding ſhelter to Lions, Wolves, and other wild Beaſts.

IN *Guienne*, near the Church of *St Jean d'Angeli*, there is another that hath almoſt no Water in it in *Winter*, but abundance in *Summer*.

THE like is found in *Spain*, about twelve Miles from *Valladolid*, which begins to flow in *May*, and gives over in *November*.

ALL hot Baths flow without ceaſing, except thoſe, already mentioned, in the *Griſons* Country.

with which it communicates by the ſeveral Holes deſcribed. There are alſo one or more Lakes, under the bordering Mountain *Javornick*, but whoſe Surface is higher than that of the Lake of *Zirchnitz*. This upper Lake is poſſibly fed by ſome of the many Rivers, which in this Country bury themſelves under Ground. When it rains, eſpecially in Thunder-ſhowers, which are the moſt haſty, the Water is precipitated with great Violence down the ſteep Vallies, in which are the Chanels of theſe Rivulets; ſo that the Water in this Lake being increaſed by the ſudden coming of the Rains, faſter than it can empty, ſwells preſently, and finding ſeveral Holes or Caverns in the Mountain higher than it's ordinary Surface, it runs over by them into the ſubterraneous Lake under that of *Zirchnitz*, into which the Water comes up by the ſeveral Holes or Pits in the Bottom thereof, as likewiſe by viſible Paſſages above Ground.

SECT.

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SECT. V.

Containing one CHAPTER.

CHAP. XVIII.

Of the Changes on the terraqueous Globe, viz. *of Water into Land, or Land into Water.*

PROPOSITION I.

To enquire how much of the Surface of the terraqueous Globe, the Earth and Water severally take up.

IT is impossible to know this accurately, because we are ignorant of the Situation of the Earth and Ocean, about the North and South Pole, and because their Superficies are terminated by irregular and crooked Lines, not easily computed or measured. But so far as we can guess, from a bare Inspection of the Globe, it seems that the Superficies of the Earth and Water are nearly equal; each taking up half of the Globe's Surface.

PROPOSITION II.

The Surfaces of the Earth and Waters, are not always equally extended, but sometimes more, and sometimes less; and what the one loses the other gains.

THE Sea frequently breaks in upon the Land in several Places and overflows it, or wastes it by degrees, and washes it away; by which means it's it's Superficies is enlarged according to the bigness of the Plane of Earth it overflows; such an Inundation happened of old in *Thessaly*, *&c.* But the greatest that we know of have made no sensible Alteration in the Surface of the Globe, tho' it is possible that, some Time or other, there will happen such as may; as we shall shew in Proposition xviii.

PROPOSITION III.

To compute how much Earth and Water the terraqueous Globe contains.

TO find this accurately there ought to be known exactly the Surface of the Water; and it's Depth in different Parts of the Sea, and also the Bulk of the subterraneous Waters. All which we are ignorant of, and have no method to find them; and therefore are at a loss in finding the true quantity of either Earth or Water. We may form an Hypothesis, and take the Superficies of the Water for half the Superficies of the whole Globe, and also suppose the Sea to be a quarter or half a Mile deep, (one Place with another) not reckoning the Water in subterraneous Caverns.

THESE being granted, the quantity of Water is found thus: Take a quarter or half a Mile from the Semidiameter of the Earth, and find the Solidity of a Sphere, whose Semidiameter is equal to the Remainder. This Solidity being taken from the Solidity of the whole Globe, half the Remainder is the quantity of Water. This last being again substracted from the Solidity of the Globe, leaves the quantity of Earth, to which, for the Mountains, you must add a fourth or fifth Part of the Bulk of the Water, or even a half: yet all

all this is but guess-work, and not to be depended upon for Truth.

PROPOSITION IV.

The Water may leave the Shore, and the Places of the Earth which it covered before, for several Reasons; so that the dry Land may appear where it was Water or Sea before, and a new Plat of Earth may seem to be formed.

TRACTS of Water are seven-fold; 1. The Ocean. 2. Bays. 3. Seas or Streights. 4. Rivers. 5. Lakes. 6. Ponds. 7. Bogs.

THAT Bogs or Marshes may be drained, either by letting off the Water, or drying it up by continual Fires, or by throwing dry Earth into them, none need doubt; for in several Places and Countries there are fertile Fields, where there were formerly nothing but Bogs and Marshes; as in *Westphalia*, *Gelderland*, *Brabant*, *Holland*, *Muscovy*, &c. So the *Peloponnesus* in *Greece* was, in the Time of the *Trojans*, barren and marshy Ground, but was made fertile in *Aristotle*'s Time by draining it.

THE same may be said of Pools and Ponds, which are not very different.

PROPOSITION V.

Rivers leave their Shores (or part of their Chanels) dry, and form new Parcels of Ground in many Places.

1. IF their Water bring down a great deal of Earth, Sand, and Gravel out of the high Places, and leave it upon the low, in process of Time these will become as high as the other, from

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whence the Water flows: Or when they leave this Filth in a certain Place on one side of the Chanel, it hems in and raises Part of the Chanel which becomes dry Land.

2. IF a River take another Course, made by Art, or Nature, or some violent Cause, as the Wind, or an Inundation, it leaves it's former Chanel dry.

3. IF the Fountains that feed a River are obstructed, or cease to send out their Waters, because of the Earth falling in, or by being stopped with Heaps of Sand driven in by the Wind from the adjacent Places, the Chanel of that River becomes dry.

EXAMPLES of Rivers, whose Chanels are now dried up either wholly or in Part, are frequently met with among Authors; not of any great Rivers, but of those of the smaller sort, and some Branches of the great ones; thus that Branch of the *Rhine*, which formerly run by *Leyden* into the *German* Ocean, some Ages ago forsook it's Chanel, which is now dry Land, and stagnates between *Leyden* and *Catwic*.

WE have also several Examples of Shores that have been left dry by Rivers making themselves deeper and narrower Chanels than they used to run in; also of Rivers that are not navigable now, which have been so formerly, their Chanels being made shallower, and, in process of Time, may be quite choaked up, as the *Schelde*, &c. Therefore the Rulers of Countries take care that the Sand-Banks, Filth, and Sediment, be continually removed out of such Rivers, so that they may be kept open and navigable as much as possible.

BUT great Rivers are not dried up, or turned into dry Land in a great many Ages, or even Myriads of Ages, because a vast number of small ones

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ones flowing from different Parts make up their Waters and feed them; so that if one or two of them be dried up, or change their Course, it will be a long time before such an Accident happen to them all. One single Sand-Bank indeed might perform Wonders, in choaking up the Passage of a River, and make it take a new Chanel, whereby the former is dried up; but the River itself continues to flow, because it's Fountains and Branches are not obstructed. Nevertheless it is certain, that neither the *Nile*, the *Tanais*, the *Elbe*, nor the *Rhine*, &c. did or will always flow in the same Places, but their Chanels were formerly dry Land, and in future Ages will be so again.

PROPOSITION VI.

Lakes are dried up and turned into Earth.

IF the Lake be fed by Rivers flowing into it, the Change is made by turning the Rivers another Way, or by their ceasing to flow, together with Evaporation. If it receive it's Waters from the Ocean or Sea by subterraneous Intercourses, these are to be stopped or diverted; and so the Lake at first is changed into a Fen or Bog, and afterward into dry Ground. *Aristotle* (speaking of Lakes fed by Rivers) says, it is certain that the Force of the Water bringing Mud, or such like Matter, into any Lake, changes it into a Fen or Bog, and afterwards into dry Ground; for the Water stagnating, is in Time dried up. Thus the Mud and Sand, which the many Rivers bring down into the Lake of the *Mæotis*, have made it so shallow, that it will not admit such large Ships now, as sailed upon it about sixty Years ago.

Of

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Of ſmall Lakes that are turned into dry Land we have ſeveral Inſtances, eſpecially in *Holland.*

PROPOSITION VII.

Streights are dried up and turned into Iſthmus's, or Parts of Continents.

THIS is cauſed by the continual gathering and ſubſiding of the Mud and earthy Matter, which in Time choaks up the Streight, and ſtops the Intercourſe of the Water.

THUS it ſeems very probable that the Iſthmus between *Africa* and *Aſia*, which parts the *Red-Sea* from the *Mediterranean*, was formerly a Streight and joined them. The Depth of the Sea in ſeveral Streights is alſo found to grow leſs, and the Water to become ſhallower than it uſed to be, which is a certain Sign that ſuch a Streight, ſome Time or other, will be left bare, and be turned into dry Land. So that Bay in the *Atlantic* Sea which the *Hollanders* call the *Zuider Sea*, and the Streights of the *Texel*, will not now admit of loaded Ships of the firſt or ſecond Rate, as they uſed to do formerly; and as the Water evidently leſſens and becomes ſhallower every Year, it is likely the *Texel*, will one Time or other, become dry Ground: and that Streight which they call *Ulie* will, very likely, have the ſame Fate.

PROPOSITION VIII.

Bays may be in time dried up, and turned into firm Ground.

THIS may happen from a two-fold Cauſe: 1. If the Streights which join the Bay to the Ocean become an Iſthmus, or be choaked up with Sand and

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and Mud (that such a thing may happen, we shewed in the last Proposition); by this means the Bay is cut off from the Ocean, and becomes a Lake, which is turned into a Fen, or Bog, and then intodry Ground. 2. If the Chanel of the Bay be heightened continually by the Sand and Gravel, brought down by the Rivers into it, it will in Time be higher than the Ocean, and receive no more Sea-Water.

THUS the *Mediterranean*, *Baltic*, *Red-Sea*, *Persian* Gulph, *&c.* which are now Bays, may be changed, one Time or other, into dry Land; as we shall further prove in the next Proposition.

PROPOSITION IX.

The Ocean in some Places forsakes the Shores, so that it becomes dry Land where it was formerly Sea.

THIS is caused by these Means: 1. If the force of the Waves dashing against the Shore, be broken by Cliffs, Shoals, or Rocks, scattered here and there, under Water, the earthy Matter contained in the Water, as Slime, Mud, *&c.* is made to subside, and increase the Height of the Sand-Banks, whereby the Violence of the Ocean is more and more resisted, which makes it yield more Sediment; so that at length the Sand-Banks, being raised to a great Height and Bulk, entirely exclude the Ocean and becomes dry Land. 2. It contributes much to heightning the Shores if they be sandy and rocky, for then the Sea dashing against them, and withdrawing, carries little or nothing away from them, but every Time it approaches them it brings Dregs and Sediment, whereby they are increased in the Manner aforesaid. 3. If some neighbouring Shore consist of light, mouldring, porous, Earth, which is easily washed away by the Flux of the Sea, it is mixed with the Water, and left upon some other adjacent Shore that is harder; besides, when the Sea encroaches upon one Shore, it relinquishes another not far off. 4. Large Rivers bring down vast Quantities of Sand and Gravel to their Mouths, (where they exonerate themselves into the Sea) and leave it there, partly because the Chanel is wider and shallower, and partly because the Sea resists their Motion; but this is chiefly observed in Countries, whose Rivers annually overflow their Banks. 5. If frequent Winds blow from the Sea to the Shore-wards, and the Shore itself be rocky or of tough Earth without Sand, it gathers Slime and Mud, and becomes higher. 6. If the Tide flow quick, and without great Force, but ebb slowly, it brings a great deal of Matter to the Shore, but carries none away. 7. If the Shore descend obliquely into the Sea for a great Way, the Force of the Waves are broke and lessened by Degrees, and the Sea leaves it's Filth and Slime upon it.

THERE are several Places of the Earth, which, it is certain were formerly covered by the Ocean. Where *Egypt* is now, it was formerly Sea, as appears both from the Testimony of the Antients, and Experience; for the *Nile*, flowing from the remote Regions of *Ethiopia*, when it overflows it's Banks, covers all *Egypt* for a Time, and then settling by Degrees, it leaves the Dregs, Mud, Dirt, and earthy Matter, which the swift Course of the River had brought down; by this means *Egypt* becomes annually higher and higher. But before such a Quantity of Matter was brought down to the *Nile*, the Sea covered the Land of *Egypt*, tho' it be repulsed and hemmed in now by the Earth's acquired Altitude. *Aristotle*, among others, asserts this, and says: This Place, and the whole Coun-

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try (meaning *Egypt*) were formed by the pouring in of the *Nile*, and ſeems to gain Firmneſs every Year. But ſince the neighbouring Inhabitants, by Degrees, began to cultivate the Marſhes and Bogs as they dried up, it is impoſſible to gueſs at the Time of this Mutation. However, it ſeems that all the Mouths of the *Nile* have been made by Hand, and not by the River, except that of *Canopus*. It is further evident, that all old *Egypt* conſiſted only of one Town, which they called *Thebes*. *Homer* declares this, who flouriſhed (I may ſay) not long after theſe Changes; for he mentions that Place as if there were then no ſuch City as *Memphis*, at leaſt not ſo large. *Seneca* explains this better thus: *Egypt* (ſays he) aroſe wholly at firſt from Mud; and if we may credit *Homer*, the Iſland of *Pharos* was ſo far diſtant from the Continent, as a Ship, with all her Sails ſpread, could ſail in a Day, but now it is joined to the Continent; for the *Nile* flowing muddy and troubled, and carrying down much Slime and Dirt, leaves it about it's Mouths, whereby the Continent is annually enlarged, and *Egypt* is ſtretched further and further every Year. Hence comes the Fatneſs and Fertility of the Soil, and alſo it's Evenneſs and Solidity; for the Mud ſettles and grows dry and hard, and the Ground becomes firm by what is laid upon it.

THE *Ganges* and *Indus*, both famous Rivers in *India*, do the ſame as the *Nile*, by their Inundations; alſo the *Rio de la Plata* in *Braſil*. And it is very probable that *China* was formed by this means, or at leaſt enlarged; becauſe the impetuous River, called the *Hoambo*, flowing out of *Tartary* into *China*, and frequently overflowing it's Banks, (tho' not annually) hath ſo much Sand and Gravel in it, as to make a third Part of it's Waters.

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THESE Examples demonstrate the fourth Cause, *viz.* that Rivers make the Sea forsake the Shore; but the Sea itself, in several Countries, is the Cause of it's own retiring, by bringing to the Shore, and there leaving Sediment and Matter enough to encrease the Altitude of the Coast; so that it suffers not the Sea to overflow it any longer. Thus *Holland*, *Zeeland*, and *Gelderland*, were formed; for the Sea covered these Countries formerly, as is known both from the antient Monuments mentioned in History, and the Quality of the Soil itself. In the Mountains of *Gelderland*, not far from *Nimeguen*, there are found Sea-Shells, and at a great Depth in *Holland* are dug up Shrubs and ouzy matter; add to this, that the Sea itself is higher than these Countries, and would overflow and cover them, but that it is restrained by Banks and Dams. On the other hand, there are some that think *Holland* and *Zeeland* arose from the Mud and Sand brought down by the *Rhine* and the *Maes*; nor is this unlikely. *Prussia* also and the adjacent Countries daily become larger by the Sea's retiring.

PROPOSITION X.

To explain the Origin or Rise of Sand-Banks.

BY *Sand-Banks* we understand large Collections or Cliffs of Sand in the Water, standing up above the Chanel of a River, to such a Height as to hinder the Passage of Ships. The *Dutch* Sailors call them *een Droogte*, *een Banck*, *een Rifs*; the *Portuguese*, *Abrothes*, and *Baixes*. They differ not from Rocks, only that Rocks are hard, solid, and coherent in their parts; whereas Sand-Banks consist of grains of Sand, that stick more loosely together. Tho' these two are often confounded.

THESE Sand-Banks lie either in the Chanels of Rivers, as frequently in the *Elbe*, and the *Wolga*; or at the Mouths of Rivers, as is alſo frequent in the two Rivers juſt mentioned; or on the Sea Shores, or in the middle of the Sea. The manner of their Generation is the ſame as in the foregoing Propoſitions we obſerved of the drying up the Courſe of Rivers, and the Shores of the Sea. For it generally happens, that the Ocean, before it leaves any part of the Land for good, firſt produces theſe Sand-Banks near the Shore; then recedes by degrees, and leaves the Sand-Banks a part of the Continent. And after the ſame manner it happens in the Chanels of Rivers, before they dry up, and are totally forſaken by the Waters. The moſt common Cauſe is the increaſing of the Rivers with Rain, or melted Snow, ſo that they ruſh down violently, and waſh off their Banks, where they are narrow, Slime and Mud; which is carried down a great way from their Fountains, till 'tis brought to ſome wide Place, where the Motion is not ſo violent; and here it ſubſides and forms a Bank of Sand, or Mud.

NOR can any greater Evil happen to the moſt rich and flouriſhing trading Towns, whoſe loaded Ships have been ruined by them; not to mention Towns, that thro' Time are quite forgot, there are the Cities *Stavoren* in *Frieſland*; *Arnemude*, or *Armugen*, in *Zeeland*; and *Dordracum* in *Holland*; *Antwerp* in *Brabant*; and *Stada*, in the Biſhopric of *Bremen*; all which have had this Fate.

NOR is there ſcarce any trading Sea-Port free from the Danger. Theſe Sand Banks in the *Elbe*, have loſt a great many Ships to the *Hamburghers*, which had eſcaped many Dangers on the Ocean; and in other Places, eſpecially the *Texel*, and the *Ulie* at *Amſterdam*.

MANY of these Banks are seen on the Sea-Shore of *Flanders*, and *Friesland*, and at low Water seem to be parts of the Continent, having so little Water above them at high Tide, as not to admit of Ships. The Sand-Banks that are famous or infamous among Sailors for Shipwrecks, are 1. Those found all in one Place, at the Shore of *Brasil*, extending in a Tract of seventy Miles, which they that go to the *Indies*, ought carefully to beware of, when they are sailing that way to avoid being becalmed on the *Guinea* Shore, tho' they come as near them as they can, to get the more Wind; but ought to take Care they do not fall in between those Banks, and the Shore. 2. Those of *St Ann*, not far from *Guinea* in *Africa*, in six Degrees of North Latitude: the Ships once carried among them, are not brought easily from them; but detained for several Days, when the Seamen think they have got rid of them; for they do not lie close together, but are parted by Gulphs and deep Places; so that when they are in ten Yards Water, they on a sudden shall found but three Yards. 3. Those between *Madagascar*, and *Arabia*, and *Africa*, called the *Baixas of Judæa*: they are sharp, ragged Rocks of Coral, of various Colours. 4. Those about *China*. 5. Those towards *Flanders*; and several others that may be seen in Sea Charts.

WE have shown one Way how they are formed, *viz.* by the subsiding of the Matter which the Sea carries with it; we may add a second Way, and that is, by the Sea's coming in upon Land, that hath heaps of Sand on it, which, being covered, are Sand-Banks under the Surface of the Water. Thus at the Shores of *Gelderland*, and *Holland*, there are several such, which they call *Dunen*; they are in a long Tract raised above the Land, on the Shore;

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Shore; and if the Sea break in, then these Hills become Sand-Banks.

THEY are frequently at the Mouths of Rivers where they are broadest, and where their Motion is not so rapid but the Matter can subside, and the Waves of the Sea beat back the River-Water, which stops it's Force. It is worth while to distinguish and consider these two ways.

PROPOSITION XI.

To judge whether the Sand-Banks not far from the Shore will become a part of the Continent.

WE showed, in the preceding Proposition, that they are formed two ways; one by the subsiding of Matter, and the other by Heaps of Sand that are overflowed: if they happen in the first way, and they be found to increase still, it is likely they will be joined to the Continent; but if in the second way, and they are not increased, then it is not likely they will be joined, but rather that the Sea will come further: but this we only guess.

PROPOSITION XII.

Islands are formed in the Sea and Rivers, the same way that Sand-Banks are (which may become Islands) and also another way.

FOR if there be gathered in any part of the Sea, Sand, Gravel, Slime, or Clay, it will in time become an Island; and if the Sea break in upon the Land, and surround Hills, they become Islands; and thus 'tis likely those were formed which are very high, as *St Helena*, the Isle of *Ascension*, &c. especially if they be rocky and stony.

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AND to these belong those which the Sea cuts off from the Land that juts out into it; thus antient Writers tell us, that *Sicily* was cut off from *Italy*, by the breaking in of the Sea violently; and the Verses of the Poet on this Subject are well known.

BY the first way, *viz.* by subsiding and gathering of a great many earthy Particles, were formed the Islands of *Zeeland*, *Denmark*, and *Japan*; and also the Isles of *Molucca:* for there were found, by those that dug the Ground there a little way down, a great quantity of Sand and Shells.

THE Inhabitants of the Island of *Ceylon* say their Island was separated from *India*, and it is very likely. Thus the Island of *Sumatra* is thought to have joined *Malacca*; and it is probable, because of the several Banks and Quick-Sands there. It is certainly believed it was the golden *Cherfonesus*, and was counted to be a Peninsula, for it appears so at a distance, and to be joined to *Malacca*.

THE *Indians*, on the *Malabar* Shore, tell us, that the Isles of *Maldives*, were of old joined to *India*, in one Continent, and are now a great way from it, and divided into eleven thousand Islands; and it is probable they will all in time be joined in one Island, they being not distant in some Places above four or five Yards. The narrow Seas will become narrower, and so join one to another. And indeed all the oriental Islands, between the Continent of *Asia* and *Magellan*, seem to arise from the Sea's breaking in violently on the Land, and separating one part from another; for the *Pacific* Sea moves with a continual force to the *East* from *America* to these Isles, and the Wind blowing constantly that way increases the force; it is not therefore unlikely that, seeing all these Islands are in the *Torrid Zone*, *Asia* did of old

old join the *Magellanic*, or South Land, the Earth being broke off here and there by the Sea, 'till at last it made it's way to the *Indian* Ocean, and formed many Islands strangely situated close together, as *Java*, the *Celebes*, *Borneo*, *Madura*, *Amboyna*, &c.

WE may judge the same of the Islands in the Gulf of *Mexico*, and at the Streight of *Magellan*.

IT is uncertain whether the Islands of the *Ægean* Sea were broke off the Land by the Sea, the Waves from the *Euxine* and *Mediterranean* Sea meeting one another, or by the subsiding of the Matter which was brought from the *Euxine* to the *Propontis*; tho' the former is more probable: and perhaps this was the famous Deluge of *Deucalion*. It is certain the Isle of *Eubœa*, or *Negroponte*, joined *Greece*, as famous Writers relate; for the Sea between them is so narrow as to have a Bridge over it.

WE have several Instances of Islands made by Sand-Banks. Thus those in the *Nile*, and in the River of *St Lawrence* in North *America*, were Sand-Banks. The Rivers make Islands also when they discharge a Branch in one Place, and receive it in another, as in the *Tanais*, and *Wolga*, and others; which no doubt is done by the Industry of Men. The *Oby* does the same. The two Rivers, *Rengo* and *Coauza*, produced the Isle of *Loanda*, on the Shore of southern *Africa*, where they exonerate themselves into the Sea, because they bring down from the high Places a great quantity of Slime and Gravel with great Violence, which they deposited still in the Mouths of the Rivers, and so made the Isle of *Loanda*; which at first was but a Sand-Bank, and now it is a fruitful Island, abounding with Inhabitants and fertile Land. We believe a great many Islands on the Shore were formerly Sand-Banks, or Clay-Banks, tho'

some

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ſome were made by parting them from the Continent, as at *Norway:* and this is moſt probable of thoſe that are hard and rocky.

BUT, in the *Indian* Sea, ſuch may happen by both ways; for while the Sea wears off, it doth at the ſame time carry away with it much Earth, which ſettles in another Place; and this is much cauſed by furious Winds, and frequent Storms, that come from the breaking of the Clouds in the rainy Months; from *May* to *September.* The Sea is ſtrangely diſturbed by theſe, ſo that the Sand and Clay is raiſed from the bottom, and carried to the *Indian* Shores. Thus the Mouths of the Harbours at *Goa* are ſo obſtructed by Heaps of Sand, which come with the force of the Storms from *May* to *September*, that ſmall Ships can ſcarcely enter; and theſe Heaps of Sand ſo obſtruct the Harbour of *Cochin*, that they are like a Bar, or Wall, that neither great nor ſmall Ships can enter.

FOR continual Rains on Mount *Gate*, and the frequent Storms from the Clouds which are ſeen hanging as it were above the tops of the Mountains, pour out ſo much Water with ſuch Violence that the Sea carries a great deal of Sand to the Shores; where, meeting with Oppoſition, the Sand ſubſides, which is carried away again by the Sea, when the Winter is over, and the Harbours cleared.

THERE are ſome Iſlands ſo near the Land, that they are ſurrounded at the time of full Sea; and if the intervening Chanel become higher, theſe Iſlands become a Part of the Continent.

AND the overflowing of the *Nile* makes the Towns and Hills look like Iſlands; and the *Wolga* doth ſo ſwell in *May* and *June* as to cover the Iſlands and Sand-Banks in it; and ſeveral of the Iſlands near *India* become like Sand-Banks in the rainy

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rainy Months, when the *Nile* and *Ganges* overflow these Countries.

PROPOSITION XIII.

There is another way that Islands are formed besides the two abovementioned, which is delivered by some Writers, viz. *that the Earth on a sudden is carried from the bottom of the Sea, and suddenly rises to the Surface.*

OTHERS think very justly that this fabulous way comes from the fabulous *Greeks* and Poets, who will have *Delos* to have come up that way; and the grave Author *Seneca* says, the Island *Therasia* did, in his Time, come up in the *Ægean* Sea, and that the Seamen observed it: and tho' indeed there are but few Examples of this kind, yet we are not therefore to think it impossible; for there may be in the bottom of the Sea some porous, spongy, hollow, and sulphureous, Earth, (as there are many sorts of light Earth,) which is now grown to a great Height under the Water; and if it come to break off by the force of the Sea, and being of less or equal Weight with the Water, it may come to the Superficies, and an Island appear on a sudden. Or a Spirit shut up under the Earth, and endeavouring to break out, may without the force of the Water bring it up to the Surface; for these Spirits included have great Power, as appears in Earthquakes, by which whole Mountains have been thrown up and swallowed down, and the same way are great Towers and Walls blown up by Gun-Powder placed under Ground.

IF therefore the Island that thus appears suddenly do yet adhere to the Bottom, it must be that it was forced up by the Spirits inclosed underneath; as some write, that sometimes Moun-

tains

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tains have been blown up that way; but if it do not adhere to the Bottom, it might be loosened from the Bottom, partly by the force of the Water, and partly by the inclosed Spirits, and come up by it's own Lightness.

PROPOSITION XIV.

FROM this another doubt arises; *Whether there are floating Islands*; as *Thales* thought the whole Earth did float on the Water of the Ocean: but his Opinion is sufficiently refuted from the Sea's Chanel being continued every where, and yet there may be floating Islands if the Earth be hollow, light, and sulphureous. *Seneca* tells his Experience, that he saw in the Lake *Cutilia*, in the Fields of the Town *Reate*, belonging to the *Sabines*, an Island that floated, and Trees and Herbs on it, that was carried here and there by the Wind, yea by a gentle Gale; and that he never found it for a Day and Night in the same Place; and he says there was another Island that floated in the Lake of *Vadimone*; and another in the Lake of *Statione*. Thus the Antients say, that *Delos*, and all the Islands of the *Cyclades*, did of old float on the Sea. Nor need it be objected, why don't they swim now? for the Answer is easy; the floating cannot hold out long, for they reaching near the Bottom, and being carried from one place to another, they meet with a Sand-Bank and settle there, especially if they come between two Sand-Banks, then they join and become fixed. In *Honduras*, a Province of *America*, there is a Lake in which there are several little Hills, planted with Shrubs and Herbs tossed up and down with the Wind.

IN the large *Loch*, called *Lomond* in *Scotland*, there is an Island that floats, and is driven by the

the Wind: it feeds Cattle, as *Boëthius*, the Writer of the *Scots* Hiſtory, relates.

SO far of the forming of dry Land where Sea was; now we ſhall conſider how there can Water come where there was dry Land.

PROPOSITION XV.

The Rivers run in new Chanels for ſeveral Cauſes.

1. WHEN they come from their Fountains, and get a Chanel either made by Art or Nature.

2. IF a River ſend out a Branch from it, which is cauſed for the moſt part by Men, either to bring Water to a Town, or to another River: Examples whereof we ſhewed above.

3. IF Rivers gain more and more upon their Banks; which happens, 1. When the Chanel grows higher thro' the ſubſiding of Mud and Sand. 2. If it wear off the Banks by it's ſwift Courſe. 3. If it be increaſed by another River flowing into it, or by Rains or Snow.

4. IF they overflow the Land, and become Lakes by not returning to their former Chanel, which if they do and leave a good deal behind they make Bogs.

COROLLARY.

IT is probable Time was, when the Chanels of the *Rhine*, *Elbe*, *Nile*, and all other Rivers, were dry Ground, and may again become ſo.

PROPOSITION XVI.

Lakes, Bogs, and ſtanding Pools, occupy Places that they did not before.

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1. WHEN they are first formed and enlarged as in Chapter xv.

2. IF plenty of Rain fall.

3. IF the Rivers carry much Water into the Lakes with great force.

4. IF their Chanel become higher.

5. IF the Lakes by the frequent and strong Waves wear off the Banks, and cover more Ground. Thus the Lake of *Harlem*, within these thirty or forty Years past, is enlarged about one twentieth of a Mile round.

COROLLARY.

IT is probable, that the Places where the Lake *Zaire*, or *Leman*, or *Parime*, or of *Harlem*, or of *Mæotis*, and the Bogs in *Westphalia*, and all others, were once dry Ground.

PROPOSITION XVII.

There is Ocean where there was none before.

THIS may happen several ways; 1. When it breaks into the Land, making Bays and Streights, as the *Mediterranean*, the Bay of *Bengal*, the *Arabian* Gulph, and Bay of *Camboia*, *&c.* Thus the Streights between *Sicily* and *Italy*, between *Ceylon* and *India*, between *Greece* and *Negroponte*, the Streights of *Magellan*, *Manilha*, and at the *Sound*; yea some will have the *Atlantic* Ocean thus made, and to have parted *America* from *Europe*, that they may better deduce the Generations of Men there from *Adam*. It is certain the *Egyptian* Priest told *Solon*, the *Athenian*, that about six hundred Years before Christ (as may be seen in *Plato*'s Dialogue called *Timæus*) that there was once an Island over against the *Herculean* Streights

of

of *Gibralter*, greater than *Africa* and *Asia*, called *Atlantis*, and by a great Earthquake and Inundation in a Day and Night, that it was afterward sunk (*viz.* a Part of it); by which we may understand there was a Tradition among the *Egyptians*, who were given to Learning, that *America* was separated from the old World, many Ages before. It is much more probable as to the North part of *America*, that *New-France*, *New-England*, and *Canada*, did of old join *Ireland*; the Antients say the Streights of *Gibralter* were dug by *Hercules*.

2. WHEN the Sea is driven on the Shore with strong Winds breaking down the Shores and Banks, made by Art or Nature; there are several Instances of Inundations, as in *Thessaly* of old, and not long ago in *Friesland* and *Holstein*.

3. WHEN it doth, by the same Causes, go over the Land in several Places making Islands; as we said of those in the *East Indies*, and the Bay of *Bengal* and *Camboia*, which flowed into the Land.

4. WHEN it wears off the Shores, and spreads in upon the Land: thus the *Baltic* Ocean came in upon *Pomerania*, and destroyed *Vineta*, a most famous Sea-Port. Thus on the Shore of *Norway* it broke in, and cut off some Islands from the Continent, and the *German* Ocean broke in on *Holland*, near the Village of the *Catti*, and overspread a great Tract of Ground; thus the Ruins of an old *British* Castle, that was a Garrison of the *Romans*, is, a great way in the Sea, hid under Water. And on the North part of *Ceylon* near *India*, the Sea took off twenty Miles, and made the Island less; and there are many other Examples also,

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COROLLARY.

HENCE we underſtand, that where there is now Sea there was Land, and again may be, if the Earth hath laſted, and ſhall continue, ſome thouſand Years; of which ſee *Ariſtotle* in his Book of Meteors, Chap. xii. Lib. i. and *Stevin's Geography*. If it be aſked how the Sea can cover the Mountains, we anſwer they are not to be covered, but will be high Rocks therein, or Iſlands, for all Iſlands almoſt have Mountains in them; as *Ceylon*, *Sumatra*, *Java*; and ſome are nothing but Mountains; as *St Helen*, the Iſle of *Aſcenſion*, the *Heſperides*: and ſeeing theſe Places were once Land, then theſe Iſlands and Mountains in it were high Places on the Continent.

PROPOSITION XVIII.

Whether the whole Surface of this Globe may be either all Land or Sea; or if there may be more Land or Water one time than another.

IT is ſufficiently ſhown in the ſecond Propoſition, that there may be leſs Earth, and conſequently more Sea, one time than another. But to that Queſtion, whether there may be a Deluge that ſhall cover the whole, even the very Iſlands; we anſwer the way how ſuch a thing may happen, may be conceived and explained, yet can ſcarce ever happen, the Earth being ſo compactly joined and the Mountains ſo high. The way it may happen is the ſame as in in the ſecond Propoſition. If the Ocean continually waſh away the Shores and lay them in deep Places, at laſt all the high Parts will come down and be waſhed away, and the Sea come in on the whole Earth; there may be ſome Mountains or their Roots waſhed

washed away, and they fall down; and it were easier done if, as some think, the Sea were higher than the Land, but this we have before refuted. And to that, whether the Sea can ever go all into Caverns of the Earth, and there be nothing but dry Land, we answer the same way; tho' it may scarce ever be: there is only one way by supposing the Caverns so large as to contain the Sea, and none have yet demonstrated the contrary; and tho' they are not, they may be made so by the force of the Water or subterraneous Spirits.

PROPOSITION XIX.

Why there are few Islands in the middle of the Ocean, and no Clusters of them, except at large Islands, or near the Continent.

WE need not doubt of the Truth of this, being confirmed by Experience. There is scarce one little Island in the middle of the *Pacific* Ocean, and there are but few found in the vast Ocean between *Africa* and *Brasil*, except *St Helen* and the Isle of *Ascension*; but on the Shores of the Ocean, or great Continent, are all the Islands, except the few I mentioned, especially the Clusters of Islands; those of the *Ægean* Sea are near *Europe* and *Asia*, the *Hesperides* near *Africa*, the *Maldives* near *India*, and all the *Indian* Islands lie between *Asia* and the South Land, only the *Azores*, or *Flandrian* Isles, seem to be in the middle of the Ocean, between *America* and the Old World; tho' they are nearer the later.

THE Cause of this Phænomenon no doubt is, that they were cut off the main Land by the Sea's breaking in upon it, which could not cover all Places it came to, because of their Height. It is likely they are also some of them made thus: the

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the Sea waſhing off ſome Lands cannot carry their ſmall Parts far off, but lets them fall down by degrees near the Shore, which being done for a long Time, Iſlands are at laſt formed. 1. But in the middle Ocean there are few Iſlands, for the Particles waſhed off the Shore do not go ſo far. 2. Becauſe there is a greater Motion and Force of the Water, which rather increaſes the Depth of the Chanel than cauſes any Iſlands. 3. Becauſe there being no Continent there, no Cluſter of Iſlands can be formed, according to the firſt way that we ſhewed they were made; yet of old when the middle of the Ocean was not where it is now, there might be a Cluſter of Iſlands, which might be gradually waſhed away.

SECT. VI.

Containing the Explanation of the Atmosphere and Winds, in three Chapters.

CHAP. XIX.

Of the ATMOSPHERE and AIR.

PROPOSITION I.

There are continually Vapours and Fumes exhaled from the dry as well as moist Parts, into the Space which surrounds the Earth.

THE Cause is twofold; 1. The celestial Heat of the Stars, especially the Sun and Moon. 2. The terrestrial Heat, or subterraneous Fire, mixed with the Earth, for we find all Bodies almost send out Exhalations when brought near the Fire, tho' very gentle; and seeing celestial and terrestrial Heat is nothing but Fire, therefore Vapours and Fumes must be raised thereby. And as the Nature of Heat, so Experience confirms the Truth of it; for Travellers in the Night may see, especially when the Moon shines, and near Waters, the Vapours that are raised wandering about the Air, and that they are raised in the Day-time by the Sun is commonly known; as also when little Clouds ascend, which is a sure sign of Rain.

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PROPOSITION II.

The Atmosphere is all that Space about the Earth, in which the Vapours are; and it is uncertain if any thing else be contained in it but Exhalations.

IT is also taken for the Exhalations themselves that are about the Earth. It is no small Controversy among the modern Philosophers, what that is which is about the Earth. Several famous Mathematicians are of Opinion there is nothing there but Exhalations; and so the Atmosphere and Air is counted the same: and above the Atmosphere is the æthereal Substance next it. Others think that there is a kind of Body besides these Exhalations, which is called Air, tho' they allow that Exhalations may turn to Air, and Air to thick Vapour and Clouds; and after this Air, all the Way to the Orbit of the Moon, they place another subtile Body, different from *Æther*, which they call Fire, indeed; but they confess, improperly, as no way agreeing with our Fires; for it is hot, (tho' not burning) dry, and very subtile, not causing the Refractions of the Rays of the Sun and Stars, which they own to be in their Air. These things considered, the two Opinions of the Philosophers differ rather in Words than in the Thing itself; for as to the Air, that is so gross as to cause Refraction, and may be generated from Exhalations, that may be only a more refined Exhalation, tho' not from the Earth. As to the sublunary Fire, seeing they own it is improperly called so, and is so subtile as to cause no Refraction, it seems to differ but little from the æthereal Matter; we may then say the Atmosphere, or Air, is a Body about the Earth, into which the Rays falling, are refracted (laying aside the Question whence it comes); which Definition

nition agrees with the foregoing one, nor is it very likely a Body so subtile could be exhaled from the Earth, as to make no refraction or hinderance to the Rays of the Sun, that come thro' the *Æther*; and if there be such, we know how high they are or if they be out of the Atmosphere; which yet, if any would strongly maintain, believing the Particles of Fire that come from the Sun, on the Earth, do again travel back to it, they will not deny but the foregoing Definition is proper. Therefore the Atmosphere and Air is nothing but a great many small Bodies interwoven together and adhering to the Earth; as the Down on a Quince or Peach.

PROPOSITION III.

There are sometimes more, sometimes fewer Exhalations sent up; especially in different Places.

THE Cause is, 1. The different Elevation or Depression of the Sun above or below the Horizon. 2. The different Age of the Moon, and it's Elevation above the Horizon. 3. The rising and setting of the other Stars, and their Situation above the Horizon. 4. The Difference in the Parts of the Earth; for Water and moist Places send out more Vapours than dry and earthy.

PROPOSITION IV.

The Exhalations that compose the Atmosphere are of different Kinds, especially in different Countries, viz. *watery, saline, sulphureous, earthy, and spirituous.*

THE Cause is, because there are such different Bodies in the Earth, and some are most easily, and others with difficulty drawn up; some may

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doubt of the earthy Particles, becaufe of their Weight; but yet this may be, 1. Becaufe of the exceeding fmallnefs of the minute Particles of Duft, that have more Superficies in proportion to the quantity of Matter in them, and therefore are lighter. 2. Becaufe of the mixture of fulphureous Particles, which carry them violently along with them.

AND that there are fulphureous Parts in the Air, appears from the fiery Meteors that are feen, as Lightning, Thunder, *Jack* with his Lanthorn, and the fulphureous Smell that is after Thunder and Lightning.

THERE can be no doubt of the watery Exhalations that are fpirituous and faline, they being very fmall and eafily drawn up; and the little Animals that are bred in the Air, in great Quantities do teftify the fame.

THE *Ariftotelians* divide Exhalations into two forts, Vapours, and Smoke. The Vapours are from the Water, and do eafily turn to Water again, and the Smoke from dry things; thus *Sal Ammoniac* turns all to Fume above the Fire; and hence it is that different Countries have different Air, and that it rains in one Place, and not in another.

PROPOSITION V.

The leaft and infenfible Particles of Air beat back or reflect all the Rays, as a Looking-Glafs doth; but fome of thofe that are perceivable and compounded tranfmit more Rays and reflect fewer; others again, tranfmit fewer Rays and reflect more.

THEREFORE the Parts of the Air are divided into opake and pellucid; the former tranfmit fewer Rays, the latter more.

BECAUSE the least Particles, like Atoms both from the Earth and Water, are little solid Bodies without Pores, and therefore do reflect and disallow a Passage to the Rays; for it is very probable, that Transparency, or the passing of the Rays, requires Pores duly disposed, and void of Matter.

BUT the Parts of the Atmosphere, or Air, that are compounded of the least Particles, if they have several Pores, duly disposed, will be transparent and transmit many Rays; but if the Particles be joined very confusedly, and be without many Pores, they will not admit many Rays to pass through.

HENCE it is, that the Sun dispersing a thick dark and cloudy Air, makes it more porous and transparent.

THAT the least Particles reflect the Rays, appears from this; if the Sun's Rays be admitted into a dark Room, in a clear Day, thro' a narrow Hole, you will clearly see the Rays reflected in great Number (from the Particles flying in the Air) to your Eye, as it were from a Looking-Glass; and as these Particles are still visible, we may conclude, in some Degree, the same of those that escape the Sight, and are least of all.

SOME would have the moist Exhalations to be transparent, and not the dry Fumes; but they are confuted by Experience and Reason; 1. By Reason; because the Fumes and dry Exhalations may become as small and porous as those that are moist; for they think that Transparency does not consist in Porosity, but that it is a peculiar Quality of the Medium: and 2. By Experience; because a clear Air hath more dry than moist Particles in it. This is understood from the new kind of Wind-Guns which are discharged not by Powder and Fire, but by help of the Air, which is com-

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preſſed and condenſed, that it ſcarce takes up the ſixtieth Part of the Room it had before, and yet there is no moiſtneſs in the Gun; which muſt have been if the Particles of the clear Air had been from Water.

PROPOSITION VI.

Exhalations do not of themſelves and of their own Nature aſcend, but are forced up: or thus, the Air is not light, but heavy, conſidered abſolutely.

ALL Things are ſaid to be heavy which would tend to the Center of the Earth if they were not hindered, and that the Air doth; for the Earth being dug, the Air goes down to the Room made there, and it's tending upwards is; 1. Becauſe Heats rarifies and makes it take up a greater Room. 2. Becauſe it is forced by other Vapours.

THUS in cold Countries, as *Nova Zembla*, and with us, no Cloud aſcends in the Night, but the Heat of the Sun coming on rarifies it, and makes one Part to preſs and force another: but if the leaſt Particles of Air were not folded together, but at Liberty, they would move up and be light (*p*).

PRO-

(*p*) That Air is a ponderous Body, appears from a variety of Experiments, particularly one, from which it's Weight uſes likewiſe to be eſtimated.

Take a Glaſs Tube, cloſed at one end, which fill with Quickſilver, then invert it with the open end, into a Veſſel, alſo filled with Mercury, and the Mercury in the Tube will ſo thwith ſubſide, and after a few reciprocations, ſtand at thirty Inches above the Surface of the Mercury, contained in the Veſſel. The Reaſon why the Quickſilver is ſuſpended at ſuch a Height is, becauſe it is impoſſible for it to deſcend, unleſs at the ſame Time the Mercury in the Veſſel aſcend; which, being on every Side preſſed with the Weight of the ambient Air, cannot quit it's Place, unleſs the Weight of Air exceeded the Weight of Mercury in the Tube. And that this is the Caſe will appear from hence; put all the above-mentioned Apparatus into a large Receiver, out of which, by the Air-Pump, extract the Air; then, as the Air is extracted, you may perceive the Mercury, contained

in

PROPOSITION VII.

The upper Parts of the Atmosphere are more subtile than those below; yet it may be, that those in the middle Region may be thicker and grosser than those near the Earth.

FOR the lighter Parts go upwards and the more subtile Parts are the lighter. which shows the Truth

in the Tube, gradually to subside; but if again you shall by degrees let in the Air, the Mercury in the Tube will ascend, in proportion to the quantity of Air intromitted, 'till at last it reach it's pristine Height of thirty Inches. This Apparatus, of the Tube and Vessel, together with the contained Mercury, is, from it's Use in measuring the Air, called a *Barometer:* and from it's Author, *Torricellius*, any Experiment perform'd by means thereof, is called *Torricellian*.

'Tis manifest, that the Weight of the Mercury contained in the Tube, and the Weight of a Column of Air, whose Altitude is that of the whole Atmosphere, and whose Basis is equal to the Orifice of the Tube, if weighed separately, the one will be equal to the other; so that when the Weight of the Air is diminished, the Barometer is depressed, and *vice versa*. Hence by taking a View of the Barometer, you may, at any time, know the present Gravity of the Air; which is a Problem of vast Moment both in Universal Physics, and in Meteorology in particular, and which deserves to be ranked among the noblest Inventions of the modern Philosophers.

By the Experiments performed some time ago before the Royal Society, for comparing the Weight of Air with Water, and so with other Bodies; by the first Experiment the proportion was found to be as 1 to 840; by the next, as 1 to 852; and by the third as 1 to 860. And lately the Ingenious Mr *Hauksbee*, by a very simple and accurately performed Experiment, found the *Ratio* of Air and Water to be as 1 to 885. All which Experiments being made in the Summer time, at which Season the Air is by the Heat expanded, and consequently lighter; and the Barometer standing at about 29¼ Inches higher; this might perhaps be safely determined upon, that the Barometer ascending to 30 Inches, and the Constitution of the Air at a Medium, as to Cold and Heat, the *Ratio* of Air to Water would be as 1 to 800; and therefore seeing, the Weight of Water compared

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Truth of the firſt Part of the Propoſition: and the Cauſe of the ſecond Part is, that thoſe in the middle Region eaſily go together and become groſſer, the hot Particles carried up with them having left them, and the Rays reflected from the Earth having but ſmall force in the middle Region, that is ſo diſtant from the Earth.

WHENCE it is, that after Rain the middle Region is more clear; the groſſer Part being fallen down (*q*).

PRO-

compared with Mercury, is as 1 to $13\frac{1}{2}$, the Gravity of the Air compared to the Gravity of Mercury would be as 1 to 10800.

Jurin's Appendix.

(*q*) If with the Hands we ſqueeze a blown Bladder, we feel the included Air make a ſtrong Reſiſtance, and by the Spring thereof, jumping back and diſengaging itſelf, the Impreſſions, or Cavities, made by the Hands on the Surface of the Bladder, are immediately, on ceaſing to preſs, expanded and ſmoothed; and this is called the Elaſtic Force of the Air. This Force, every Particle of Air continually exerciſes, and affecting a larger Space, contends againſt an equal Force of ambient Particles; whoſe Reſiſtance being either fortuitouſly taken away or impaired, the Particle inſtantly expands itſelf into the whole Extent, be it ever ſo large. Hence if ſlender glaſs Vials, or Bladders full of Air, and carefully ſtopp'd, be put into an Air-Pump, they are burſt by the Force of the included Air. Thus if a Bladder, only a little blown and flagging, be carried to the Top of a Mountain, or lofty Edifice, it immediately ſwells to ſuch a Degree. that if the Mountain be of ſufficient Height, it ſeems to be wholly ſtuffed with Air. For the Altitude of the Atmoſphere not being the ſame upon the Top of a Mountain, as upon the plain Surface of the Earth, the preſſure of the ambient Air is not therefore ſo ſtrong upon the Bladder placed there, and therefore the Air, included in it, ſprings into a larger Space. That the Air likewiſe upon the Top of a Mountain, is lighter than in Places of lower Situation, is evident from the Barometer, which being taken to the Top of a Mountain, the Mercury ſubſides; ſo that by means of it the Altitude, of Mountains might be very exactly calculated, were it once known in what proportion the Mercury falls; according to the different Height of the Place.

Vaſtly great, yea almoſt incredible is this elaſtic Force, by which, according to the famous

PROPOSITION VIII.

The Atmosphere, or Air, growing hot, takes up more Room than before, and the more the Heat leaves it, it contracts the more, and takes up less Room.

THIS is abundantly confirmed by that Instrument called a Thermometer, by which is measured

mous Mr *Boyle* *, the Air, without the Assistance of Heat, was dilated into a Space not only 60 or 150, but 8000, yea 10000, and at last 13769 times larger than that it possessed in it's natural State near the Surface of the Earth. And seeing the Air can be artificially compressed † to the sixtieth part of it's natural Space; it appears that the Place into which the Air may be artificially condensed, to the Place, into which it would dilate itself, if freed from all Pressure, is at least, as 1 to sixty times 13769; or more than 826000.

By a great many Experiments performed in *England, France,* and *Italy,* relating to the Contraction and Expansion of Air, it is found that the Spaces into which, by different Weights, it is condensed, are among themselves in a reciprocal Proportion to their Gravities; or, the greater the Pressure is on the Air, the less Space it possesses.

From which Theorem, together with the Proportion above determined betwixt the Weight of Air and Mercury, it is easy to see the Grounds of the Controversies contained here and there in the Writings of the modern Philosophers, concerning the lesser density of the Air in the upper Regions, as also the Altitude of the whole Atmosphere.

First then, if we allow the the Air to have no Elasticity, but that thro' the whole Space 'twixt the Earth and the utmost bounds and extent of the Atmosphere it is every where of the same Density; just as Water, which, howsoever deep, is every where from top to bottom equally dense; now since from what has been already said, it appears, that the Weight of a Column of Air, reaching to the top of the Atmosphere, is equal to the Weight of Mercury contained in a Barometer; and seeing also the Proportion of Weight betwixt equal quantities of Mercury and Air is found; it were easy to give a Definition of the Altitude of that Column of Air, or of the whole Atmosphere. For seeing a Column

* *Wallis's Hydrost. Prop.* 13.
† *Philos. Transact.* No 181.

sured the Heat or Cold in the Air, for the colder the Air in the Glass, it takes up less Room, and the

lumn of Air one Inch high, is to the like Column of Mercury, as 1 to 10800, it appears that these 10800 Columns, or a Column of Air 900 Foot high, is equal in Weight to 1 Inch of the Mercury, and consequently that all the 30 Inches of Mercury, contained in the Barometer, require a Column of Air 27000 Foot high. So that, according to this Hypothesis, the Altitude of the Atmosphere would be only 27000 Foot, or a little more than 5 Miles.

But when, in the high Regions, the Air, by it's elastic Force, resiles and expands itself, according as the Weight of the incumbent Atmosphere is diminished, it must of necessity be far more rarified and subtile than the Air near the Surface of the Earth: and consequently a much greater Altitude must be assigned to the Atmosphere, than what was found by the just now mentioned Computation.

For seeing, according to the Theorem above laid down, the Spaces in which the Air is included, are reciprocally proportional to the compressing Gravities; but the density of every Body is in a reciprocal Ratio to the Spaces, which that Body possesses; the Density therefore of the Air in any Part of the Atmosphere will be proportional to the Weight of the whole incumbent Air. And further, if we suppose the Altitude of the whole Atmosphere divided into innumerable equal Parts, seeing the Density of Air included in any one of these Parts is in proportion to it's quantity, and the Weight of the Atmosphere is also as the quantity of the whole incumbent Air; it appears, that the quantity of the whole incumbent Air is every where, as the quantity of Air included in the lower Part, which constitutes a Difference between every two nearest quantities of the whole incumbent Air. It is a Theorem in Geometry; that such Magnitudes whose Differences are proportional to the Magnitudes themselves, these Magnitudes are in a continued geometrical Proportion. Whence if, according to the Hypothesis, the Altitude of the Air, by adding the equal Parts, into which it is divided, increase in a continued arithmetical Proportion, it's Density will be diminished, or, which is the same, the Rarefaction of the Air will be increased in a continued geometrical Proportion. Such as know the way of following such a Series, by taking a View of one or more of the Rarefactions of the Air at different Altitudes, may, without any Trouble, determine it's Rarefaction in any Altitude, or the Altitude answering to any Rarefaction, and so also the Altitude of the whole Atmosphere, if it may be the more Room, the more Heat it acquires; as we shall show in the following Proposition. The natural

be known, or made the extream Degree of Rarefaction, beyond which the Air cannot pass. Such as incline to know more on this Subject, may consult the famous Dr *Gregory*'s Astronomy, *Lib.* v. *Prop.* 3. as also the excellent Dr *Halley*'s Dissertation in *Philosophical Transactions* N° 181. who have demonstrated the same in a different, and somewhat more difficult way of reasoning, which I have here borrowed from the Demonstrations of a very learned Friend.

But withal we must not conceal, that these things have been rendered uncertain by the Observations of the famous *Cassini* * and his Assistants; who, in order to extend the Meridian Line of the *Paris* Observatory, after having with great exactness measured the Altitudes of several Mountains, and marked the Height of the Barometer on the Top of each of them, they found that the Rarefactions discovered by that Method, no ways agreed with those we have lately laid down, but that they were far greater than what ought to come out from the abovementioned Proportion: whence becoming suspicious, that the Experiments they had formerly made for finding out the Rarefaction of the Air under different pressures, had not been managed with sufficient Accuracy, they determined again to put the Matter upon Tryal, which Subject being diligently treated of in the *Royal Academy*, and when there were made great Dilatations of Air, compared to which, the Rarefactions found on the Tops of Mountains, were woundrous small; yet they found that all these exactly followed the reciprocal Ratio of their incumbent Gravities. So that it seems to be put beyond all doubt, that such is the Nature of the Air, which comes nearest to the Earth's Surface, that the less pressure it has upon it, the greater Space it dilates itself into: and seeing the upper Air, or such as environs the Tops of Mountains, does not observe this Proportion, it follows, that it is of a different Nature from the Air that is next us, which notwithstanding needs be no cause of wonder to us, if, according to the most approved Sentiments of Philosophers, we allow that there is in our Atmosphere, besides Vapours and terrestrial Exhalations, a certain Body of kin to itself, and endowed with such Affections, as we have above assigned to the Air; and further, that these Vapours and Exhalations, are no ways capable of so great Rarefaction, as is the Air; and that these are mixed in far greater

* *Hist de l' Acad. Roy.* 1703, and 1705.

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natural Cause of the Proposition is this; that the hot Particles of the Sun's Rays, or any Fire, are the

greater plenty with the Air nearest us, than in the upper Air. These things being laid down, it is manifest that the Air of the higher Countries being less stored with Vapours, has, in proportion to it's Density, more Elasticity in it than that which comes next to the Earth, whence the reciprocal Ratio of Gravity, which is in the Air next the Earth, does not hold here; and further, that Vapours and Exhalations have not such Elasticity as Air, but that this is much more rarefied and extenuated. But the excellent Mr *Fontenelle*, Secretary of the Society, explains these Phænomena in a quite different Manner, in his History of the Academy, *Anno* 1708.

He proposes some Experiments performed by the famous Mr *De la Hire*, and others, from which he infers, that the elastic Force of the Air is increased when it is mixed with Moisture, or when compounded of Air and aqueous Vapours, the Rarefaction will be greater, than from pure Air; and that therefore on the Tops of Mountains the Air is found more rarefied, because many Vapours are carried thither for producing of Rain. The Experiments are these:

They took a slender glass Siphon, one of whose Legs ended in a large hollow Sphere, being open at the other. This Siphon was full of common Air, and exposed to the external Air coming into the Siphon. The Globe and Siphon was plunged into hot Water, found by previous Experiments to be of the same degree of Heat as boiling Water, and consequently causing the same degree of Rarefaction; tho' the Fire underneath were greater or less.

When the Air included in the Globe was rarefied with this degree of Heat, it would be gradually thrust out at the other end of the Siphon; 'till at length the Globe being heated to the utmost, there was left a very small quantity of Air, highly rarefied, that possessed the whole Cavity. Then the Water being removed from the Fire, the Air, as it gradually cooled, which before possessed the whole Globe, being gradually contracted by the Cold, gave way to the Water that entered at the Orifice of the external Leg, and at length, when the Water became entirely cold, it was contracted into a very small Space, whilst the rest of the Globe remained filled with Water. Now by comparing the Space, possessed by the Air, cooled and reduced to it's natural State, and the whole Cavity of the Globe which it had at the utmost Heat, it appears how much the Air was rarefied with that degree of Heat.

This

the most subtile in the World, and inconstant Motion, and while these are mixed with the Atmosphere,

This Experiment was first made in clear Weather, again in a moist and rainy Season; and at a third time, a little Water was left adhering to the inner Surface of the Globe. And it was observed that the Air condensed at the end of the Experiment, in the first Case possessed $\frac{2}{5}$ of the Globe, in the second possessed but $\frac{2}{9}$, and in the third $\frac{1}{35\frac{1}{2}}$. Whence Mr *Fontenelle* concludes, that the Air was more dilated in the second Case, but particularly in the third, than in the first Case; and therefore as the Air is the more dilated the more moist Vapour is mixed with it; hence he concludes it probable, that for the same Reason, there is a greater Rarefactionon the Tops of Mountains, because the Air that surrounds them is mixed with a greater quantity of Vapour. But there are two Considerations that render the Argument inconclusive. For first in the two later Experiments, as aqueous Vapours were plentifully mixed with the Air, it might happen that when the Air was condensed, and the Water entered thro' the Siphon into the Globe, these Vapours might again return to Water, and mixing with the other Water partly by the Force of Condensation, and partly by the mutual Attraction there is betwixt the Particles of Liquors, leave but little true Air included in the very small Space. Whence it might seem, that the quantity of Air which rarefied with the same degree of Heat possessed the whole Cavity, was less in the two later, than in the former Case; and therefore more dilated, so as to possess the whole Space.

Again, allowing that the Air was more rarefied in the later Cases, yet as this was effected by the means of Heat, I do not see how it follows that because the Vapours mixed with the Air, and agitated by Heat, are more rarefied than Air without Vapours, therefore these Vapours without Heat, should have a greater Elasticity than pure Air.

We shall here add a Table of M. *Cassini, junior*, made from the foregoing Observations, and exhibiting the Height of the Air from the Surface of the Sea, corresponding to the Sinkings of the Barometer; as also the Spaces increasing in arithmetical Proportion, wherein the Height of the Air increases almost half a *French* League, whilst the Barometer sinks in twelfths of an Inch, at a time when, being placed on the Surface of the Sea, it stands at about 28 *French* Inches or $29\frac{2}{13}$ of *English*. I use the *French* Measures, being unwilling, by reducing them to the *English* Feet, to disturb the beautiful Series of Proportions by small fractional Parts; tho' these may, by the help of the mosphere, they separate them, with great Force, and so make more Pores, and these fiery Particles going away, the Particles of Air left by themselves, do

the lesser Table subjoined be easily reduced to *English* Measure.

Barometer falling.		*Divisions answering to each twelfth of an Inch.*		*Height of the Air above the Sea' Surface.*	
Inch.	*Twelfths of an Inch.*	*Fathoms.*	*Feet.*	*Fathoms.*	*Feet*
0	0	10	0	0	0
	1	10	1	10	1
	2	10	2	20	3
	3	10	3	31	0
	4	10	4	41	4
	5	10	5	52	3
	6	11	0	63	3
	7	11	1	74	4
	8	11	2	86	0
	9	11	3	97	3
	10	11	4	109	1
	11	11	5	121	0
1	0	12	0	133	0
1	1	12	1	145	1
	2	12	2	157	3
	3	12	3	170	0
	4	12	4	182	4
	5	12	5	195	3
	6	13	0	208	3
	7	13	1	221	4
	8	13	2	235	0
	9	13	3	248	3
	10	13	4	262	1
	11	13	5	276	0
2	0	14	0	290	0
	1	14	1	304	1
	2	14	2	318	3
	3	14	3	333	0
	4	14	4	347	4
	5	14	5	362	3
	6	15	0	377	3

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Barometer falling.		*Divisions answering to each twelfth of an Inch.*		*Height of the Air above the Sea' Surface.*	
Inch.	*Twelfths of an Inch.*	*Fathoms.*	*Feet.*	*Fathoms.*	*Feet.*
2	7	15	1	392	4
	8	15	2	408	0
	9	15	3	423	3
	10	15	4	439	1
	11	15	5	455	0
3	0	16	0	471	0
	1	16	1	487	1
	2	16	2	503	3
	3	16	3	520	0
	4	16	4	536	4
	5	16	5	553	3
	6	17	0	570	3
	7	17	1	587	4
	8	17	2	605	0
	9	17	3	622	3
	10	17	4	640	1
	11	17	5	658	0
4	0	18	0	676	0
	1	18	1	694	1
	2	18	2	712	3
	3	18	3	731	0
4	4	18	4	749	4
	5	18	5	768	3
	6	19	0	787	3
	7	19	1	806	4
	8	19	2	826	0
	9	19	3	845	3
	10	19	4	865	1
	11	19	5	885	0
5	0	20	0	905	0
	1	20	1	925	1
	2	20	2	945	3
	3	20	3	966	0
	4	20	4	986	4
	5	20	5	1007	3
	6	21	0	1028	3

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Barometer falling. Inch.	Twelfths of an Inch.	Divisions answering to each twelfth of an Inch. Fathoms.	Feet.	Height of the Air above the Sea's Surface. Fathoms.	Feet.
	7	21	1	1049	4
	8	21	2	1071	0
	6	21	3	1092	3
	10	21	4	1114	1
	11	21	5	1136	0
6	0	22	0	1158	0
	1	22	1	1180	1
	2	22	2	1202	3
	3	22	3	1225	0
6	4	22	4	1247	4
	5	22	5	1270	3
	6	23	0	1293	3
	7	23	1	1316	4
	8	23	2	1340	0
	9	23	3	1363	3
	10	23	4	1387	1
	11	23	5	1411	0
7	0	24	0	1435	0
	1	24	1	1459	1
	2	24	2	1483	3

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Fathoms, Feet, Inches, and Twelfths of an Inch.

French.	English.	French.	English.
1	1 1/15	60	64
2	2 2/15	70	74 10/15
3	3 3/15	80	85 5/15
4	4 4/15	90	96
5	5 5/15	100	106 10/15
6	6 6/15	200	213 5/15
7	7 7/15	300	320
8	8 8/15	400	426 10/15
9	9 9/15	500	533 5/15
10	10 10/15	600	640
20	21 5/15	700	746 10/15
30	32	800	853 5/15
40	42 10/15	900	960
50	53 5/15	1000	1066 10/15

English.	French.	English.	French.
1	15/16	60	56 4/16
2	1 14/16	70	65 10/16
3	2 13/16	80	75
4	3 12/16	90	84 6/16
5	4 11/16	100	93 12/16
6	5 12/16	200	187 8/16
7	6 9/16	300	281 4/16
8	7 8/16	400	375
9	8 7/16	500	468 12/16
10	9 6/16	600	562 8/16
20	18 12/16	700	656 4/16
30	28 2/16	800	750
40	37 8/16	900	843 12/16
50	46 14/16	1000	937 8/16

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do again come together, and are folded into one another (*r*).

(*r*) Mr *Hauksbee*, in his *Physico-Mechanical Experiments*, pag. 218. has, by a very curious Experiment, determined the Ratio of the Places possessed by the Air according as it is differently heated.

A B C (*Fig*. 25.) is a rectangular Glass Tube, B a little Column of Quicksilver: A the extremity of the Tube, cemented to a Screw, fitted with a Cap, and shut after the settling of the Quicksilver, the Space AB is full of common Air, included betwixt the Screw and the Quicksilver; whilst the part of the Tube BC, is open to the external Air. This Tube Mr *Hauksbee* placed in a proper Vessel, along with a Thermometer, then pouring in hot Water enough to cover the Ball of the Thermometer, the Quicksilver B moved from or approached towards A, according as the Air AB was more or less contracted by the Degrees of Heat. And by means of these Observations he made the following Table; wherein the Degrees are the same with those marked on the Thermometer for measuring the ascent of the Liquor; being the intermediate Degrees betwixt the greatest Heat, and the greatest Cold of our Climate. The Column of Parts shews the Proportion of the Spaces wherein the same Bulk of Air is included according to the Degree of Heat annexed; where it is to be observed, that the Air constantly and uniformly loses one 144th part of the Space it occupies in the greatest Heat, every twelve Degrees that the Thermometer sinks.

	Degrees.	*Parts.*	*The Part of the greatest Space lost.*
	130	144	
	120	143	$\frac{1}{144}$
	110	142	$\frac{1}{72}$
	100	141	$\frac{1}{48}$
Above.	90	140	$\frac{1}{38}$
	80	139	$\frac{1}{28}$ 8
	70	138	$\frac{1}{24}$
	60	137	$\frac{1}{20}$ 5
	50	136	$\frac{1}{18}$
	40	135	$\frac{1}{16}$
	30	134	$\frac{1}{14}$ 4
	20	133	$\frac{1}{13}$ 09
	10	132	$\frac{1}{12}$
Freezing	00	131	$\frac{1}{11}$ 08
Point.	10	130	$\frac{1}{10}$ 3
	20	129	$\frac{1}{9}$ 6
Below.	30	128	$\frac{1}{9}$
	40	127	$\frac{1}{8}$ 4
	50	126	$\frac{1}{8}$

Jurin's Appendix.

COROL-

COROLLARY.

THEREFORE the Height of the Atmosphere is not constant, but increaseth and decreaseth, at Mid-day greatest, and Mid-night least, and of a mean Height at Sun-rising or setting, as in Proposition xiv.

PROPOSITION IX.

To make a Thermometer, or Thermoscope, by which we may try the Changes in the Air, as to Heat and Cold.

LET us take a Glass with a long round Neck and round Body L H (*Fig.* 26.), let it be fastened to a Board M N P Q, with it's Neck downward, and let there be a Vessel so filled with coloured Water, put under it, that the Part of the Neck L F may be under the Water, and chuse a Day of a middle Constitution between Heat and Cold, with which the Heat and Cold at other times may be compared; and let the Water be poured into the Vessel at that time, when the Air growing cold the Water will ascend above F of it's own accord; for the Air that before filled the Space F A being condensed by the Cold takes up less Space. On the other Hand, the Air being made more hot, the Water will come down from F towards L; for the Air F H being rarified takes up more Space.

AND the Degrees of increase and decrease of Heat and Cold may be known, if you divide the Line F A into a certain Number of Parts.

OR without a Vessel underneath, let the Glass L H have, at the end L, a hollow Ball of Glass, with a small Hole on one Side, filled with Water,

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and the Degrees of Heat and Cold will be shown by the Rising and Falling of the Water (*s*).

PROPOSITION X.

A clear Air may be so rarified by a great Fire as to take up seventy times a greater Space than before, and so condensed in a Wind-Gun as to take up only the sixtieth part of the former Space; but the Heat of the Sun will not rarify so much, nor the ordinary Cold condense so much.

THIS is proved from the *Æolipile*, which if it be taken when white with Heat, it will then receive thirteen Ounces of Water; but the same *Æolipile* when cold, or in it's natural State, will take thirteen and half a Dram, and that Part which contains the half Dram is the Difference of the two Spaces, and is almost the seventieth Part of the whole Cavity of the *Æolipile*.

(*s*) This kind of Thermometer was thought to shew the Heat or Coldness of the Air, with sufficient Accuracy before the discovery of the Barometer. But after it was found that the Air was not of one constant Weight, but differed at different Times, it was remarked, that the Water included in the Glass Neck, according as the Weight of the Air increased or diminished, and reeking upon the Water contained in the Vessel, must also ascend or descend tho' the Degree of Heat should remain the same. Whence the Structure of the Thermometer was necessarily altered. Most at present use a similar Tube A B C (*Fig.* 27.) ending in a Ball at the Bottom. This they fill to a proper Height with Spirit of Wine, suppose to B, then close the Instrument by melting it's Extremity A at the Flame of a Lamp. The Spirit of Wine, being now rarified or condensed, according to the different Temperature of the Air, marks, by it's ascent or descent in the Tube, the greater or less Degree of Heat. In making this Thermometer they observe such a Proportion in the Capacity of the Ball to the Stem, that the Spirit of Wine may neither fill the whole Tube in the greatest Degree of Heat, nor all sink into the Ball in the greatest Cold.

Jurin's Appendix.

PRO-

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PROPOSITION XI.

Why in Places of the Frigid Zone, *when they have not the Sun rising and setting, the Air is some Days clear, but gross and cloudy for the most part.*

THE Cause of that thick Cloudiness, which is almost constant, is, the small Heat of the subterraneous Earth, or that comes from the Sun, or Moón, (which remains for several Days and Nights above the Horizon whilst the Sun is below,) and other Stars; which Heat, being weak, is not able to dispel the Cloud; and some Days being clear, is not from the gross Vapours being made small, but from their falling down on the Earth, or being driven away by the Wind.

PROPOSITION XII.

Why sometimes in the greatest Cold in Winter the Air is subtile and clear; whereas Cold condenses and contracts the Air.

COLD is twofold, moderate and excessive: a moderate Cold does not make the Air clear but cloudy, for by the small Heat that is joined with the Cold, the Vapours are raised but not dispelled; but a vehement excessive Cold renders the Air clear, for two Reasons; 1. It makes the gross Vapours in the Air more gross; and so they fall down, and the Air is thus cleared. 2. Because the Pores of the Earth are shut up, and the Vapours are not exhaled from it, that render the Air turbid and cloudy. The Sea indeed is not frozen with Cold; yet it's Particles are made so thick with Cold, that it doth not so readily send out Exhalations, tho' it doth a great many, being of another Nature than the Earth.

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PROPOSITION XIII.

Why when we look thro' the Air in an horizontal Line it appears thicker and more cloudy than that above, or that in which we breathe.

THE Cauſe is twofold; the firſt becauſe the Air near the Horizon is really more cloudy; the other is a deceit in our Sight; for the Eye takes in the Diſtances of the Parts of an Arch in the Horizon, by very ſmall Angles; as it does the Diſtances of Pillars in a long Row: and as we judge thoſe that are diſtant to be near, ſo the diſtant Particles of Air are judged to be joined cloſe; but the Diſtance of the Particles of Air that is higher, the Eye ſees under great Angles and apprehends them the better.

THE ſame is the Cauſe why the Air at a Diſtance appears to be cloudy; but when we approach to it, it does not ſeem ſo cloudy.

PROPOSITION XIV.

Whether the Atmoſphere or Air be always of the ſame Height in all Places; or if it's Figure be ſpherical.

THAT it is not of the ſame but of very different Heights, appears in that the Sun is only vertical to one Place at once, and ſends it's Rays obliquely to other Places; and ſo more weakly the more they are remote from the Sun, or the nearer the Poles: and therefore the power of the Sun is different in different Places, and muſt raiſe the Vapours differently; they are higheſt directly under the Sun, and loweſt in the oppoſite Point, and in a middle Height at the Pole, ſo that the Air is of an oval Figure.

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YET the contrary, that the Height is the same in all Places, seems more probable; tho' the Vapours are more elevated in some Places than others; yet because the Air is fluid and by it's Gravity tends downward, therefore the higher Parts press those below; and those again others sideways, 'till all the Parts come to be alike high; and thus it's spherical Figure is proved the same way as that of the Water is proved by *Archimedes*, Chap. xiii. for the Suppositions here are the same as there; which if false the Demonstration fails.

DES Cartes also makes it oval, for a particular Reason; see Chap. xiv.

PROPOSITION XV.

The Condensation or Rarifaction of the Air doth not alter it's Height.

FOR not the whole, but a part only is condensed or rarified, sometimes here, sometimes there; which doth not alter the Height in one Place more than another: only there may be a greater Condensation in one Part than in another: which cân alter the Height but very little.

PROPOSITION XVI.

The Altitude of the Atmosphere or Air is not only the same in different Places, but is always the same both Summer and Winter.

FOR tho' the Heat in our Summer doth attenuate our Air, and raise it more than in Winter, yet because then there is Winter in another Place, the Air there is less raised, and therefore a Part of our Air will flow there: and when our Air is low by the Cold, the Air of another Place that is hotter will

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will move to us, 'till the whole Air be equally distant from the Center.

AND the same may be said as to Day and Night; for while at Night it is condensed with us, and is low, it rarifies more in another Place, and moves to our Air 'till it makes a spherical Figure; and because all things are every where equal, the Height will continue the same every where; and tho' it may rarify and condense more in one Place and Time than another, yet the Difference being small will not much alter the Altitude; as we said in the preceding Proposition.

THE same may be said of the Clouds, Rain, or Vapours, in our or another Place, as from these a greater or less Altitude seems to arise: but I answer, there is scarce any time in which it doth not rain, or a Cloud fall, in some Place or other; and therefore while it rains in one Place the Air becomes no less than it was, because it rained before in another Place, and so it comes all to the same thing, and the quantity of the Air is neither encreased nor diminished.

PROPOSITION. XVII.

The colder the Air is, the thicker: and therefore it is for the most part colder in Winter than Summer (in any particular Place), and likewise in the Night more than in the Day, and the gross Exhalations from the Water in the Winter-time, increase that Density, especially in the Evening and Morning.

THE Truth of the Proposition is clear from the preceding; nor is it any Objection, that a Part of the hotter Air moves where it is colder, and more low; for it is not that but some neighbouring Air that moves to the Place, because of the continual Protrusion, or Pressure; or tho' it came itself,

itself, yet by coming there, it would become cold.

PROPOSITION XVIII.

There are commonly reckoned three Regions of the Air, of which that is in the middle where the Snow, Hail, and Rain are formed; the first is that in which we live reaching to the middle Region; the third is from the middle Region to the utmost Bounds of the Atmosphere, even to the fiery Region, as the Aristotelians *speak.*

THE middle Region is colder than the first and third, which are counted hotter: because the third contains more subtile, fiery, and sulphureous Exhalations which go up into it above the Place of the Particles of Water, or are thrust there being lighter. The *Aristotelians* say 'tis hotter because nearer to the fiery Sphere, and colder than the first; because the Rays falling, join with those that are reflected from the Earth, and so double the Heat. Moreover the Particles of the subterraneous Fire coming out of the Earth are dissipated there in the lower Region; and the middle Region being without all these Advantages must needs be colder.

PROPOSITION XIX.

The nearer a Place is to the Pole, or the more distant from the Place where the Sun is vertical, the Place of the Air in which Rain, Snow, and Hail is formed is the nearer the Earth.

THE Cause is, that the Rays fall more obliquely on the Places about the Poles than on those about the Equator, and therefore being refracted are far removed from the Perpendicular, and thus the

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the Heat becomes leſs, and the watry Vapours contract into leſs Room, and by joining form the watry Meteors.

COROLLARY.

THE Superficies of the firſt Region is oval, or rather elliptical, or like a Spheriod, bulging out under the *Torrid Zone.*

PROPOSITION XX.

The nearer a Place is to the Pole, the third Region (in which the more ſubtile and ſulphureous parts move up and down) begins further from the Earth.

FOR that Part of the Atmoſphere which is nearer the Pole contains fewer ſubtile and ſulphureous Particles; for the Sun brings fewer of them thither from the Earth. And a leſs Number being raiſed there than in the *Temperate Zone*, and fewer in the *Temperate* than in the *Torrid Zone*, and the utmoſt Bounds of the third Region equally diſtant from the Earth's Center by Propoſition 16; therefore the beginning of that Region under the *Frigid Zone*, is further from the Earth's Center than it's beginning in the *Torrid* or *Temperate Zone.*

COROLLARY.

THE Superficies bounding the ſecond Region is as a Spheroid bulging in the *Frigid Zone.* Theſe are all to be ſhown to Students by a Diagram.

PROPOSITION XXI.

The Rays of the Sun, Moon, and Stars, do not come directly from the Heavens thro' the Air, to our

our Eyes, but turn a little aside from the strait Course, as soon as they enter the Air; which is called, by Writers in Optics, their Refraction.

THAT Part of Optics which treats of the Refraction of Light is very fine. Experience testifies, that the Rays coming from any Object out of one Medium into another more gross, or more fine, do refract or turn aside: the Thing is plain from a common Experiment. Take a Vessel, to the Bottom of which fix a Globe of Gold, or Brass, or Peice of Money, then go from the Vessel 'till you cannot see the Money for the Sides of the Vessel, then fill the Vessel with Water and you will see the Money; which shews, that the Rays coming from the Money as they go from the Water into the Air turn from their Course, before they can come to the Eye; which is called *Refraction*, because the Line is broke, as it were, coming from Water to Air.

THUS, Let the Center of the Earth be T, (*Fig.* 28) and L the Eye on it's Surface, and *d r f* the Surface of the Atmosphere, or Air; and therefore no Ray can come to the Eye at L, which is under L *f g* for the Rays below would fall on the rising Part of the Earth L *o*; and thus no Star can appear by a strait Ray 'till it come to the horizontal Line L *f g*, but the Stars appear before that, while they are under L *g*: for Example in S, from which no Ray can come strait to the Eye, but must be refracted; *i. e.* the Line or Ray S *f* coming into a thicker Medium at S, on the Atmosphere, is refracted and runs on in the Line *f* L, tho' it was directed to *n*, and thus the Star appears before it comes to the horizontal Line L *f g*.

THUS the Star in *f* is not seen by the direct Ray *f r*, but by the refracted Ray *r* L, tho' it was directed at the first to *m*; and therefore the Star at *f* appears higher by the Refraction than it really is,

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is, it's Height being the Angle *r* L *g* or the Arch *xg*, as if it were in the Point *x* when it is really in *ſ*.

THIS being the Law of Refraction, that the Rays going into a groſſer Medium, turn to the perpendicular at the Point of Incidence, as here *ſ* is the Point of Incidence, and T *ſ* the Perpendicular drawn thro' *ſ*, thro' the Superficies *drſ*; therefore the Ray S*ſn* will be refracted towards *ſ*T that from *ſn* it may become *ſ*L.

AND thus the Line or Ray *rm* becomes *r* L: but the contrary happens when the Ray goes into a fine Medium, for then it goes from the Perpendicular.

BESIDE it is the Nature of Refraction, that the Rays falling perpendicularly on the Superficies of another Medium, are not refracted, but only thoſe that fall obliquely, and thoſe are the more refracted the more obliquely they fall. Thus the Rays S T, *ſ*T, M *d* T being perpendicular to the Superficies are not refracted, but the Rays S*ſ*, *ſr* that fall obliquely are, and S*ſ* more than *ſr*.

FROM whence it alſo follows, and is manifeſt by Experience, that the nearer the Stars are to the Horizon, their Rays are the more refracted, and the higher they are, the leſs; and Aſtronomers have found, that when a Star is twenty Degrees high, the Refraction is inſenſible, tho' there is ſtill a ſmall Refraction.

AND Mathematicians, ſkilled in Optics, have by Obſervations found the Laws of Refraction of all oblique Rays, and that in every Medium there is a conſtant fixed Proportion between the Sine of the Angle of Incidence and of the refracted Angle (*i. e.*) between the Angle *nſ*T and L*ſ*T, the Angle *nſ*L being the Angle of Refraction; and ſo in the Refraction of the Ray *ſrm*. Therefore the ſame Proportion that is between the Sine of the Angle

Angle T*f n* and the Sine of the Angle T*f* L, the same is between the Sine of the Angle T *r m* and the Sine of T *r* L. Therefore if the Quantity of Refraction be known by Observation at one Elevation of a Star, the Quantity of Refraction for all other Elevations may be known (*t*).

PRO-

(*t*) It is of great Moment in the making of exact Astronomical Observations, to know the Refraction which the Rays of Light suffer in passing thro' our Atmosphere. This was determined by the learned Mr *Lowthorp*, by an Experiment made before the *Royal Society*, and shewn to be as the Sine of the Angle of Incidence and Refraction. See *Philos. Trans.* N° 257. But this Experiment being questioned by the *Royal Academy of Sciences at Paris*, who had not the same Success, [see their *Memoirs* for the Year 1700.] Mr *Lowthorp* repeated it at the Request of the *Royal Society*, and Mr *Hauksbee* also performed it with much greater Accuracy. See *Hauksbee's Physico Mechanical Experiments p.* 175 and found the Proportion betwixt the Angle of Incidence and Refraction was as 1000000 to 999736; so that the refractive Power of the Air to bend a Ray of Light from it's strait Course in coming out of a Vacuum, or the Difference of the said Sines, proportionable to the Sines themselves, is 264 1000000 Parts. And the Experiment being several Times repeated, he found that this refractive Power exactly answered to the Proportion of the different Densities of the Air thro' which the Ray passed, so as to be twice or thrice as large when the Air had twice or thrice the Density. Whence we have an easy Rule for finding the Refraction in any Time or Place, as being always correspondent to the Density of the Air. But the Density of the Air may be measured by a joint Observation of the Barometer and Thermometer. For as the Spaces, possessed by the Air, are reciprocally proportional to the Weights that compress it [see the Note upon *Proposition* 7. above] and it's Density reciprocally as the Space it possesses, the Density of the Air must be proportional to the Weight that compresses it, or the Weight of the incumbent Atmosphere; that is, the Height of the Quicksilver in the Barometer. And this will be the Case if the Heat of the Air remain the same. But if the Height of the Barometer be known, the Density of the Air is reciprocally proportional to the Spaces marked against the Degrees of the Thermometer in the Tube above. [See the Note to *Proposition* 8.] Whence it follows, according to the known Theorem of compounding Ratios, that the Density of

the

PROPOSITION XXII.

The Atmosphere or Air causes the Sun and other Stars to appear before they come to the Horizon at rising, or after they are passed it, at setting; and appear higher than they really are, while they are under twenty Degrees of Elevation.

THE Cause is sufficiently explained in the preceding Proposition. We may add some Experiments or natural Phænomena. When the *Dutch* wintered in *Nova Zembla*, the Sun appeared to them sixteen Days before it came to the Horizon, that is, when under the Horizon four Degrees, and that in a clear Sky; and famous Astronomers have

the Air is always as the direct Ratio of the Heights of the Barometer, compounded with the reciprocal Ratio of the Spaces marked against the Degrees of the Thermometer.

'For Example, at the time 'the Experiment was made, 'the Height of the Barometer 'was 29 Inches, $7\frac{1}{2}$ decimal 'Parts, and the Thermometer 'at 60, over against which 'the Space of 137 Parts is 'marked; Then, it must be 'enquired, what the Density 'of the Air is, when the Barometer is up at 30 Inches, 'and the Thermometer 50 'degr. below the Line of Freezing, then the Column of Air 'in the former Experiments 'will not possess above the 'Space of 126 Parts; so that 'the Density of the Air sought 'for, will be to the Density 'of the Air at the Time the 'Experiment was made, as '30×137, to $29, 7\frac{1}{2} \times 126$; 'or as 4110 to 3748. 5.

And hence may be understood the Reason why the *Dutch* who wintered in *Nova Zembla*, found so great a Refraction. See *Sect.* vi. *Chap.* 19. *Prop.* 30. For hence we understand, according to the Observations of the *French* and others, (see *Hist. de l' Acad. Scien.* 1700, 1706, and *La Mesure de la Terre*) that the Refractions are greater towards the Poles than near the Equator, and greater in the same Place in the Morning or Evening than at Noon; tho' there be no Difference perceived in the Height of the Barometer. For all this seems to proceed from the same Cause *viz.* the greater Density of the Air by reason of Cold.

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found, with *Tycho*, that, with us, when the Air is clear in the Morning the Sun is seen elevated above the Horizon thirty four Minutes, while 'tis yet under the Horizon and it's Limb but just touching it, and as long in the Evening.

THUS the *Virgin's Spike* appears when 'tis thirty two Minutes under the *Horizon*, for it seems to rise when the Lion's Tail is thirty four Degrees, thirty Minutes high, and on the same Point. But these two Stars are distant thirty five Degrees two Minutes.

PROPOSITION XXIII.

The grosser the Atmosphere is, the Refraction is the greater, (other things being alike) i. e. *there being the same Elevation of the Star, and the same Height of the Air.*

THUS the Angle *nf*L, (*Fig.* 28.) which is the Angle of Refraction, is the greater, or the refracted Ray *f*L comes nearer to *f* T the thicker the Atmosphere is, which those skilled in Optics have found in all kinds of Mediums.

PROPOSITION XXIV.

The grosser the Air is, the more the Star is under the Horizon when it first appears.

THE Ray L*f* (*Fig.* 28.) is refracted and first shows the Star, and L*f*T is the refracted Angle; and S*fn* being the incident Ray, *nf*T will be the Angle of Incidence, and *nf* L the Refraction.

LET us then suppose the Air *fd*LO to be grosser than when it made the Refraction *nf*L, it will thus make the Angle of Refraction greater, *viz.* *of*L, and the incident Ray will be K*fe*. Therefore

fore the Star being in K, the Ray K*f* will be refracted, that the refracted *f* L may shew the Star; but when the Air was not so gross the Star was first seen when in S.

PROPOSITION XXV.

The lower the Air, the Star is the more under the Horizon when it first appears (other things being alike) i. e. *there being the same Clearness or Thickness in the Air, or is seen the sooner or later before it rise.*

FOR, supposing the Air low, the refracted Angle T*f*L (*Fig.* 28.) will be greater; for Example, if the Altitude of the Air be T 4 the Angle refracted (according to the first Ray that comes to L) will be T 4 L. Let then 4, 9 be drawn parallel with *fn*; then, by the Hypothesis in *Prop.* xxi. as the Sine of one refracted Angle T*f*L is to the Sine of another refracted Angle T 4 L, (for the Air differs only in height by supposition and not in thickness) so is the Sine of the Angle of Incidence *nf*T to the Sine of the Angle of Incidence 3, 4, T, for the refracted Ray 4, L, and the incident Ray 3, 4, 6. But the Sine of the Angle T 4 L hath to the Sine T 4 9, the same Proportion which the Sine of T*f*L hath to T*fn*, as is easily demonstrated by the Figure for this proposition. Therefore the Sine of the Angle T, 4, L hath a greater Proportion to the Sine of T, 4, 9, than the same Sine T 4 L hath to the Sine T, 4, 3; therefore the Sine T 4, 9 is less than the Sine T, 4, 3; and so the Angle T 4, 3 is greater than the Angle T, 4, 9, and 3, 4, L than 9, 4, L, that is, than *nf*L; and therefore the Line 4, 3 drawn out, *viz.* 3, 4, 6 the incident Ray for the refracted one 4, L will fall under S*f*, and the

Star will be in 6 to cause the refracted Ray 4 L; and thus 'tis lower than when in S where the Altitude of the Air was T *f*.

PROPOSITION XXVI.

A Star may have a different Refraction even in the same Place, provided the Density of Air be different.

THE Problem is better put thus: *The Altitude of a Star and it's Refraction being given, viz. that which is made at a given Height; and there being given likewise another Altitude of the Air; to find the Density of the Air requisite to cause the same Refraction in that Altitude as was in the other.* For Example, in the Altitude of the Air T *f*, (*Fig.* 28.) the Ray S*f* makes the Angle of Refraction *nf* L; if then there be another Altitude of the Air T 4, and yet the Refraction of the Star S in the same Place of the incident Ray 6, 4 which is almost parallel with S*f*, because of the great Distance; 'tis asked whether the Refraction 3, 4, L may be equal to the Refraction *nf* L; and if it may, whether or no must the other Air be thicker or thinner, and in what Proportion?

I answer it may be, if the other given Altitude of the Air be greater than the former T *f*, the Density or Thickness of this second Air must be greater; but if the other given Altitude be less as T, 4, then the Thickness of the second Air must be less, or have a greater Rarefaction in it, and how much that must be is known from this.

1. FIND the Angle T 9 L (having T 4 and T L) and T *f* L, then the Sine of the Angle T 4 L, and the Sine of the Angle T 4 3 (which is the Angle of Incidence of the Ray 3, 4, 6) thence is found the Proportion of the Density of the Air, to that of the Ethereal Matter, from which the inci-

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dent Ray comes. In the ſame manner, let the Sines of the Angle T*fn* and T*ſ*L be taken, and they will ſhew the Proportion of the Denſity of the firſt Air to that of the Ethereal Matter; and by comparing theſe Proportions it may be known, how much more denſe or rare the Air of the leſſer Height ſhould be.

YET properly ſpeaking 'tis not the ſame Refraction, for the incident Rays are not equally elevated above the Superficies of the Medium's.

PROPOSITION XXVII.

If the Air of one Place be both thicker and lower than the Air of another, the Sun, and the reſt of the Stars, will be the more depreſſed, under the Horizon of the former Place, when they firſt begin to appear than in the latter Place.

THE Demonſtration of this Propoſition is manifeſt from *Prop.* xxv. and xxvi; and it alſo thence follows, that if the Air be lower and groſſer in Places of the *Frigid Zone* than in the *Temperate* and *Torrid Zone*, the Sun may be ſeen there longer before the riſing and longer after the ſetting, than in other Places that are higher and more ſubtile; for when 'tis more depreſſed under the Horizon, and comes to it more obliquely and more ſlowly as in the *Frigid Zone*, it muſt then be ſeen much ſooner in the *Frigid* than in the *Torrid Zone*. But 'tis doubtful whether the Air be lower in the *Frigid Zone*; and tho' the Sun be ſeen ſooner before it riſe, whether that may be only on Account of the groſſneſs of the Air; of which afterward.

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PROPOSITION XXVIII.

If the Air of one Place be grosser and higher than that of another; it may be on account of the greater Thickness of the Air in one Place than the other, that they do not see the Stars before they rise, when they are a good way under the Horizon. And such also may be the great Thickness of the Air that thereby they shall see the Stars before they rise, tho' they have the same Depression: Yea the Air may be so thick as to shew the Stars when in a much greater Depression under the Horizon of one Place than of another.

YEA the thickness of the Air will cause a much greater Depression than the lowness of the Air; and for the Refractions in *Nova Zembla* there is required a great Height of the Air with some thickness.

PROPOSITION XXIX.

It is impossible that the Refractions of a Star in different Altitudes should be equal (if the thickness of the Air be the same) to the Refractions of the same Star in the same Altitudes, if the Air be either higher or lower, or thicker or thinner.

WE shewed, in the preceding Proposition, that if in the Altitude of the Air T *f*, (*Fig.* 28.) the incident Ray S *f n* make the Refraction *n f* L, the Ray 6, 4, which, because of the great Distance, may be reckoned parallel with S *f*, the Rays from the same Point, we say the Ray 6, 4 may, in another Altitude of the Air, as T 4, make the same Refraction 3 4 L equal to *n f* L, if the Air 4 *o* L *e* be thinner than the Air *f o* L *d*; now 'tis demanded if that may be in two Altitudes of a Star. For Example, suppose the Star in S, the Air *f o* L *d*, and the Air 4 *o* L *e* be so disposed as to make the same Refraction, whether in another Altitude as S, and in the same Atmosphere *f r d* L *o* and 4 *e* L *o*, the Refraction may be again equal, or the same *m r* L? And I say that it cannot be.

FOR if a Circle be described with the Center T bounding the Air of another Altitude cutting L *r* in 2, then 2 L will be the refracted Ray in the other Air, by which the Star *f* is seen; for the Ray 2 L must be the same with *r* L, as the same apparent Altitude of the Star *x g* is supposed, or the Angle *r* L *f*. Moreover, let the incident Ray, answering that refracted one, be drawn thro' 2 as 7 2 *w*, which will be parallel with *f r m*, if the Refraction L 2 *w* were equal to the Refraction L *r m*; for if T 2 be also drawn, T 2 *w* will be the Angle of Incidence, and T 2 L the Angle refracted, and *w* 2 L the Refraction.

THEREFORE as the Sine of 3 4 T to the Sine L 4 T, so is the Sine of *w* 2 T to the Sine of L 2 T.

AND as the Sine of *n f* T to the Sine of L *f* T, so is the Sine of *m r* L to the Sine of L *r* T, and 3 4 L being equal to *n f* L, the Angle *w* 2 T is not equal to *m r* L, or *w* 2 is not parallel with *m r*. This requires a longer Demonstration than can be given here, as belonging to Geometry, which will be evident from the following *Algebraic Work*.

PROPOSITION XXX.

Having in two Altitudes of a Star observed the Refractions, to find from thence the Altitude of the Air, and the Proportion of their Densities, or the Law of Refraction in that Air.

THE

THE Refraction of a Star is equal to the Difference between the observed Altitude, and the true Altitude, which is known by Calculation, and thus Refractions are easily known. Then to our purpose:

IF it were to be solved Geometrically, it would be brought to this Problem:

LET the Star be in S (*Fig.* 29.) sending out the Ray S*f*, and the Refraction *nf* L.

AND in the Altitude *fg* it's Refraction *m r* L.

THEREFORE in the Circle *d r f*, whose Center is T, there is given T L the Semidiameter of the Earth, and drawing T *r*, T *f*, L *f*, L *r*, the Angles T *l f* and T L *r* may be had; the latter being made of the Star's Altitude, and a right Angle, and the Angles *n f* L and *m r* L are given; and we know that the Proportion of the Sine of the Angle *n f* T to L *f* T is the same as the Sine of the Angle *m r* T to the Sine of L *r* T. From these to find the Semidiameter T *f* or T *r*, and the Proportion of the Sine of *n f* T to the Sine L *f* T, or to find the Angle T *f* L. Which will give the Proportion of the Sines.

THE Algebraic Solution is something difficult, but the common synthetic way requires many Lemmata to be premised, which the former Solution doth not. Let us therefore produce the analytic Solution, to shew that it will confirm the preceding Proposition. Let the Sine of the right Angle T L F, or

The Radius be	*b*
and Sine T L *r*	*c*
Sine *n f* L	*d*
Sine comp.	*g*
Sine *m r* L	*b*
Sine comp.	*k*
Sine T *f* L	*a*

Let us find the Angle L *f* T; for this being known T F, and all the rest are known.

 FIRST,

FIRST, because there is given the Sine of both the Angles $T f L$ and $L f n$, the Sine of the whole Angle $n f T$ is given, *viz.* if the Sine of each Angle be multiplied into the Co-Sine of the other, and the Sum of their Products divided by the Radius. Thus the Sine of the Angle $n f T$ will be $\frac{ag + d\sqrt{bb - aa}}{b}$.

MOREOVER, seeing the Sine $T L f$ is to the Sine $T f L$ (So is $T f$ to $T L$ or $T r$ to $T L$) so is the Sine $T L r$ to the Sine $T r L$; that Sine $T r L$ will be $\frac{ca}{b}$. And seeing there is given also the Sine $M r L$, let there be found, according to the former Rule, the Sine of the whole $m r T$, which is $\frac{kca + b\sqrt{b^4 - ccaa}}{bb}$. Thus we have the Sine of four Angles $L f T$, $n f T$, $L r T$, $m r T$, for we know they are proportional since as $a : \frac{ag + d\sqrt{bb - aa}}{b} :: \frac{ca}{b} : \frac{kca + b\sqrt{b^4 - ccaa}}{bb}$.

And therefore $cga + cd\sqrt{bb - aa} = kca + b\sqrt{b^4 - ccaa}$; or if $\frac{b^4}{cc}$ be $= mm$, and $g - k = n$; then, after due Reduction, it will be $na + d\sqrt{bb - aa} = b\sqrt{mm - aa}$. And both Sides squared $bbmm - bbaa - nnaa - ddbb + d^2a^2 = 2nad\sqrt{bb - aa}$. For p^4 write $bbmm - ddbb$, and qq for $dd - bb - nn$, and square again $p^4 + qqaa = 2nad\sqrt{bb - aa}$, and it will be $p^8 + q^4a^4 + 2p^4qqaa = 4nnbbddaa - 4nndda^4$. And dividing by $4ndd - q^4$, and substituting other Sines

Sines $a^4 = rraa - s4$. And $aa = \frac{1}{2}rr +$ $\sqrt{\frac{1}{4}r^4 - S^4}$ or $aa = \sqrt{\frac{1}{4}r^4} + \sqrt{\frac{1}{4}r^4 - S^4}$.

FROM this Equation it appears that the Problem is determined, and that a, which is the Sine of the Angle TfL, may be found by extracting the ſquare Root. And from thence 'tis found, that two Refractions are ſufficient to find the Altitude of the Air T F, and the Rule of Proportion between them; which I take Notice of becauſe I ſee *Kepler*, in his *Epitome of Aſtronomy p.* 65. takes three Refractions, tho' he did not try this Method himſelf.

THE Reſolution of this Problem may be alſo had by the Rule of Poſition, by aſſuming Tf in a certain Proportion to T L, and trying if, by that Aſſumption, the Sines of the four Angles TfL, Tfn, TrL, Trm will be proportional.

THEREFORE, in the Triangle fLT, let there be found the Angle TfL from having fT, T L, and T Lf. And likewiſe in the Triangle T L r, find the Angle TrL from having Tr, TL, and TLr.

LET there be then taken the Sine of the Angles TfL, Tfn, TrL, Trm; and let there be a fourth Proportional taken to the Sines TfL, Tfn, TrL. And if Trm be equal to this fourth Proportional, then the aſſumed Height of the Air Tf will be juſt; but if the Sine Trm be greater than the fourth Proportional, then Tf muſt be taken leſs; but if leſs, then it muſt be taken more; and ſo always 'till they become equal.

EXAMPLE.

SUPPOSE the *Virgin's Spike*, or any other Star, or the Sun, to be ſeen in the Horizon Lf when

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when 32 Minutes under it, as in S; thus the Refraction *nf* L is 32.

THEN when the Sun hath the apparent Altitude *g x* 1 *degr.* 22 *min.* or the true Altitude 1 *degr.* the Refraction L *r m* is 22 *min.*

THE Semidiameter T L is 860 *German* Miles. But suppose it 10000, and the Altitude *o f* to be 5 of these Parts, *viz.* $\frac{5}{10000}$ or $\frac{1}{2000}$ of the Semidiameter T L; that is, abont $\frac{1}{8}$ of a Mile.

THEREFORE in the Triangle T L *f*, the Radius being 10,000,000.

AS *f* T to T L, so is the Sine T L *f* to the Sine T *f* L.

2001 : 2000 : : 10,000,000 : 9,995,992, the Sine of 88 *degr.* 22 *min.* 40 *sec.*

AND thus T *fn* will be 88 *deg.* 54 *min.* 40 *sec.* whose Sine is 9,998,200.

AGAIN, in the Triangle T *r* L.

AS T *r* : T L, so is the Sine of the Angle T L *r* to the Sine T *r* L.

2001 : 2000 : : 9,997,155 : 9,992,159, the Sine of 87 *degr.* 43 *min.* 40 *sec.*

THEREFORE T *r m* is 88 *degr.* 5 *min.* 40 *sec.* whose Sine is 9,994,500.

THEN let there be found a fourth Proportional to the Sines of T *f* L, T *f n*, T *r* L.

AS T *f* L : T *f n* : : T *r* L.

AS 9,995,992 : 9,998,200 : : 9,992,159 : 9,994,366.

AND with that fourth Number compare the Sine of the Angle T *r m*, which is 9,994,500.

AND we find that this Sine is very near to that fourth Number; and therefore the assumed Altitude of the Air, *viz.* $\frac{1}{8}$ of a Mile, is not far from the Truth. And if any one desire it more accurately, he may assume another Altitude, and work the same way, 'till the Sine of T *r m* be nearer

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nearer to the fourth Proportional; or, by the Rule of Falſe, having it twice too little, you may find the true Altitude as near as poſſible, for it cannot be found perfectly true; becauſe a ſmall Difference in the Sines changes it very much if it be but half a Minute: and beſides this the Canon of Sines muſt be very exact.

WE conclude therefore, that the Height of the Air is about the 2000 part of the Semidiameter of the Earth, which is 1,633,190 Perches; and the Altitude of the Air 816 Perches, one Perch being twelve *Rhinlandiſh* Feet: but 'tis better allowed to be half a *German* Mile, for the Refraction L*fn* was found, by *Tycho*, to be greater, and may be thirty ſix or forty eight Minutes; and then the Height of the Air will be one Mile.

THE Height of the Air being known, there is alſo known the Proportion of the Denſity of the Air to that of the Ethereal Matter, or the Law of Refraction, in that Air making ſuch Refractions in ſuch Altitudes, *i. e.* the Proportion of the Sine T*f*L to the Sine T*fn*, before found, is the Proportion ſought.

AS 9,995,992 to 9,998,200. And the Reaſon why theſe Refractions are ſo ſmall is, becauſe we ſuppoſed a clear Air, not much differing from the Ethereal Matter in Denſity; as ſome have imagined.

MOREOVER, whether the Altitude of the Air be the ſame in all Places and Times may be known; if we uſe the ſame way two Refractions at two Altitudes in a different Air and Time. And that Students may underſtand theſe Secrets of Nature, I have, that they may try a Calculation, ſet down Examples from *Tycho*'s Obſervations, who obſerved the Refractions of the Sun and Moon for every Degree of their Height; and becauſe they differ from the Obſervations of *Lansberg*,

made

made in a different Air (if made at all), I will also add them.

Degrees of Altitude.	*Refraction of the Sun, according to* Tycho.	*Refraction of the Moon, according to* Tycho.	*Refraction of the Sun and Moon, according to* Lansberg.	
Degrees.	*Minutes.*	*Minutes.*	*Minutes.*	*Seconds.*
0	34	33	34	
1	26	25	26	
2	20	20	21	
3	17	17	18	
4	15	15	15	45
5	14	14	14	0
6	13	14	12	30
7	12	13	11	15
8	11	12	10	5
9	10	11	9	5
10	10	11	8	15
11	9	10	7	35
12	9	10	7	5
13	8	9	6	40
14	8	8	6	19
15	7	8	6	0
16	7	7	5	42
17	6	7	5	27
18	6	6	5	7
19	5	6	4	50
20	4	5	4	33
21	4	4	4	16
22	3	3	4	0
23	3	3	3	44
24	3	3	3	28
25	2	2	3	2
26	2	2	2	56
27	2	2	2	40
28	2	2	2	24
29	2	2	2	9
30	1	1	1	54
31	1	1	1	39
32	1	1	1	24
33	1	1	1	9
34	1	1	0	55
35	1	1	0	41
36	1	1	0	27
37	0	1	0	13
38	0	1	0	0

LANSBERG

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LANSBERG sets down the same Refractions for the Sun and Moon; and *Tycho* makes a small Difference near the Horizon, those of the Sun greater, and at the fifth Degree equal; and afterward the Moon's Refractions somewhat greater than those of the Sun: I confess I do not see why, except it be attributed to the weakness of the Moon's Light. And moreover, *Tycho* omitted Seconds, which are not to be neglected, if they approach near sixty, for they are of use in calculating the Height of the Air. But as for the Refractions of all the Stars they are equal, or very little different, if in one Air; but if the Air be grosser, the Refractions are greater. For Example, the *Dutch*, at *Nova Zembla*, found in Winter that the Sun began to appear after a Night of some Months, when it was 4 Degr. under the Horizon, at least it's Limb; therefore the Refraction *mf*L is 4 *degr.* 30 *min.* the Cause whereof none have sufficiently explained.

AND then, when it was 3 *degr.* 45 *min.* under the Horizon, they saw it elevated above the Horizon 30 *min. viz.* it's upper Limb; therefore the Refraction *mr*L (for we must conceive *mrs* to fall under the Horizon, or *r*L*g* to be 30 *min.*) will be 4 *degr.* 15 *min.* and *r*LT 90 *degr.* 30 *min.* From this may be found the Altitude of the Air L*f*, and the Density of the Air at *Nova Zembla*, which was clear at the time of Observation. And the Altitude of the Air is thereby found much greater, almost two Miles; nor will the supposition of a greater thickness in the Air help the Matter, as we shall shew in the following Proposition; because the Angle T*f*L cannot be greater than 85 *degr.* 30 *min.* (if *nf*L be 4 *degr.* 30 *min.*) tho' it will be greater if *df* be supposed less than two Miles; therefore the Truth of the Observation may be justly doubted of, seeing there is no such Observation any where; yea the contrary hath been observed in the same Place,

see

ſee *Chap.* xxvi. *Prop.* xiii. at the end. Beſides this, there can be no Reaſon given why the Air, after ſo long abſence of the Sun, ſhould be higher than when the Sun left them after it had been preſent a long time; rather the contrary ſhould happen, the Air being made groſſer and lower by Condenſation, as ſome may urge that count the Height of the Air inconſtant. Yet, when I conſider theſe things more accurately, three Particulars occur to me that might confirm that Appearance and the great Refraction: for the Obſervation cannot be denied, conſidering that the Obſerver underſtood Aſtronomy, and ſaw the Sun above the Horizon for ſome Days after, when it was ſtill under the Horizon; nor muſt we doubt of the Number of the Days in the long Night they had, for when they came back they counted the ſame Day of the Month, as their own People did; which could not be if they had miſtaken before. For if we admit ſuch an Altitude of the Air as is inconſiſtent with the Refractions in the *Temperate* and *Torrid Zone*, we muſt ſay the Air is of the ſame Height every where as truly in the *Torrid* and *Temperate*, as in the *Frigid Zone*. But, in the *Torrid* and *Temperate*, the upper Region of the Air is ſo ſubtile, that it doth not cauſe Refraction, but only the middle Region of it; and therefore no wonder if the Refractions in the *Torrid* and *Temperate Zones* are leſs; for the Air that cauſes them is lower, which ſhould cauſe the Refraction to be greater; yet it muſt be much more rarified than the other Air. But to this it may be objected, that the Obſervations of the Sailors were made in a clear Air, as themſelves ſay; to which I anſwer, that yet 'tis not probable that the Air was then ſo ſubtile as the cleareſt Air in the *Torrid* and *Temperate Zone*. Secondly, it may be ſaid that the Air of the *Frigid Zone*, when the Sun returns to it after a long abſence, is firſt refined in

the

the upper Region, and that the middle is somewhat more groſs, and therefore the Sun is ſeen by two Refractions, as the Stars are thro' Air and Glaſs, and a double Refraction depreſſeth the Star under the Horizon more than a ſingle one, and ſo the Altitude of the Air of one Mile, or three Quarters, will be enough. Nor can it be objected, why doth not the ſame thing happen when the Sun departs from that Air, and the long Night begins; for then 'tis probable the Difference of the thickneſs of the Air is leſs, becauſe of the Sun's long Continuance; or we may ſay the Exhalations are more groſs, in the Mornings of that Zone, after that long abſence. Thirdly, if a double Refraction doth not ſatisfy, and it will not be granted that the upper Region cauſes no Refraction, as was ſaid, then it muſt be granted that the Air in that Place of the *Frigid Zone* was then much higher than in our *Temperate Zone*, and alſo much groſſer (for 'tis only the Altitude that leſſens the Refraction): but if there be a great thickneſs, the Refraction is much more encreaſed thereby, than 'tis diminiſhed by leſſening the Altitude. But the firſt of theſe three Cauſes is beſt, that ſuppoſes the Altitude of the Air to be two Miles (for it cannot be leſs in *Nova Zembla* where the horizontal Refraction is ſaid to be 4 *degr.* 30 *min.*): the other two lie under ſeveral Difficulties. We have ſaid it was the thickneſs of the Air that was the Cauſe why, the Altitude being the ſame, the Sun was not ſeen for ſo many Days after it ceaſed to riſe on the third of *November*; and ſo we muſt anſwer, that the Cauſe may be the ſame why the ſame *Dutchmen* did not, on the thirtieth of *May* 1596, ſee the Sun in the middle of the Night, in the Latitude 69 *degr.* 42 *min.* when it was not one Degree under the Horizon. But we have ſaid too much of this, occaſioned by the difficulty of the thing; there muſt

must be, for an accurate knowledge of it, most accurate Observations. Yet we must not think, that if Observations of a Star, in different Elevations, do not give the same Altitude, that therefore it hath different Altitudes, on account of the Difference of the Density of the Air, which is greater the nearer the Horizon; and therefore Observation will give a different Altitude, tho' it be the same, for, in the Calculation, the Density, and consequently the Refraction, is accounted the same.

PROPOSITION XXXI.

Having the Depression of a Star under the Horizon when it first begins to appear (that is, having the horizontal Refraction of a Star), to find the least possible Altitude of that Air, in which the Refraction is made; and the Grossness of that Air and the greatest Quantity possible by which it exceeds the Density of the Æther; that is, the greatest Refraction possible. Or more generally thus: Having the Refraction of a Star, at it's apparent Altitude, to find the least possible Height.

LET the horizontal Refraction be *nf* L, (*Fig.* 28.) or the Depression of the Star under the Horizon *gfs* or *g* L *s*, when it first begins to appear, as it was in *Nova Zembla* 4 *degr.* 30 *min.* 'Tis known from the Doctrine of Optics, if a Ray, as *sf*, touch the Air in *f*; that is, if the Angle S*f*ϖ or *nf*T be a right Angle, then the Ray is not refracted; but if the Star be under the Tangent, then no Ray can come to *f* directly. Therefore it is requisite the Star be above that Tangent, and that *sf*ϖ or *nf*T be less than 90 *degr.* Let it then be 89 *degr.* 59 *min.* or 90 itself, provided it be no greater than from *nf*T. Let there be taken the Angle of horizontal Refraction 4 *degr.* 30 *min.* and there remains the Angle

T*f*L

T*f*L 85 *degr.* 29 *min.* the greatest that can be; then if it be made as the Sine T*f*L is to the Radius, so is L T to T*f*, which is the least Altitude of the Air possible. For because the Sine T*f*L is the greatest that can be, the fourth Proportional T*f* is the least that can be, if the middle Terms, *viz.* the whole Sine T L*f* and T L, be still the same: if the Refraction of the Ray, that appears at the Horizon, be not given, but the Refraction in the Altitude *x* L*g*, we may work the same way in the Triangle L*r*T.

LIKEWISE the Proportion of the Sine of the Angle *nf*T 89 *degr.* 59 *min.* to the Sine T*f*L 85 *degr.* 29 *min.* will be the greatest possible Proportion between the Density of the Air and that of the Æther.

PROPOSITION XXXII.

Having the Altitude of the Air, and one Refraction in it of a Star in a certain Altitude, to find the Law of Refraction, or the Proportion of the Sine of the Angle of Incidence, to the Sine of the refracted Angle; or to find the thickness of the Air by that Refraction.

THE Altitude of the Air must be greater than that we found to be the least possible, otherwise the Refraction is not right taken, and the Problem is impossible. (*Fig.* 28.) Let it therefore be greater, suppose T*r*; and also let the Refraction in the apparent Altitude *x*L*g* be *mr*L. Then there may be found the refracted Angle T*r*L (having T*r*, T L, and the Angle T L*r*) to which T*r*L if you add *mr*L, you will have the Angle of Incidence *mr*T, and the Proportion of the Sine *mr*T to the Sine L*r*T; which will be the Rule of refracting in

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in that Air, or the Proportion of the Air's Density to that of the Æther.

PROPOSITION XXXIII.

Having the Altitude of the Air, and the Refraction of a Star in one Altitude; to find the Refraction in another Altitude.

FOR Example, let the Altitude of the Air be T*f* or T*r*, and the Refraction *nf*L at the apparent Altitude *o*, and the horizontal Ray is the refracted Angle. Then let there be given the apparent Altitude *r*L*g* or *x*L*g*, and let the Refraction be found by the preceding Proposition, or the Proportion of the Sine *nf*T to T*f*L. Then in the Triangle T*r*L, having T*r* and TL, and the Angle *r*LT, find the Angle T*r*L; and as the Sine T*f*L is to the Sine T*fn*. So let T*r*L be to another Sine, which will be the Sine of the Angle *mr*T, from which take T*r*L, and there remains the Refraction *mr*L which was sought.

THE Antients used a more intricate and also a false Method for finding it.

PROPOSITION XXXIV.

Having the Altitude of the Air, and the Law of Refraction; to find the Refraction at the apparent Altitude of the Star, and from thence the true Altitude.

THIS is the same with the former, where the Law of Refraction was to be found from a given Refraction in a given Height. Examples for working may be taken, from the Table laid down before.

Of the Reflection of Light in the Air.

PROPOSITION XXXV.

The Rays of the Sun and Moon are not only refracted after they have entered the Atmosphere, but also reflected from the Particles of Air, or beat back as it were from a rough Mirror, because of the irregular Situation of the Particles.

FOR if otherwise, no part of the Atmosphere would be lucid, except that the Sun is above; and the Sun being in the East, the Air in the South and West would be dark; therefore as some Rays pass thro' the Atmosphere, so some are reflected several Ways, from one Particle to another, and thus they make the Air lucid.

PROPOSITION XXXVI.

Reflection of the Rays of the Sun from the Particles of Air, is the chief Cause of the Twilight, that is in the Morning and Evening.

THIS is evident from the preceding Proposition; for as the Sun being in the East, it's Rays, darted to the West, are reflected to our Eyes, and so render the West Part visible; so the Sun being under the Horizon, it's Rays shot into our Air, are reflected to our Eyes from the East in the Morning, and from the West in the Evening.

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PROPOSITION XXXVII.

The firſt of the Morning Twilight, that is, the enlightned Air in the Eaſt, and alſo the end of the Evening Twilight, begins when the Sun is about 18 degr. *under the Horizon.*

THIS Propoſition is built on Obſervation; for if in the Morning, ſuppoſe about one or two o'Clock, we obſerve narrowly towards the Eaſt, when a little white Colour begins to appear in the Air to the Eaſt Part of the Horizon, and note the Hour and Minute, we may thence know the Depreſſion of the Sun.

WE here ſuppoſe that the Air is clear, of which there being a great Difference, ſome have therefore thought the Twilight begun and ended at the twentieth Degree under the Horizon, others only at the ſixteenth Degree; for the groſſer the Air is, the Twilight is the leſs ſenſible; the contrary of which we ſaid happened in the Refraction, which is then moſt ſenſible.

PROPOSITION XXXVIII.

The Altitude of the Air, or the Matter that cauſes the Twilight, cannot be known from the Quantity of Twilight, as ſome have thought; nor does the beginning of the Twilight proceed from a ſingle, but a double Reflection.

Let T L *b* (*Fig.* 29.) be the Earth, *g f o m* the Bounds of the Air, and L the Place of the Earth in which the Twilight appears, or the Light in the horizontal Air *f*, and therefore *f* L, is the Ray reflected from the Air *f*, and the incident ſolar Ray *f g* S. Mathematicians, who have written of the Twilight, will have

have the incident Ray in *f*, which makes the reflected Ray *f* L, to come from the Sun *s*; and because no Ray can come to *f* from the Sun, while the Sun is under the Tangent *fbs*; therefore when the Sun comes to the Tangent *fbs*, for Example to *s*, then doth the Ray begin to come to *f*; and because they will have the Reflection to be from *f*, as from a concave Mirror, therefore T*fb* must be equal to T*f*L; and because the Sun is found to be 18 *degr.* under the Horizon, *nfs* must be 18 *degr.* and L*fb* 162 *degr.* and T*fb* or T*f*L 81 *degr.* and LT 9 *degr.* from whence T*f* is found 174 *German* Miles (as *Clavius* and *Nonius* make it) and the Air about eleven Miles: nay *Albazen* and *Vitellio* make it thirteen Miles.

SO great an Altitude of the Air is not to be allowed as disagreeing with other Phænomena, and being founded on a false Hypothesis, that the Ray *gbs*, which makes the reflected Ray *f* L, comes from the Sun itself, which is false; for it comes, by Reflection, from another Ray, for Example from the Ray *gl*. And that it is not necessary to make a small Light in *s*, that the Ray *fg* should come from the Sun itself, but that another Ray may serve, is proved from hence, that we see, in the western Air, some Light before the Sun rises, tho' 'tis certain no direct Ray can come from the Sun to the western Air, but from another Particle of Air, for Example from *f* and *o*; and so the reflected Ray L*m* comes from the incident Ray *fm* which is reflected from the incident Ray *gf*, and again *gf* from another *g* L; which perhaps comes again from another. Secondly, 'tis worth remarking, that they have made the Reflection from the Air as from a concave Mirror; the Center of which Cavity is T the Center of the Earth, which is false; for the Rays reflect from the Air without any regard to the Center of the Earth, but to their Superficies, as is evident from the Ray L*m*, which comes from the western Air to L; for if it came from *m* as from a Concavity, it's incident Ray should have come from the Place *x*, whereas it comes from *o*, or between *f* and *o*. Therefore the Ray L*m* so reflected, is from the Particle *m* as the Figure required. And in the Air there are Particles of very different Figures; and so no wonder if they make Reflections thro' the Air every way.

PROPOSITION XXXIX.

Supposing the Twilight is not made by one but a double Reflection, to find from thence the Altitude of the Air, which may agree better with other Observations.

IT was said in the last Proposition, that the Ray *g h f*, (*Fig.* 29.) which makes the first reflected Ray in the Beginning of the Twilight, does not come from the Sun itself, but that 'tis reflected in *g*; let therefore the incident Ray be *g l* (which may touch the Earth *m p*, and so *lg* is the first Ray which can come to g) and let us now suppose it to come from the Sun itself immediately, and by Refraction to be turned a little aside; that is, let QL be the Ray from the Sun, and let *l p g* be the refracted Ray, and *g h s* the reflected Ray, and *f* L the second reflected Ray. The Altitude of the Air T*f* is to be found; and, because the incident Ray Q*l* refracts into *g l x*, let us suppose the Angle of Refraction *g l x* to be 30 *min.* and that the Center of the Sun is 17 *degr.* under the Horizon, when the Twilight begins; therefore the Limb of the Sun will be 16 *degr.* 45 *min.* under it, and substracting the 30 *min.* for the Refraction, and Angle *n* K *x* will be 16 *degr.* 15 *min.* which is the Depression of the Sun's Limb after Refraction. And because

KL,

Plate VI

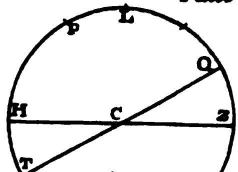


Fig. 30 P. 538.

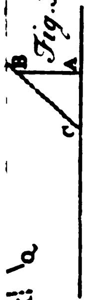


Fig. 31.

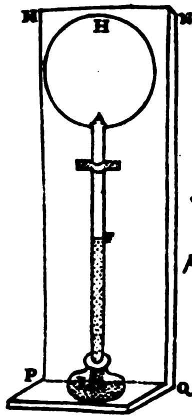
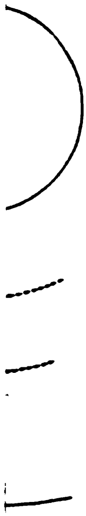


Fig. 26. p. 437



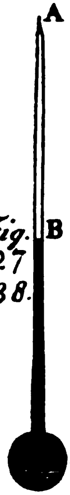


Fig. 27 p. 438.

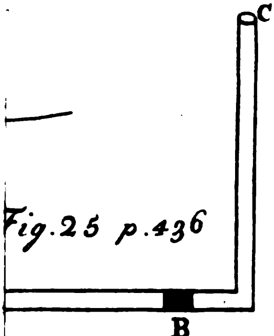


Fig. 25 p. 436

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KL, Kp are equal, and also fL, gp, then Kg, Kf will be equal, and the Angle Kfg equal to Kgf, and both together equal to gKn 16 *degr.* 15 *min.* therefore Kfg is 8 *degr.* 7 *min.* and fTL 4 *degr.* and TfL 80 *degr.* whence Tf is found to be 861 Miles and a half, and thus the Air's Altitude 1 Mile and a half, which is far less than was formerly made by the Twilight, and will be found much less if a threefold Reflection be made the beginning of the Twilight; which is not impossible. And this double or triple Reflection is better allowed for the Cause of the Twilight's Continuance, than that which *Kepler* brings from the splendid Matter about the Sun. You may see more of the Time of Twilight and it's various lengths, in the second Part of this Book.

PROPOSITION XL.

To find the Altitude of the Clouds by the Quadrant (*a*).

THE Air being calm and clear, fix on some Point in the Cloud that is remarkable, and measure

(*a*) Mr *Boyle* tells us, that a good Astronomer, who had divers times measured the Height of the Clouds, assured him, that he could never find any that were above three quarters of a Mile high, and that few exceeded half a Mile. And Mr *Crabtrie* (an excellent Mathematician of the last age) upon measuring their Height, was surprized to find them no higher, and wrote to his friend (that great Genius of the last age) Mr *Horrox*, about it. Who in his Letter, *Nov.* 23. 1637, tells him, 'I am not surprized that 'you found the Clouds so low, 'because I have often found it 'so. I remember that I contrived a way, about two or 'three years ago, of taking the 'Height of the Clouds with 'a Quadrant, all at one Station; 'and I never could find any, 'that were at most above a 'Mile and half high.' Afterwards, *saith he*, 'I found the 'same method in *Kepler* (*Astr. Cop.* p. 70.) where he saith, 'The Clouds are never above 'a quarter of a *German* Mile 'high, that is one of our '*English* Miles.

ſure it's Height as if it were the Top of a Steeple, at two Stations: by two Obſervers at the ſame time; and thus you may find it's Height, which is never found to be above a Quarter of a Mile.

PROPOSITION XLI.

To meaſure the Quantity of the Air, having it's Altitude given.

THIS is only to meaſure the Space between the Earth and the utmoſt Bounds of the Air, which is eaſily done, having the Altitude of the Air, by meaſuring the Solidity of the Sphere made of the Earth and Air, and then of the Earth only; and ſubſtracting the one from the other, there remains the Quantity of Air.

PROPOSITION XLII.

The Air of certain Places hath ſome peculiar Properties.

THUS in *Egypt* it ſeldom, or rather never, rains; and if ſmall Rain fall at any Time, there follow Diſeaſes, as Catarrhs, Fevers, Aſthmas, *&c.* The Inundation of the *Nile*, and the daily Hoar-froſts in the Morning, ſupply the want of Rain. And ſo in the Kingdom of *Peru*, there are never ſeen Rains: and in ſeveral Places under the Equator it rains for a whole half Year, and is fair the other. See *Part* ii. *Chap.* xxvi.

THE Iſland *Pulon Timor* is for the moſt part covered with Miſts and Hoar-froſt.

IN the Iſland *Sumatra*, the Air is unwholeſome, on account of the ſeveral ſtanding Pools in it; and the like holds of ſeveral other Places, as in old *Mexico*, *Malacca*, *&c.*

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THE Island of *St Thomas*, lying under the Equator, is thought of all Countries to have the grossest unwholsomest Air, tho' it be most fruitful in every kind.

IN the Province of *Chili* the Air is so very fine and subtile that the Blade of a Sword, sheathed without wiping, will not rust.

IN the *Azores* the Air and Winds are so sharp as in a short time to corrode Plates of Iron and the Tiles on the Houses, reducing them to powder.

ARISTOTLE says, that on Mount *Olympus* there is not the least Motion of the Air, nor even any Air at all, for the Characters, written on the Dust there, remain as at first, after many Years; and they that go up it, cannot live there, except they carry with them wet Sponges, by the help of which they breathe.

IN *America*, when the *Spaniards* were passing from *Nicaragua* to the Province of *Peru*, many of them, as they passed over the Tops of the Mountains, did, with their Horses, there breathe their last, or were turned into Statues with the Cold; and thus continued 'till they that escaped returned. Some think this was owing to want of Air, but that is not likely; nor what *Aristotle* says of *Olympus*; for the contrary is found on higher Mountains, whose Tops are covered with Snow. Therefore 'tis certain these Mountains could not be above the Air, but the Air snowed upon them. *See the Chap. of Mountains.* *Busbequius*, an Eye-witness, says, that *Olympus* in Summer is covered with Snow.

THE Air about the Islands in the *Indian* Ocean is so fragrant with the smell of *Spices*, that Seamen perceive it (especially when the Spices are ripe) three or four Miles off, when the Wind is against them.

THE Sea Air is more unwholsome than that on Land, and less agreeable to those that are not used to it. The Difference is very ſenſible when Seamen come near the Shore; for they know when they are within a Mile of the Land, by drawing in the Land Air in breathing. This the Seamen of *Soffala*, on the eaſtern Shore of *Africa*, know eſpecially.

WHILST this was printing, I met with an Obſervation made by *David Frœlichius* on Mount *Carphathus* in *Hungary*, which, becauſe 'tis very uſeful in forming a Judgment of the Altitude of the Air, and of it's ſeveral Regions, I thought proper to add it here, tho' it ſhould have come in at *Prop*. xviii. He ſays ' *Carpathus* is the chief of the ' Mountains in *Hungary*, which Name is common ' to all that Tract of the *Sarmatian* Mountains, ' which ſeparates the *Hungarians* from the *Ruſſians*, ' *Polanders*, *Moravians*, *Sileſians*, and thoſe in that ' Part of *Auſtria* beyond the *Danube*. Their high ' and frightful Tops that are above the Clouds ' appear at *Cæſareopolis*. They are called ſometimes ' by a Name importing that they are almoſt conti- ' nually covered with Snows; and by another ' Name that imports them to be bald and ſhaven ' as it were. And indeed the Rocks there do far ' exceed the *Alps* in *Italy*, *Switzerland*, and *Tyrol*, ' in roughneſs and Precipices: they are almoſt un- ' paſſable, and no Body goes near them but thoſe ' that are curious Admirers of Nature.

' AND to mention this by the way; when I ' was a Youth, having, in *June* 1615, a Deſire to ' try how high theſe Mountains might be, I went ' up with two of my School-Fellows: when I had ' got up to the Top of the firſt Rock with great ' Difficulty, and thought I was on the Top of all, ' there appeared another ragged Rock much high- ' er; and when I had clamber'd to it, over many ' large and looſe Stones, (any one whereof being ' thrown down would carry ſome hundreds far

' greater

'greater before it, with such a Noise, that one 'would think the whole Mountain were tumbling) 'again another higher appeared, and then some 'lesser, the latter whereof still exceeded the former 'in Height. Through all these Caverns I was obli-'ged to pass, with the utmost Danger of my Life 'till I gained the Summit. Whenever I look'd 'down from the steep Rocks into the Vales below, 'that were thick set with large Trees, the Appear-'ance was like that of a dark Night; or else of 'the blue and high Sky, which we sometimes see 'in fair Weather. And it appeared to me, that 'if I had been to fall, I should have tumbled, 'not to the Earth but into the Heavens. For the 'visible Objects, on account of the great Declivi-'ty, appeared diminished and confused. But when 'I ascended to a higher Mountain, I came into 'thick Clouds, and having got thro' them, I did 'after some Hours sit down, when I was not far 'from the Top, and plainly observed the white 'Clouds, I was among, moving below; and over 'them I had a clear prospect some Miles beyond the 'Bounds of the Country of *Sepusiam*, in which the 'Mountains were. I also saw other Clouds higher, 'others lower, and some equally distant from the 'Earth; from all which I gathered three things, '1. That I had passed the beginning of the middle 'Region of the Air. 2. That the Distance of the 'Clouds from the Earth is different in different 'Places, acccording to the Vapours raised. 3. That 'the Distance of the lowest Clouds from the 'Earth, is far from being seventy two *German* 'Miles, as some would have it; and is only half 'a *German* Mile. When I came to the Top of 'the Mountain the Air was so thin and calm 'that I could not perceive the Motion of a Hair, 'tho' there was a vehement Wind when I was on 'the Mountains below. From whence I find that

'the

‘ the highest Top of Mount *Carpathus* rises a *German* ‘ Mile from it's lowest Root up to the highest Re‘ gion of the Air, to which the Winds never ‘ reach. I fired a Pistol on the Top, which at ‘ first made no greater Noise than if I had broke ‘ a Stick or Staff; but, after a little time, there was ‘ a murmuring for a long while, which filled the ‘ Vallies and Woods below. And coming down ‘ thro' the ancient Snows to the Vallies, I fired ‘ again, which made a dreadful Sound, as if ‘ great Guns had been fired, and I was afraid the ‘ whole Mountain should come down on me. The ‘ Sound lasted for half a Quarter of an Hour, ‘ 'till it had reached the most secret Caverns, ‘ where the Sound being enlarged reflected back ‘ every Way; which Caverns not being above, ‘ there was at first little rebounding, but when ‘ the Sound reached those below, it rebounded vio‘ lently. On these high Mountains it hails or ‘ snows for the most Part, even in the middle of ‘ Summer; *viz.* as oft as it rains in the neighbour‘ ing Vallies below: which I have found. The ‘ Snows of different Years may be known from ‘ their Colour and firm Surface.

CHAP.

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CHAP. XX.

Of the Winds in general, and of the Points of the Compass.

THE Wind is a Motion of the Air; and therefore the Consideration of it belongs to the *Absolute Part of Geography*; especially seeing the Knowledge of it belongs to Hydrography, and most of all to Navigation, which requires some Knowledge of Geography: and tho' I willingly allow 'tis more Physical, yet because it contains several things, that relate to Geography we shall speak briefly to it.

PROPOSITION I.

The Wind is a Commotion of the Air which may be felt, or which hath some Force.

THUS it may be defined by the Consent of all Nations: nor do I care to dispute with Critics about it. If the Motion be gentle, 'tis called a Gale or Breeze; and if it be not felt, 'tis not called a Wind; for such small Motions are constantly in the Air, tho' there is no Wind, as appears from the Sun-Beams let into a dark Chamber, thro' a small Hole, where you see the Atoms carried with the Air: and therefore we put in the Word *felt* in the Definition, because the Motion of the Atoms is only seen.

PRO-

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PROPOSITION II.

The Winds for the most part tend from one Point to the opposite, and drive Bodies before them.

THIS appears from the Force of Wind on our Bodies, and especially from the Vanes set on the Top-masts of Ships, which turn to the Point contrary to that the Wind comes from. Yet this is not always direct and constant, but with some Agitation to the adjacent Points. Some think there should be added in the Definition, a Commotion towards one Point, or to the same Part; but we think it may be better left out, seeing there are some circular Winds; and, speaking accurately, no Wind exactly observes the same Point.

PROPOSITION III.

A Point of the Compass is an imaginary Plane, perpendicularly extended from any Point of the Earth to one of those that are on the Circumference of a Circle, having that Point for it's Center.

SUCH is the true and common Notion of a Point of the Horizon. Sometimes the Points on the Horizon, are the Things we call Points by way of Eminence.

THE explaining of the Points of the Compass doth not belong to this Section of Geography, but to the third, of the *Comparative Properties*; but because the several Winds are called by them, or they by the other; therefore we here anticipate treating of them. And this is their Use, that when several Things have different Situations we determine them thereby.

PRO-

PROPOSITION IV.

The Points are infinite in number, for Planes may be drawn from all the Points on the Horizon; but only thirty two of them, have got Names, which are common to the Winds that blow from them.

THE Points, and alſo the Winds, are two-fold as the *Cardinal* and *Collateral*; the *Cardinal* are North, South, Eaſt, and Weſt. The *Collateral* are thoſe between two *Cardinal* ones, of which there are twenty eight, there being ſeven in every fourth Part of the Horizon; and of theſe, thoſe that are exactly in the middle between the two are the chief ones, being 45 *degr.* diſtant from the *Cardinals*, as N. E. S. E. S. W. N. W.

PROPOSITION V.

Theſe thirty two Points are equally diſtant from each other, viz. *each from it's adjacent Point; whence there are* 11 degr. *of the Horizon, and* 15 min. *betwixt every two adjacent Points: And the Cardinal Points are* 90 degr. *from each other.*

THERE being 360 *degr.* in all Circles, ſo on the Horizon; and thirty two Points being on the Horizon, each Point muſt be 11 *degr.* 15 *min.*

THIS Diviſion, with the ſeveral Names of every Point, was made by the *Germans*, as moſt commodious; their Names are not eaſily expreſſed in other Languages: tho' Their Order and Names are in the following Table.

N *for*

N *for North*, S *for South*, E *for East*, *and* W *for West*.

North	East.	South.	West.
N and by E	E and by S	S and by W	W and by N
N N E	E S E	S S W	W N W
NE and by N	S E and by E	S W and by S	N W and by W
N E	S E	S W	N W
N E and by E	S E and by S	S W and by W	N W and by N
E N E	S S E	W S W	N N W
E and by N	S and by E	W and by S	N and by W.

PROPOSITION VI.

Because there is a considerable Distance between these thirty two Points, some put a Point between every two, and make sixty four; which are observed in long Voyages.

BUT Mathematicians, finding that Division not accurate enough, made as many Points as Degrees on the Horizon. *viz.* three hundred and sixty, which are expressed by their Distance from the North and South; but there is not required so nice a Division for the Wind.

YET the thirty two Winds might be better designed than from the thirty two Points, from which they blow; and this would serve in all Languages; that is, if they were called the first, second, and third, as they are in order from the one Cardinal to the other.

PROPOSITION VII.

The Antients, both Greeks *and* Latins, *counted few Winds, or rather they gave Names to few; nor are these few determinate, one Wind having several Names, not taken from any order, which make it hard to understand their several Points.*

INDEED

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INDEED the *Greeks* had antiently but the four Cardinal Winds; nor are any more mentioned by *Homer*: and to these they afterwards added four; 1. That was made one where the Sun riseth at the Winter Solstice, between the South and East, called *Eurus*; for the East Wind itself was called *Subsolanus*; but *Gellius* calls the former *Vulturnus*, and the East Wind *Eurus*. 2. That Point in which it then sets, called *Africus*. 3. That where the Sun riseth in the Summer Solstice, between the East and North; and the Wind from thence was called *Aquilo*. 4. Where it then sets between North and West, called by the *Grecians* *Corus*.

PROPOSITION VIII.

The Designation of the Winds by the Greeks *was very incommodious for Sailors, and others; which Inconvenience they did not much find, not going far from* Greece *in their Navigations.*

FOR in Places of different Latitudes, those Divisions they made, were not the same; yet the *Greeks* retained them, augmenting them with other four intermediate Winds, which they gave Names to, and so made twelve in all: tho' others among them gave other Names to some of them. The *Latins* added one between every two adjacent Winds; and so made twenty four. And *Seneca* speaks of their being observed of old by *Varro* to be incommodious, and therefore they were so ordered as to be made equally distant, without regard to the Place of the Sun's rising and setting at different Times of the Year. But what *Seneca* says, that there are no more Winds than twelve, is erroneous and ridiculous: For they are infinite.

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PROPOSITION IX.

We have explained the ſeveral Winds that have their Names from the Points they blow from, and ſhewn that the Diviſions of the Greeks *and* Latins *are incommodious for Navigation and Geography.*

THEREFORE we retain the Diviſion of the Moderns into thirty two Winds, equally diſtant. And thoſe are called oppoſite and contrary Winds that blow from the Points diametrically oppoſite: for we conſider the Winds as coming from another Place to us; but the Points we conceive as extending from us to another Place.

PROPOSITION X.

The Cauſes of the Winds are various; for ſeeing the Wind is nothing but a continual Impulſe of the Air, all thoſe things that cauſe the one, are Cauſes of the other.

1. THE principal and general Cauſe is the Sun itſelf, which, by it's fiery Beams, rarifies and attenuates the Air; eſpecially that which is juſt under it; and the Air rarified takes up more Room: and hence it is, that the Air thruſts forward the Air next to it; and the Sun going round from Eaſt to Weſt, the Preſſure is made weſtward, as appears in moſt Places of the *Torrid Zone*, and every where there on the Sea a continual Eaſt Wind blows: and the Air rarified preſſes weſtward within the Tropics. There is a Preſſure indeed all round, but the Air is not admitted to other Points, the Preſſure not being ſo great as towards the Weſt, becauſe the Sun moves that way, but in our Climate, 'tis ſo only for the moſt

part,

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part, before and after Sun riſing, when there are no other Winds that blow ſtronger, and overcome it. And ſome Places, or other Points, are more diſpoſed to receive this Force than others; and therefore when the Air is thruſt moſt to the North, the Wind is ſaid to blow from the South; and ſo of other Winds. And 'tis to be obſerved, that when this is to any Point between the four Cardinals, then the Wind ſeems different in different Countries. For tho' the Point, in reſpect of the Place the Sun is vertical to, be but one, yet it is different in reſpect of other Places. And thus one and the ſame Cauſe makes a Wind that hath different Names in different Places: if that Cauſe be aſſiſted by others the Wind is ſtrong, if hindered but weak. And oft-times another Wind blows that is helped by the general Cauſe.

2. THE ſecond and moſt frequent Cauſe of the Wind, are the Exhalations from Sea and Land that are raiſed plentifully, and with ſome Force; but they do not cauſe a Wind 'till they begin to rarify.

3. THE Rarefaction and Attenuation of the Clouds, great or ſmall, made by the Sun and other Stars, or by the ſulphureous Particles and Fire incloſed in a Place.

4. THE melting of Snow and Ice, eſpecially that which lies on high Places: for they are not intirely melted.

5. THE Riſing, and various Situation, of the Moon and Stars.

6. THE Condenſation or Rarefaction of the Air and Vapours by Heat or Cold.

7. THE deſcending of Clouds that thereby preſs the Air below.

THE Conſideration of the *Æolipile* is of uſe, for underſtanding theſe Cauſes of the Wind; for the Water incloſed in it, being heated with Fire, ſends, out of a ſmall Hole of it, a ſtrong Steam of Vapours, like a Wind blowing, which continues 'till the Water is all exhaled. The groſſer Air that ſurrounds ſerves inſtead of that ſmall Hole; and ſometimes 'tis ſtrengthned by other Vapours and little Clouds behind it, and ſometimes 'tis condenſed, and ſo makes way for the Air to move to that Point.

PROPOSITION XI.

Why the Wind may blow in a Line perpendicular to the Horizon.

THE Reaſon is, that the Air ſurrounds the Earth in a ſpherical Figure, and the Air is thruſt about for the moſt part in a great Circle of the Earth; and tho' the Air may be alſo thruſt in a tranſverſe Line, yet becauſe the Air doth not preſs ſo much, or reſiſts more at the Sides, therefore the Wind blows in the middle.

WE ſhall underſtand this better if we conſider the firſt Cauſe of the Winds. For the Sun thruſts the Air to all the Points of the Place that it is vertical to; but 'tis not received in all theſe Points, as was ſaid. If we then conſider great Circles to be drawn from that Place, and between theſe, thoſe to which the Air is forced, or in which 'tis received, all the Places of the Earth ſituated in that Circle, or Semicircle, will feel the Wind coming down perpendicularly; becauſe all great Circles that paſs thro' any Place are perpendicular to the Horizon of that Place; for the ſame Reaſon, if the Wind break out from a Cloud broke, or diſſolved, thoſe Places that are ſituated, beyond thoſe Circles will not feel the Wind, tho' the Air move above their Horizon; becauſe 'tis not perpendicular, but oblique to that Horizon.

YET

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YET 'tis not generally true, that the Wind goes down perpendicular to the Horizon; for often it blows in the Air transversly.

THUS we may see the Smoke that comes out of a Chimney is not carried by the Wind all one way, but a part of it goes another way.

PROPOSITION XII.

Why the Winds blow with some Interruption, resting as it were for a Time, and on a sudden return with Force; and why on the Sea they are more constant.

THE Reason I suppose is, that the Cause of the Wind is not constant, and takes some time to gather it's Strength; and the Exhalations being more constant on the Sea, and the Motion of the Wind less hindered; therefore that Change is not so sensible there, tho' there is some Change as to the Degrees of blowing.

PROPOSITION XIII.

Why no Wind blows perpendicularly from the Air or Places of the Earth.

ARISTOTLE, in his second Book of *Meteors chap.* ix. treats very obscurely of this Question; so that his Followers do not agree about his Opinion: nor shall I be at Pains to write their Opinions. The Cause which seems to be more intelligible is, that the Air being thrust down to the Center of the Earth cannot go that way, but is hindered by other Vapours that are forced up; and the great Resistance of the Air below causes the Force downwards, to tend sideways: which is the more probable because that which

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the Wind consists of is lighter for the most part than that Air; and also more rarified than the Air near the Earth.

PROPOSITION XIV.

Why the East Winds are more frequent than the West.

THE Cause of this is manifest from *Prop.* 10, where we made the Sun the chief Cause which rarifies the Air from East to West; and therefore the Air is more pressed towards the West: and this cannot be hindered except there are a great Quantity of Exhalations or Clouds in the western Parts, which is not very frequent.

PROPOSITION XV.

Why the North and East Winds are more strong and severe, and the South and West Winds more weak and gentle.

THE Reason is because the North Air is grosser on account of the Cold, and the South Air in our Zone is more rarified by the Sun; and the more rarified the Air is, it's Motion is the less forcible; yet the South Winds are cold, dry, and strong, in the *Temperate Zone*, contrary to ours, no less than the North Winds are to us. But the East Winds are severe or more intense on another Account, *viz.* that they arise for the most part from the Rarefaction of the Air by the Sun, which is continually carried from East to West, and so is forced more towards the West. But 'tis likely there are other Causes which hinder or promote this Motion. The *Portuguese* Sailors call the North and East Wind *Brysas*; but the South and West they call *Vendavales*.

PRO-

PROPOSITION XVI.

Why the South and West Winds are found to be hotter than the East or North, which have a much greater frigorific Power.

THUS is the Queſtion uſually propoſed; but we muſt know 'tis not to be underſtood generally of all Places, but only thoſe in our Zone; for in the other *Temperate Zone*, towards the South from the Equator, the contrary holds good; for in thoſe Places the North Winds are hot, and the South more cold, and ſo the Nature of the Thing requires. For the South Wind being more hot, and the North more cold, proceeds hence that the South Winds come from Places near the *Torrid Zone*, and the North Winds from the *Frigid Zone*; but the contrary happens in Places near the *Antarctic* Pole; for the North Winds come to them from the *Torrid Zone*, and the South Winds from the *Frigid*. But another Account is to be given of the Eaſt and Weſt Winds; for the different Places of the two *Temperate Zones* are not to be regarded here. Firſt we ſaid in the preceding Propoſition, that the Weſt Winds are leſs frequent in all Places; the Cauſe of which is the ſame with that for which the Weſt are found to be hotter; *viz.* becauſe they blow for the moſt part in the Night-time after Sun ſet, where the Air, preſſed to our Place, is hotter or leſs cold than the Air of our Place; as being further from the ſetting Sun than the Place between us and the Sun then. There is another Cauſe which alſo holds good in the Difference between the North and South Wind; *viz.* that the Weſt Winds do not blow ſo ſtrongly, but with ſome ſlowneſs; for 'tis known that a Gale or Breeze is the colder the more fiercely it blows;

tho' it be really in itself not colder; as our Breath (which we can make either cold or hot) shews.

PROPOSITION XVII.

Why Seamen when they see a small black Cloud expect Wind from the Part in which it is, especially if it be of a pale and blackish Colour; and to explain other Signs of the approaching Winds.

A twofold Reason may be given; for either the Clouds of that Colour show that they are soon to be resolved and dissipated into a Wind; or the Clouds falling down by their Weight, press the Air below, which causes a Wind: of that peculiar little Cloud which the *Dutch* call the *Ox-eye*, see the *Chapter* following.

WHEN the Sun appears spotted, at it's rising, and hiding itself as it were under a pale or black Cloud, it foretels Showers or Winds to come. 2. If the rising Sun seem hollow, casting it's Beams as it were from it's middle, it shews a wet or windy Season approaching. 3. If the Sun be of a pale Colour at setting, it denotes Rain; but if it be of a red Colour, it shews the next Day will be clear and calm. 4. If the Sun set pale behind black Clouds it shews there will be a North Wind soon. 5. If the Moon be red, like Gold, 'tis a sure Sign of a Wind to come, according to the common Verse

Pallida Luna pluit, rubicunda flat, alba serenat.

6. A Halo about the Moon; 7. If the Moon's Horns be blackish, and, 8. If the North Horn of the Moon appear to be more stretched out, 'tis a Sign of a North Wind; but if the South Horn appear

so, 'tis a Sign of a South Wind approaching. 9. The rising of the Moon, and remarkable Stars, as *Arcturus*, *Orion*, and especially the rising of those in *Capricorn*, with the Sun. 10. If the two small Stars in *Cancer*, called *Aselli*, be covered with a Cloud; if the North one, then a South Wind; but if the South one, then a North Wind. 11. The Winds do, for the most part, begin to settle in a Point, when the Rains are over. 12. A certain Noise and Murmuring; as if there were a Boiling heard in the Sea. 13. The Antients also took their Signs from living Creatures; as the Crow, the Goat, the Dolphin, *&c.* 14. From fiery Meteors, Lightening, and opening of the Ground, and falling Stars; but not that Light seen in the Dark, or *Jack with his Lanthorn.*

PROPOSITION XVIII.

Why the Winds in Spring and Autumn blow more strongly and frequently, than in the Heat of Summer or Cold of Winter.

I suppose 'tis so in Spring, partly because of the melting of the Snow, especially in high Places; partly because the Pores of the Earth are then open, and send forth more Exhalations; and partly because the Air and Vapour then becomes more rare; being condensed in the Winter. Moreover, there falls much Rain a Month before the Spring, and in the Spring itself, because the moist Constellations are in those Places of the Zodiac, into which when the Sun enters the Spring begins. But the Cause of the frequent Rains, and blowing of the Winds in Harvest, is, that the Sun then draws up some Vapours; but the Heat being small, it only draws those that are grosser and not fine enough. But in the Summer there are

few

few Winds, for the same Cause for which there are Rains but seldom then; *viz.* that the Sun does too much attenuate the Exhalations, and suffers them not to go so much together as is necessary to produce Wind. Which Cause is not indeed general, nor always true; nor is it generally true, that there are no Winds in the hot Summer, but only that it often happens so. In a severe Winter there are few Winds; because few Vapours are then exhaled, and those that are raised are either condensed to Snow, or else are not so rarified or dissipated thro' the Cold, as to cause a Wind.

PROPOSITION XIX.

In what Altitude, or in what Region, of the Air, do the Winds begin to blow?

SOME think they are not above the lower Region of the Air; because the Tops of high Mountains, as *Olympus*, are found to have no Wind on them. I doubt the Truth thereof, for the Smoke from the Top of Mount *Ætna* is seen to be tossed here and there; and therefore I think there may be such a Commotion of the Air in the highest Region also.

PROPOSITION XX.

How far may one and the same Wind blow?

THERE is a great Difference in this Matter; for the Winds blowing from East to West, under the *Torrid Zone*, seem to go round the Earth; and those also that blow thither from the South or North use to accompany the Seamen a great way for many Days. The same seems also true of collateral Winds; but here lies the Difference, that the

same

same Winds differ in different Places, as we said under *Prop.* 10. at the end of the Explication of the first Cause.

CHAP. XXI.

Of the Kinds of Winds, and of Tempests.

IN the preceding Chapter we gave the Division of the Winds, their Differences, or rather different Names, which they have from the several Points they seem to blow from. This Division was therefore accidental, and respecting a certain Place on the Earth, which these Points referred to. We shall in this Chapter give other Divisions and Properties of the Winds belonging to certain Places of the Earth, or certain Times of the Year; tho' we wish we had more and exacter Observations of them. But we shall produce some that we have gathered with much Pains from the Journals of Sailors.

PROPOSITION I.

Some Winds are constant, others inconstant.

THE constant are such as blow at least one Hour, or two, from the same Point.

THE inconstant are such as blow one while from one Point, and another while from another, in a small Time.

THE Cause of their short continuance in one Point, and of their changing on a sudden, seems to be first their proceeding from a general Cause, or a Cause that is more or less durable.

THUS the Winds that proceed from the Motion of the Air with the Sun are constant; and those likewise that proceed from the melting of the Snow especially in high Places. 2. There being no such Vapours in that Quarter the Wind blows from as are fit to make Wind. 3. If the Air about the Cloud, from which the Wind comes, be thicker, and hinder it's Passage; but if the Air is not thick or close together, and but a few Vapours, here and there, in the several Quarters; or lastly, if the general Causes do not operate there, then the Wind is found to be changeable, and for the most part gentle.

PROPOSITION II.

There is a General and Particular Wind.

THAT is called by Sailors a General Wind which blows in several Places at one Time, thro' a large Tract of the Earth, almost all the Year round.

AND this Wind is hindered, 1. In Places of the Sea near Land; for here they drive against the Vapours that come from other Points; and therefore 'tis in the middle of the Sea that this General Wind is observed. 2. There may also blow another Wind in the middle of the Sea, when there is a Cloud, or some other Cause in another Point, strong enough to produce Wind. From these two Causes it is that the Geral Winds are not so constant as they might be otherwise.

THESE General Winds are found only between the Tropics round the Earth, except in some Places where they are seven Degrees beyond the Tropics;

Tropics; and they are ever from the Eaſt, or from collateral Points, as South-Eaſt and North-Eaſt, and that the whole Year round; yet not always with the ſame Degree of Force in all thoſe Places, but they are hindered in ſome Places more, in others leſs. They are moſt conſtant in the *Pacific* Sea; *viz.* that Part of it which lies between the Tropics; ſo that the Ships which come from the *Aquapulco*, a Port in *New Spain* in *America*, to the *Phillippine* Iſlands, that is, from Eaſt to Weſt, often ſail three Months without ever changing or ſhifting their Sails; having a conſtant Eaſt or North-Eaſt Wind: nor did ever any Ship yet periſh in that vaſt Voyage of one thouſand ſix hundred and fifty Miles. And therefore the Sailors think they may ſleep there ſecurely: nor is there any need of taking care of the Ship, when that General Wind carries them ſtrait to their deſired Port, the *Philippine* Iſles; near to which indeed there are ſome other Winds that come againſt the General Wind. And thus 'tis alſo in ſailing from the Cape of *Good-Hope* to *Braſil* in *America*; in the middle of which Voyage lies the Iſle of *St Helena*, to which they commonly go as they return from *India* to *Europe*, and lies about three hundred and fifty Miles from the ſaid Cape: which is run oft-times in ſixteen Days, and ſometimes in twelve, as the General Winds are more or leſs ſtrong; and the Seamen are as ſecure when they come to the ſame Parallel of Latitude with *St Helena* (for the Cape is beyond the South Tropic); their chiefeſt care is to obſerve that they do not paſs by the Iſland, as 'tis very ſmall, for if they paſs it but the eighth part of a Mile, they cannot return to it for the eaſterly Wind. Thus they are forced to go to *Braſil* for freſh Water, or the other Iſland called *Aſcenſion* with great loſs of Time.

IF

IF it be asked how they sail when they come the contrary way, *i. e.* from the *Philippines* to *New Spain*, or from *Brasil* to the Cape of *Good-Hope* going to *India*; in these Voyages the Reader must observe a threefold Artifice; for either they sail the Sea beyond the Tropics, (and thus do not go to *St Helena* while they go from *Europe* to *India*), or when they sail within the Tropics they do not go directly from West to East but obliquely, from the North, or a Point collateral to it, to the South, and some Point collateral to it; or lastly, they chuse those Times for sailing in which they know the General Wind is often diverted: but this last seldom happens, and therefore the other two are more frequent; of which we shall say more in the Chapter of Navigation.

THERE are then two Seas under the *Torrid Zone* in which the General Wind, from the East and collateral Points, prevails thro' the whole Year; *viz.* that between South *Africa* and *Brasil*, and that between *America* and the *Oriental* Isles, of which the *Philippines* are a Part. And the third Part of this Sea in the *Torrid Zone*, *viz.* between South *Africa* and the *Oriental* Isles, is not without the General Wind; tho' 'tis often interrupted because of the many Islands there; and more in some Places than others. This Wind blows most between *Mozambique*, in *Africa*, and *India*, in the Months of *January*, *February*, *March*, *April*; and in the rest of the Months other Winds blow, of which in the following Proposition: This general Wind is more hindered in the Seas among the *Indian* Isles. The East Winds begin to blow hard in the Month of *May* at the Isle of *Banda*, with some Rain; and at *Malacca* in *September*; and in other Places otherwise, as will be shewn in the following Proposition.

YET this General Wind does not happen alike near the Tropic in all Places, but extends itself diffe-

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te.VII

Fig: 30.


183.
V h
III h
IIII h
VI h
FLORIDA
Bermuda
Variable W
Bahama Isles
THE NORTH SE
Cuba
Spagniola
OR
Jamaica
Caribe Isles
ATLANTICK
PART OF
GUIANA
OCEA
80
70
60
50
40
THE
PERU
PACIFICK
AMERICA
BRASILIA
OR
SOUTH SEA
15
20
25
30

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rently; for the Tropics are distant from the Equator on both Sides twenty three Degrees and thirty Minutes; and the General Wind extends itself in one Meridian to the Latitude of twenty Degrees; in another to fifteen, in another to twelve.

THUS in the *Indian* Ocean, when the East or South-East Wind blows, in the Month of *January* and *February*, 'tis not sensible 'till you come to the fifteenth Degree of Latitude.

SO in going from *Goa* to the Cape of *Good-Hope*, they have not the General Wind 'till they come to the twelfth Degree of South Latitude; which they have to the twenty-eighth Degree of the same Latitude.

LIKEWISE in the Sea between *Africa* and *America*, between the fourth Degree of North Latitude, and the tenth or eleventh Degree, Seamen have not observed the General Wind to blow; for when they have sailed from *St Helena* beyond the Equator with that Wind, to the fourth Degree of North Latitude, then they have been without it 'till they came to the tenth Degree of North Latitude; from which to the thirtieth Degree the North-East Wind is found to blow constantly, tho' that thirtieth Degree is seven Degrees from the *Torrid Zone*; yet in the Parallel of six, seven, or eight Degrees of Latitude, *&c.* it blows in some Places, but in the tenth Degree in all Places 'till they come to the thirtieth. In the same manner beyond the Tropic of *Capricorn*, between the Cape of *Good-Hope* and *Brasil*, the South-East Wind blows to the thirtieth Degree thro' the whole Year.

AND tho', as we said, this Wind is not sensible on all Shores, and much less in the inland Parts, yet on some it is sensible enough; thus on the Shores of *Brasil*, and on the Shores of the Kingdom of *Lowango*, in *Africa*, the South-East Winds blow daily,

daily, although other Winds are mixed with them.

THERE is a threefold Cause assigned by Naturalists for this General Wind (for the Antients knew nothing of it, nor of the *Torrid Zone* itself). Some think the Sun's moving from East to West is the Cause of it; because it rarifies the Air that it goes over; which Rarifaction follows the Sun, still thrusting the Air before it.

OTHERS, *viz.* those who suppose the Heavens fixed, and the Earth to revolve, are of Opinion, that the General Wind comes from the Earth's moving from West to East, and the Air with it, but not so fast as we; and therefore that we go against the Air, or the Air against us, from East to West.

A third Cause is brought by *des Cartes*, which is altogether new; (*Part* 4. *Prop*. 49. of his *Principles*) where he endeavours to shew that the Moon causes this Motion of the Air as well as the Tides; but because the Knowledge of his Opinion requires also the Knowledge of his other Suppositions, we shall not say any thing of it here; being afterwards to shew that it cannot be so. The first Cause pleases us best; and the second seems not to be received; because several of the *Copernicans* do not admit it; and no Reason can be thus given why it should blow only within the Tropics, and not also beyond them (*u*).

PRO-

(*u*) Dr *Halley*, a Person well skilled in Meteorology, as well as in all parts of Physics, has, with extraordinary Accuracy, prosecuted the History of the Constant periodical Winds; which he deduces not only from the Observations of Seamen, but also from his own Experience. But he only takes Notice of such Winds as blow in the Ocean; there being so much inconstancy and variableness in Land-Winds, that from them a Person can make out nothing clear or certain.

First of all then, he divides the Ocean into three ample Seas

PROPOSITION III.

Some Winds have a ſtated Time and Period, others are unfixed, and blow at uncertain Times.

THOSE are called Stated and Periodical Winds that blow at certain Times of the Year, and

Seas, *viz.* 1. The *Atlantic.* 2. The *Indian*; and, 3. The *Pacific* Sea; proceeding to deſcribe in order, the Winds that generally blow in each of theſe.

In the *Atlantic* Ocean, thro' the whole Year, blows the Eaſt Wind; yet ſo as to turn a little South or North, according to the different Situation of Places. Of which Turnings this is the Sum.

1. Seamen near the *African* Shore, as ſoon as they have ſailed paſt the *Canary* Iſlands, about twenty eight Degrees of North Latitude, obſerve the Wind to blow pretty loud from South-Eaſt. This Wind continues with them in their Courſe ſouthward 'till they come at the tenth Degr. of North Latitude, provided they be an hundred or more Leagues from the Coaſt of *Guinea*, between which Degree, and the 4th of North Latitude, there are interchangeably frequent Calms and Hurricanes.

2. They who ſail to the *Caribbee* Iſlands, as they approach the Coaſt of *America*, perceive the North-Eaſt Wind more and more to retire eaſtward, inſomuch that ſometimes it is full Eaſt; ſometimes alſo, tho' rarely, it may turn a little to the South; whoſe violence they obſerved perpetually to abate.

3. As to the conſtant Winds, they don't extend further than twenty eight Degrees North Latitude, to the Coaſt of *Africa*, and near the Border of *America* they go to thirty, thirty one, or thirty two Degrees. The ſame is obſervable South of the Equator; where, near the Cape of *Good-Hope*, the Limits of theſe Winds are three or four Degrees further diſtant from the Equinoctial Line, than on the Coaſts of *Braſil.*

4. From the fourth Degree of North Latitude to the abovementioned Bounds on the South Side of the Equator, the Wind is obſerved almoſt perpetually to blow from the intermediate Parts 'twixt South and Eaſt, tho' for the moſt part 'twixt Eaſt and South-Eaſt; yet ſo, as that thoſe who ſail near the Coaſt of *Africa* have the Wind turning rather South, but approaching *America* they obſerve it decline ſo much to the eaſtward, that it almoſt blows direct Eaſt. I had Occaſion to tarry for the Space of a Year on this part of the Ocean, during which time the Changes of the Weather were

and cease for a set Time, and then begin to blow again; some of these are anniversary, others blow after

so frequent, that I had sufficient Employment in observing these Matters. I found therefore the Wind almost always to possess the third or fourth Point from the East. As oft as it approached nearer the East, it blew more vehemently and raised a Storm; but when it came from the Points more southward, it was much more calm, and made the Air clear. But I never perceived a Wind blowing from East to North, or from South to West.

5. These Winds undergo some Change, which is owing to the different Seasons of the Year. For when the Sun passes the Equator northward a pretty way, this South-East Wind, especially in this narrow Tract of Sea between *Guinea* and *Brasil*, declines somewhat more to the South, as the North-East does to East. And again, upon the Sun's entering the Tropic of *Capricorn*, the South-East Wind approaches nigher to East, as doth the North-East to North.

6. There is found a certain Tract of Sea in this Ocean, which, near the Coast of *Guinea*, extends for the Space of five hundred Leagues, from Mount *Leo* to *St Thomas's* Isle, wherein South, or South-West, Winds constantly blow. For the South-East Wind having once passed the Equator becomes constant, which in our fourth Observation we demonstrated to blow to the South of the Equator. About eighty or one hundred Leagues from the Coast of *Guinea*, it turns by degrees southward, and having turned that Point, it declines to Points near the West, 'till touching the very Shore, it either obtains the South-West Point, or that 'twixt it and direct West. Such kind of Winds on this Coast are fix'd, tho' frequently interrupted with Calms and Tempests, which violently proceed from any Air. Seamen also, much to their loss, sometimes find the Winds easterly; which being attended with Clouds and a grosser Air, are very unwholesome.

7. 'Twixt the tenth and fourth Degrees of North Lat. in that Tract which is bounded by the Meridians of Cape *Verd*, and the remote Islands adjacent to it, I know not if I can say that any Wind blows either constant or variable. The Calm is almost perpetual, the Thunder and Lightening extreamly terrible, and Rains so very frequent, that from them the Tract is named *rainy*. If there happen any Winds they go off into Blasts, blowing with such inconstancy, that they don't continue for the Space of one Hour, without Calms; and the Ships of the same Fleet, which are all in Sight one of another, have each of them their proper Winds. On which Account sailing is so difficult in these Places, that

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after they have ceased half a Year, and others return in a Month's time: and some blow once a Day.

that sometimes Ships with great difficulty sail these six Degrees in whole Months.

From the three foregoing Observations two things may be explained, which Mariners experience in sailing betwixt *Europe* and *India*, or *Guinea*.

In the first Place, that tho' this Sea, in that Part where it is narrowest between *Guinea* and *Brasil*, extends no less than five hundred Leagues, yet with great Difficulty Ships, steering their Course southward, pass this Tract, especially in the Months *July* and *August*; which arises hence, that during these Months the South-East Wind, blowing on the South of the Equator, passes it's ordinary bounds four Degreees North Latitude; and further, turns so far South, that sometimes 'tis carried strait from that Point, sometimes also from the intermediate Points betwixt it and the West. When therefore the Course must be steered against the Wind, if that be towards the South-West Point, they have a Wind that turns more and more to East, as they retire from the Continent of *Africa*; but the Danger is in passing the Coast of *Brasil*, where Quicksands are so frequent, But if they go towards South-East, they must of necessity come near the Coast of *Guinea*, from which they can't otherwise retire, than by sailing towards the East as far as *St Thomas's* Island.

2. What all Ships loosing from *Guinea* to *Europe*, necessarily do for the Reason laid down in our Sixth Observation. For near the Shore blows the South-West Wind, with which they can neither sail, the land lying in the way, nor go so against it, as to direct their Course northward to *Europe*. They sail then in a Course quite different from that intended, *viz.* either South, or to the Point next to South-eastward. Following this Course they indeed retire from the Shore, but have the Wind more and more contrary, and are obliged to steer still more to the East, 'till they make the Island of *St Thomas*, and the *Lopesian* Cape; where finding a Wind declining from South to East, sail westerly with it 'till they come to the fourth Degree of South Latitude, where they find a South-east Wind blowing perpetually.

On Account of these constant Winds, all Mariners who sail to *America*, or *Virginia*, first steer southward. that by the Assistance of this constant East-Wind they may be carried westward. For the same Reason, they who come from those Countries for *Europe*, directing their Course northward, endeavour, as soon as possible, to come at the thirtieth Degree of North Latitude. For here, first, they find the Winds variable;

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Day. The ſtated Winds are otherwiſe ſubdivided, *viz.* ſome when they begin to blow, continue for ſome

yet more frequently blowing from the South-Weſt Points.

II. As in the *Atlantic*, ſo in the *Indian* Ocean, the Winds are partly conſtant, and partly periodical; that is, they blow for ſix Months in one Point, and the ſix following in the very oppoſite Point. Both theſe Points, and the Seaſons at which they turn to the oppoſite Sides, differ with the Places. And tho' it be matter of great difficulty to obſerve how the Tracts of the Sea may be defined when ſubject to each periodical Wind, or Monſoons as they call them: Yet having uſed cloſe Application, I don't ſcruple believing the following Particulars.

1. Betwixt ten and thirty Degrees of South Latitude thro' that Tract of Sea bounded by *St Laurence*'s Iſland and *New Holland*, the South-Eaſt Wind blows all the Year; yet ſo as to be ſomewhat nearer the Eaſt than South; juſt as about the ſame Latitude in the *Atlantic* Sea, we above ſhew'd them to be.

2. That South-Eaſt Wind blows, from *May* to *November*, to the ſecond Degree from the Equator; in which Month of *November*, between the third and tenth Degrees of South Latitude, near that Meridian which paſſes thro' the northern Part of *St Laurence*'s Iſland, as alſo between the ſecond and twelfth Degree about *Sumatra* and *Java*, ariſes a Wind contrary to the former, *viz.* the North-Weſt, which reigns the other ſix Months; *viz.* from *November* to *May*. This Motion of Winds is found to extend to the *Molucca* Iſlands.

3. Northward from the third Degree of South Latitude, in all the *Arabian* or *Indian* Sea, and in the Bay of *Bengal*, from *Sumatra* as far as the Shore of *Africa*, is obſerved a Motion differing from the former, breathing from the North-Eaſt Climates from *October* to *April*, which for the next ſix Months riſes from the oppoſite, or South-Weſt, Points. Then it breathes more violently, and brings Clouds and Rain; but upon the blowing of the North-Eaſt Wind the Heavens become ſerene. But it is to be obſerved, that in the Bay of *Bengal* the Winds keep neither their Force nor their Points with the ſame Conſtancy, as in the *Indian* Sea. Alſo the South-Weſt Winds, near the *African* Shore, decline more ſouthward; near *India*, more weſtward.

4. On the South of the Equator, that Tract of Sea, which lies between *Africa* and *Laurence* Iſland, and which goes as far as the Equator, ſeems to appertain to the Motion of Winds juſt now laid down. For in theſe Places the South-Weſt Wind blows from *October* to *April*,

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ſome Months, ſome for half a Year, ſome for a Month, and ſome for a few Days.

AMONG

April, ſomewhat nearer the South; but ſuch as ſail to the North perceive it decline towards the Weſt, which at length coincides with the periodical South-Weſt Wind, which they ſay blows at that Seaſon of the Year, from the North Side of the Equator. But what Winds during the reſt of the Year, reign in that Sea, I cannot ſufficiently determine: becauſe our Sailors, in their return from *India*, ſteer their Courſe beyond the Iſland of *St Laurence*. This only I could learn, that the Wind for the moſt part comes from the eaſtern Points, ſometimes declining to the North, and at other times to the South.

5. On the Eaſt of *Sumatra*, and North of the Equator, as alſo on the Coaſts of *Camboia* and *China*, the periodical North-Eaſt Winds come nearer to North, as do the South-Weſt Winds to South. And this is obſerved to hold 'till you have gone beyond the *Philippine* Iſlands on the Eaſt, and as far as *Japan* towards the North. In the Month *October*, or *November*, a northerly Gale ariſes; and in *May* a ſoutherly, which continues from that time during the whole Summer. But it is to be marked, that the Points of the Winds are not ſo ſteadily fixed in theſe Parts, as they are in other Seas: ſo that ſometimes the South Winds decline a Point or two towards the Eaſt, as the northern do towards the Weſt: which ſeems to take it's riſe from the Bulk of the Lands, that are every where interpoſed in this Sea.

6. About the ſame Longitude on the South of the Equator, *viz.* in the intermediate Space between the Iſlands *Sumatra* and *Java* lying to the Weſt, and *New Guinea* to the Eaſt, nearly the ſame periodical Winds blow from the North or South; but ſo that the North Winds incline to the Weſt, and the South to the Eaſt. And theſe blow with the ſame inconſtancy and ſhifting of the Point, as thoſe of the Quarter abovementioned; but the Motions begin four or ſix Weeks later than in that Sea.

7. The Change of theſe Motions does not happen ſuddenly, or at once; but in ſome Places there are Calms, and in others changeable Winds. And often on the Shore of *Cormandel*, towards the end of the accidental Motion; and the two laſt Months there ariſe furious Tempeſts in the *Chineſe* Sea; with the periodical Wind at South.

All Navigation in neceſſarily regulated according to theſe Winds; for if Sailors ſhould delay the Seaſon 'till the contrary Motion begins, they muſt either ſail back, or go into Harbour, and wait for the return of the Trade-Wind.

AMONG these the chief are those which Sailors find to blow, for some Months, in some Parts of the Sea;

III. The third, or *Pacific* Ocean, stretches nearly as far as the two former taken together; *viz.* one hundred and fifty Degrees, from the western Shore of *America* to the *Philippine* Isles. But as this is sailed by very few besides the *Spaniards*, from *Spain* to the *Manilhas*, and that only once a Year; whilst they constantly take the same Course; it remains in a great Measure unknown to us; and cannot therefore be described with the same exactness as the rest. Thus much is certain; as well from the Observations of the *Spaniards*, as others, that the Winds which blow here have a great affinity with those in the *Atlantic*; for the North-East blows to the North of the Equator, and the South-West to the North of the same, with such a Strength and Constancy, that the vast extent of this Ocean may be sailed in about ten Weeks, without shifting the Sails. Here also are no Tempests, so that sailing is no where so commodious, as neither Wind is wanted, nor it's Violence to be feared. Whence some imagine, that it is as short a Voyage thro' the Streights of *Magellan* to *China* or *Japan*, as by doubling the Cape of *Good-Hope*.

These Trade-Winds extend not to above thirty Degrees of Latitude on both Sides of the Equator, as in the *Atlantic* Ocean. This appears in part from the Course observed by the *Spaniards* returning from the *Manilhas* to *New Spain*; for by means of the southern Wind, which blows in these Islands during the Summer Months, they sail to the South up to the Latitude of *Japan*; where they first meet with various Winds that will carry them to the East. And in part again, from the Observations of *Schouten* and others, who sailing to *India* thro' the Streights of *Magellan*, found almost the same Distance of the Winds on the South of the Equator. And in this also the Winds of the *Pacific* agree with those of the *Atlantic* Ocean; that near the Coast of *Peru* they approach to the South, as on the Coast of *Angola*.

That the Reader may form the better Notion, we shall add a Figure (see *Fig.* 30.) representing to the Eye all the Quarters and Points of all the Winds. The Limits of each Tract are marked with pricked Lines, as well in the *Atlantic*, whether they separate the variable Winds from the constant, as in the *Indian* Ocean, where they also separate the different *Monsoons* from one another. The easiest way of marking the Quarters of the Winds seemed to be by a Series of little sharp-headed Lines, pointing alternately to the Parts of the Horizon from whence the Winds blow. But as the

Pacific

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Sea; and these (as also the times of their blowing) are called *Monsoons*; which are found chiefly

Pacific Ocean is so extreamly large, and yet in a great measure unknown to us; I was unwilling to exhibit the whole, to prevent enlarging the Map beyond a reasonable size.

There arises, from the Premises, various Questions worthy the Consideration of Philosophers: the principal are these. 1. Why does the Wind in the *Atlantic* and *Pacific* Ocean, continually blow from the East within thirty Degrees on both Sides the Equator? 2. Why is not the like constant Wind found beyond these Limits? 3. Why is the West Wind found perpetual near the Coast of *Guinea*? 4. Why, in the northern Part of the *Indian* Ocean, do the Winds for six Months conspire with the aforesaid Winds; and for the other six, blow from the opposite Point; whilst that part of the same Ocean which lies on the South Side of the Equator, has no other Winds but what are found in other Seas? 5. Why do the constant Winds on the North Side of the Equator incline to the North; and on the South Side to the South; 6. Why in the *Chinese* Sea, chiefly, is there so remarkable an Inclination of the Winds to the North?

For the solving of these Problems, I offer the following Particulars to the Consideration of the Learned.

Wind is properly defined a Current, or Motion of the Air, which if constant, or perpetual, must have a permanent or constant Cause. Some imagine this Cause to be the annual Revolution of the Earth about it's own Axis. This might perhaps be allowed, if almost continual Calms were not found in the *Atlantic* Ocean near the Equator; and also West Winds upon the Coast of *Guinea*, and western Trade-Winds in the *Indian* Ocean, under the Equator. Besides, the Air being a ponderous or gravitating Body, it will acquire the same Velocity as the Earth; and as it rolls along therewith in the annual Motion, it will seem more to do it in the diurnal; which is not above a thirtieth so swift as the other. So that some other Cause must be sought for.

The true Cause we judge to be the Sun continually permeating the Ocean; with the Addition of the Nature of the Soil and adjacent Country.

For by the known Laws of of Hydrostatics, that part of the Air which is most rarified by Heat, is the lightest; and consequently the others tend towards it, 'till an *æquilibrium* be obtained. But as the Sun continually moves towards the West; it is manifest that the Air, most heated by it's direct Rays, must thus move the same way; and therefore the whole Mass of the lower Air. By this Means there is produced a general East Wind, which

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ly in the *Indian* Ocean, from *Africa* to the *Philippine* Isles; tho' in other Places they are not quite without

putting all the Parts of the Air, resting upon the vast Ocean into Motion, they all keep their own Motion 'till the Sun returns; whence the East Wind becomes perpetual.

And hence it follows, that the Wind on the North or South Side of the Equator, ought to incline towards the North or South. For as the Air near the Equator receives the Sun's Rays perpendicularly, twice every Year, and never more inclined than thirty Degrees, it must of course be greatly rarified by so great a Heat. Near the Tropics also the Sun is vertical, for a considerable Time; but as it is distant therefrom forty-seven Degrees for no less a time; the Air hence becomes so cold that it cannot afterwards be brought to the same Degree of Heat, which it receives under the Line. Whence the Air, being less rarified on both Sides the Equator, flows to the middle. And this Motion being compounded with the East Wind abovementioned, explains all the Phænomena of the general Winds; which, if the Surface of the Earth was every where covered with Sea, would blow with the same constancy they do in the *Atlantic* and *Ethiopic* Oceans.

But as the Ocean is interrupted with such large Tracts of Land, regard must be had to the Nature of the Soil, and the Position of high Mountains; to which two Causes the Changes of the Wind seem principally assignable. For when a Country lying near the Equator is low and sandy, the Heat of the Sun, reflected by the Sand is so great as to be almost incredible. And thus the Air of this Place being highly rarified; the denser Parts of the Air will necessarily move thither to restore the *Æquilibrium*. Whence I judge, that near the Coast of *Guinea* the Wind constantly blows to the Land; as it is exceeding probable that the inner Parts of *Africa* are violently heated: since even the most northern Parts thereof, by reason of their Heat, made the Antients believe all the Parts beyond the Tropics uninhabitable.

And hence we may explain those frequent Calms; mentioned above in our sixth Observation. For as that Part of the *Atlantic* lies betwixt the West Winds perceived near *Guinea*, and the constant East Wind that blows in the Parts somewhat more to the West, the Air lying thereon giving way to neither of these contrary Winds, keeps it's Place, and makes a Calm. And the Air not able to support the Vapours here plentifully raised by the Heat, as being more light and rarified; the opposite Winds frequently cause the Rains to fall heavy.

And

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without them; the observing of those times is very material, when Sailors go to the same Point, or

And hence it appears, that the Part of the Air rarified by Heat, being constantly compressed on all Sides by the colder and denser Air, that surrounds it, must be continually driven upwards, as it were like a Vapour, and be there every way equally dispersed to maintain the *Æquilibrium*; so that the upper Course or Motion of the Air shall be contrary the under. And thus, as it were by a circular Motion, the constant Winds that blow near the Earth, produce another Wind that blows a contrary way in the upper Regions of the Air. And this Conjecture is also in part confirmed by Experience. For when Sailors are got beyond the Limits of the Trade-Winds, they immediatly find a Wind blowing from the opposite Quarter. And hence also we may easily explain the Phænomena of periodical Winds, or the return of the Monsoons; which as it scarce admits of any other Solution, so it considerably confirms our Hypothesis of the circular Motion of the Air.

For supposing this circular Motion of the Winds, we must observe that the northern part of the *Indian* Ocean is every where interspersed with Land, running out within the Limits of the periodical Winds, *viz. Arabia, Persia, India, &c.* which Countries at the time the Sun is in the northern Signs of the Ecliptic, suffers the same Heat we above mentioned of the inner Parts of *Africa*; but when the Sun declines to the South they enjoy a temperate Air. But this is owing to the long Ridges of Mountains whose Tops being generally covered with Snow in the Winter; this greatly cools the Air. For this Reason the general North-East Wind blowing in the *Indian* Sea is at one time of the Year hotter, and at another colder than the Wind carried circularly from the South-West; which is the hottest of these contrary Winds; when it blows thro' the upper Region of the Air; it follows that the under Course of the Air one while moves from the North-East, another from the South-West; from the later in the Summer, and from the former in Winter; as we observed in explaining the Phænomena of the Trade-Winds.

From the same Cause it seems to proceed, that the North-West Wind succeeds the South-East in a certain Tract of the *Indian* Ocean, lying without the Equinoctial, at the time that the Sun approaches the Tropic of *Capricorn*.

But here we must not conceal, that there is a great difficulty in explaining the Reason why in the same Latitude of the *Indian* Ocean these Winds are found, there is a perpetual East Wind in the *Atlantic* without any Variation at all.

or one collateral to the Point they blow to; nor can they return 'till those Winds blow the contrary way, which in a certain time they will do and continue to blow so long the other way. Tho' they do not immediately begin to blow the other way, when they have done blowing the former way; but after some Days more, or less, in which the Winds are unsettled; and the Sailors sometimes surprized with Calms; and the Sea-Waves move several Ways; yea and frequent Storms arise. Some of the *Monsoons* return twice in a Year, but not with the same Vehemence.

1. IN that part of the *Atlantic* Ocean which lies in the *Torrid Zone*, and that also in the *Temperate*, the North Wind blows frequently in the Month of *October*, *November*, and *January*; and these Months are the best times to go from *Europe* to *India*, that they may get beyond the Equator with the help of them; for it hath been found, that some Ships that had gone from *Europe* in *March* have not come sooner to *Brasil* than those that left it in *October*; coming both to it in the Month of *February*; being helped by the North Winds. But because this Wind is not so constant and certain, Seamen do not reckon it among the *Monsoons*. Nor is it easy to give the cause of that Wind in these Months; except we refer them to the great quantity of thick Vapours at that time, or the constant pressure then made by the heavy Clouds. And they that wintered in *Nova Zembla* say, there was a constant North Wind all the Winter; which could not be by a Rarefaction of the Air made by the Sun, which was under the Horizon. Yet we

It is also very difficult to explain why the Limits of the constant Winds scarce reach beyond thirty Degrees of Latitude; as also why Monsoons are found only in the northern part of the *Indian* Ocean; whilst in the South part the North-East Wind perpetually reigns.

think

think it may be maintained in the general, that most of these *Monsoons* come from the melting of the Snow, or the dissolution of the Clouds in the North and South Places, especially the Mountains which I am apt to believe, because these *Monsoons* blow, for the most part, from the North or South, or the Points collateral; and because the Snow and Clouds in the northern Parts are dissolved by the Sun; especially in that half Year it goes thro' the North part of the Ecliptic, the *Monsoons* are then from the North, and in the other half from the South.

THE Cause of these *Monsoons* in the Sea, blowing mostly from collateral Points, as South-East, North-East, or those next them, seems to be from the different Situation of the Places in which the Snow and thick Clouds are; or from the general Wind which may divert them to another Point: for that Wind blowing to the West, and the *Monsoons* tending North and South, they must hinder one another; and thus go in a Point between the Cardinals. But the South-West and North-West *Monsoons* are rare and weak, and are scarce to be reckoned *Monsoons*, when the North and South Winds seem sometimes by accident to decline to the West, but are drawn to the East by the general Winds. There are required for giving the Causes of the great variety of the *Monsoons* in different Places, more accurate Observations, not of one Year only, but of several Years; with the Times of the Winter, Rains, Snows, and of the Mountains in those Places from which the stated Winds blow. We should also know the Motion and Age of the Moon; which may cause a Change in this Matter.

2. IN the Month of *July*, and some Months near it, the South Winds blow at *Cape Verd* in *Africa* (when there is a Winter of Rain there) which seems

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ſeems to be from the ſame Cauſe that makes the North Winds blow in Winter, in our Zone.

3. At the Cape of *Good-Hope* the North-Eaſt Wind blows in *September*.

4. At *Patanen* (which is a Kingdom and a Town of the ſame Name in *India*, beyond the Mountains of the *Gate*) there are conſtant Rains, and a North-Eaſt Wind that blows; but in the other Months an Eaſt Wind blows thro', and 'tis Summer then.

5. About *Sumatra* the Change of the *Monſoons* is in *November* and *December*.

6. In the Iſland of *del Mayo*, one of the ſalt Iſles in the *Azores*, there blows a vehement Wind in the end of *Auguſt* from the South, with much Rain, which moiſtens the Land, that is naturally dry, and then the Graſs begins to ſpring up; which fattens a great many Goats there, againſt the end of *December*.

7. In the Kingdom of *Congo* in *Africa*, from the middle of *March* to *September*; when the Winter reigns there, the North, Weſt, and North-Weſt Winds blow, or others intermediate, which force the Clouds together on the Tops of the Mountains, and cauſe a dark Air with Rain (ſee the next Propoſition): but from *September* to *March* the Winds are contrary, being South, Eaſt, and South-Eaſt, and others intermediate. We have taken theſe differences of the *anniverſary* and *ſtated* Winds from the Obſervations of Sailors, who call them *Monſoons* when they blow for a great way on the Sea. We would now treat of their Cauſes; but we want to know the Mountains, Snows, and the Times of their diſſolving, and other things; nor are the Obſervations of Sailors ſo exact as to deſerve an accurate Enquiry into their Cauſes.

The *Monſoons* that are moſt famous are; 1. Thoſe in the *Indian* Ocean, between *Africa* and *India*

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India; and at the *Molucca* Isles they begin in *January*, and blow to the West six Months to the beginning of *June*; and in *September* and *August* it begins to blow to the East; and in *June*, *July*, and *August*, there is a Change of the *Monsoons* and raging Storms from the North. But when we speak of Winds blowing to the East or West, we understand also the collateral Points.

2. BUT at the Shores, the eastern *Monsoon* varies much; so that only from *January* to the end of *March* or the middle of *May*, the Ships that go to *Persia*, *Arabia*, *Mecha*, and *Africa*, only sail when they come from *India* on this Side the *Gate*, or the Shore of *Malabar*; for the Storms rage in the end of *May*, and all *June*, *July*, and *August*, with a North Wind often, or a raging North-East Wind; therefore no Ships go from *India* on this Side the *Gate* in these Months. But on the Shore of *India*, beyond the *Gate*, or the East Shore, or the Shore of *Cormandel*, they know nothing of these Storms. They sail in the Month of *September* from *Ceylon* and *Java*, and other Isles there to the *Molucca* Isles; for then the West *Monsoons* begin, that hinder the general East Wind: but when they come to the fifteenth Degree of South Latitude, from the Equator, the western *Monsoon* is sensible in the *Indian* Ocean, and a general South-East Wind fills the Sails.

3. FROM *Cochin* to *Malacca*, *i. e.* from West to East, they begin to sail in *March*; for then the West *Monsoons* begin there, or rather the North-West Wind blows often.

4. IN the Kingdom of *Guzarat*, *i. e.* in *India* on this Side of the *Gate*, the North-West Winds blow the half of the Year from *March* to *September*, and the other half Year the South Winds and that without much hindrance by other Winds.

5. THE

5. THE *Dutch* sail from *Java*, for the most Part, in the Months of *January* and *February*, when they return to *Europe*; they sail then with an East Wind to the eighteenth Degree of South Latitude. Here the South Wind begins, or the South-East with which they sail to *St Helena*.

6. THO' in the *Indian* Ocean, from *January* to *June*, the *Monsoons* are East, and from *August* to *January* West; yet, in several Parts, when you are to sail from one Place to another, there are some set times that are counted best; because the collateral Winds blow more or less at those times or other Winds do more or less mix themselves with these. Therefore they take one *Monsoon* when they are to sail from *Cochin* to *Malacca*; and another when they are to go from *Malacca* to *Maccou*, a Port-Town in *China*; and another when from *Maccou* to *Japan*.

7. AT the Isle of *Banda* the western Winds cease at the end of *March*; and at the end of *April* the Winds are variable, and become calm on a sudden; and in *May* the vehement East Winds begin, with Rain.

8. AT the Isle of *Ceylon*, near the Cape of *Ponto-Gallo*, on the fourteenth of *March* there is first a western Wind, then a constant South-West from the end of *March* to the first of *October*; then the North-East Wind begins, and blows to the middle of *March*: but sometimes the *Monsoons* come sooner or later by ten Days or more.

IN the Voyage from *Mazambique*, in *Africa*, to *Goa*, in *India*, the South Winds rule all the way to the Equator, in the Month of *May* and *June* but from the Equator to *Goa* the South and South-West Winds prevail in the Months of *July* and *August*, and the following Months.

10. IN the thirty fifth Degree of the Elevation of the Meridian that passes thro, *Tristan de Conha*,

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Conba, the West Wind rages in the Month of *May*, at New-Moon.

11. IN two Degrees thirty Minutes North Latitude, the South Wind prevails on the Sea seventy Miles from *Guinea*, from the twenty fifth of *April* to the fifth of *May* (but not on the Shore, or *Guinea* itself); and after the fifth of *May* the same Wind is felt at three, and three Degrees and thirty Minutes Latitude.

12. AT the Isle of *Madagascar* the North and North-West Winds prevail from the fifteenth of *April* to the last of *May*; but in *February* and *March* the Winds blow from East and South.

13. FROM *Madagascar* to the Cape of *Good-Hope*, both thro' Sea and Land, the North Wind and the Collateral to the East, blow continually in the Months of *March* and *April*; so that 'tis counted a wonder if a South or South-East Wind should blow then for two Days.

14. THE South Wind is vehement in the Bay of *Bengal* after the twentieth of *April*; and after that the South-West and North Winds are strong.

15. THE South and South-West Winds, and oftentimes the South-East, serve for sailing from *Malacca* to *Maccou*, in the Months of *July*, *October*, *November*, and *December*; but in *June*, and the beginning of *July* the West Winds rage about *Malacca* in the Sea of *China*.

16. THE Wind by which they sail from *Java* to *China*, *i. e.* from West to East, begins with the Month of *May*.

17. THE Wind by which they sail from *China* to *Japan*, *i. e.* from West to East, prevails in the Months of *June* and *July*; which is a South-West Wind; tho' oftentimes there comes in a North Wind, and others collateral to it eastward; and that chiefly in the Day-time: but in the Night

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there comes in a South-East Wind, and South by East.

18. BUT when they sail from *Japan* to *Maccou*, *i. e.* from East to West, in *February* and *March*, there is an East and North-East Wind; but these do not prevail on the Sea, but at the Shores of *China*; which they that sail from *Japan* find in their Voyage.

19. WHEN they sail from the *Philippines*, or *China*, to *Aquapulco*, a Port in *New Spain*, there is a West Wind in *June*, *July*, and *August*; tho' very weak, except at Full Moon; but they are mostly South-West Winds. But they keep from the *Torrid Zone* near the northern Shores of *America* to shun the general East Wind, tho' 'tis but weak then; for 'tis to be known in general, that the western Winds are more weak than the eastern, because the former are hindered, and the later promoted by the general Wind.

20. IN the Sea of *China* the South and South-West *Monsoon* is in *July*, *August*, and *October*; but these Winds turn to the East: for they never turn immediately to the South, but first they blow some Days to the East, and then to the South; tho' the North-East Wind is sometimes changed, on a sudden, to the South-West, and sometimes from the North to the South immediately; which is very common here.

THUS the more constant anniversary Winds are found at Sea; both those that are less constant, and those also that are anniversary, as well on the Shores as Places near the Shores.

PROPOSITION IV.

The Etesian *or anniversary Winds in* Greece, *proceed from the Rains and Snows melted on the Mountains.*

THE *Grecians* observed two Kinds of stated Winds each Year, which they called *Etesiæ*; 1. The Summer,

Summer, or *Dog-winds*, which were called *Etesiæ* in general; becaufe they were more ftrong and fenfible. 2. The *Winter-Winds*, which they called *Chelidonian* or *Ornithian*.

THE *Etesian Dog-winds* are from the North. Writers differ about the time of their beginning. *Ariftotle*, having told us they blow after the Summer Solftice, adds nothing of the exact time; which was a great neglect: and the more becaufe when he fpoke of the *Ornithiæ* he omitted both the time and the part they came from. Moreover, they who have marked the time of thefe *Etefiæ*, have made their forerunners, which is about eight Days fooner, to begin when the *Dog-ftar* rifeth, on the fixth or fifteenth of *July*; and to continue forty of the *Dog-days*, and fo end with *Auguft*: tho' others extend them to the middle of *September*. They blow only in the Day-time: nor do they come early in the Morning; which made the Seamen call them *delicate* and *lazy*.

THE Caufe of thefe Winds is no doubt the melting of the Snow on the northern Mountains, by the Heat of the Sun, which is then at the greateft; having for feveral Months fhone on thofe Mountains, without fetting. And with this Caufe it agrees well that they ceafe at Night; becaufe then the melting ceafes, or is fmaller than to make a Wind, the Sun being then near or under the Horizon.

THIS fame northerly *Dog-wind*, not only in *Greece*, but alfo in *Thracia*, *Macedonia*, the *Ægean* Sea, and it's Ifles, (which I know are fometimes all included in the Name of *Grecee*) yea in *Egypt* alfo, and *Africa*, and probably the fame that we faid in the former Propofition, did blow in the Kingdom of *Congo*, beyond the Equator, between *March* and *September*; we fay this fame *Dog-wind*, *&c.* are the fame with the *Etefiæ* of the *Grecians*, or come from the fame Caufe. And likewife that

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North Wind which we said blows in the Kingdom of *Guzarat*, from *March* to *September*, proceeds from the melted Snow on the Mountains of *Asia*; which they called the *Sarmatian* Mountains, and the *Earth's Belt*; and therefore we reckoned it among the *Monsoons*.

THE second anniversary Wind of the *Grecians*, is the *Chelidonian*, or the *Bird's Wind*; which they tell us began after the Winter: but they do not tell us the Day when it began. These are South Winds contrary to the *Dog-winds*, very weak, and likewise inconstant, and of less Duration; which makes the Sea pleasant, and signifies the coming of the Winter Birds, which they call *Chelidons*. *Aristotle* says they blow by turns to the middle of Summer, 'till the easterly Winds, or *Dog-winds*, from the North, begin, but very weakly.

THEIR Cause is also the melting of the Snow on the Mountains of the Moon in *Monomotapa*, which are called snowy by the *Portuguese*: which Snow the Sun melts and rarifies the Air thereby; because 'tis Summer there, when 'tis Winter with us and in *Greece*; the Sun then being in the South part of the Ecliptic. And this Wind is also found in the Kingdom of *Congo*, in *Egypt*, and in the *Ægean* Sea; and the like in *Guzarat*, but for many more Months: for it begins in *Congo* and *Guzarat* in *September*, and blows 'till *March*.

IT was the yearly Wind among the *Grecians*; which they called *Ornithias*, or the *Bird-Wind*; and they said it continued after the vernal Equinox, while the Sun was mounting to our Zenith.

PROPOSITION V.

Why these Etesian *Winds do not blow in* Italy, Germany, Prussia, *and other Kingdoms, since they are nearer the Mountains in the North, from which the* Etesian *Winds of the* Grecians *blow, as we said.*

THIS Queſtion hath no ſmall difficulty in it; and I could wiſh to have more accurate Obſervations on this Head, to determine what Winds then blow in the ſeveral Places; or if they return again each Year; for I remember to have read, that in *Aquitania*, a part of *France*, there is an anniverſary Wind.

BUT if any thing be ſaid to this Queſtion, theſe Particulars ſeem proper; 1. In our *Dog-Days* the North Wind blows, which cannot be denied. 2. 'Tis not ſo conſtant, nor doth it return every Year; perhaps it may not be felt, becauſe of the frequent blowings of other Winds. 3. It might be ſaid; the Mountain whereon the Snow begins firſt to melt, is ſituated directly towards *Greece*; and therefore the firſt *Dog-Wind* is carried thither; and the Vapours from the Snow on the reſt of the Mountain is carried thither; becauſe they then find an open Paſſage that way: but theſe extemporary Thoughts I ſhall lay aſide, ſo ſoon as I find better from better Obſervations.

PROPOSITION VI.

Some Winds are proper, and almoſt perpetual, to ſome Place or Tract of the Earth, others inconſtant.

THERE are few Places where a Wind blows always; the principal are theſe: *viz.* 1. Places under the *Torrid Zone*, eſpecially the Parts of the *Pacific* and *Ethiopic* Sea in that Zone have a perpetual Wind from the Eaſt, or ſome collateral Point, which we called, *Prop.* 11, a general Wind. And this Wind is not ſo much to be termed proper as common, or belonging to many Places; for 'tis by accident that 'tis not felt in all Places; *viz.* becauſe other Winds blow more ſtrongly. The Cauſe of it is given in the forecited Place.

2. ON the Shores of the Kingdom of *Peru* and Parts of *Chili*, and the adjacent Places on the Sea,

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the Wind is almost perpetually South, or in some collateral Point to the West. It begins at the forty sixth Degree of Latitude, and blows to *Panama* at the *American* Isthmus, and makes the Ships (loaded with Gold and Silver) come from *Lima* to *Panama*, in a few Days; tho' it takes a great many Days to return: but in Places remote from the Sea this Wind doth not blow. 'Tis hard to give the cause of this Wind; because the South Land, from which it seems to blow, is not yet known to us; yet I suppose there are found therein Mountains continually covered with Snow, from the constant meltings whereof these Winds blow. But I would not here prepossess the Reader's Judgment with my Conjectures. Perhaps the Snows that are found at the Streights of *Magellan*, all the Year, are the Cause of this Wind. But yet these Mountains lie from the South eastward, and the Winds blow from a Point declining from the South westward. Let us then leave this 'till we have a better knowledge of the South Continent.

3. AT the Shores of the *Magellanic* Land, or *del Fuogo*, about the Streights of *La Maire*, there blow almost constant West Winds strongly; so that the Trees decline from a perpendicular to the East. Nor is there any Place where these West Winds blow so much. But on the other Side of the Streights of *La Maire*, the South Wind blows on the Shores of the South Land. I can give no other reason for it than the melting of the Snow, and the breaking of the Clouds in the South Land; which extends itself on the West Side of that Streight, from South to North. These Things are doubtful, and to be more diligently enquired into.

4. ON the Shore of *Malabar*, in *India*, the North and North-West Wind blows almost the whole Year. The Cause is the melting of the Snow on the Mountains of *Sarmatia*, in *Asia*, as those

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of *Imaus*, *Caucasus*, or from the Clouds on other Mountains in *Asia* that press the Air below.

5. ON the Sea, near *Guinea*, the North-West Wind blows frequently; but further off the North-East Wind blows.

6. HALF way between *Japan* and *Liampo*, a Sea-Port Town in *China*, the West Winds blow all the way to *Japan*, these blow there in *November* and *December*.

7. AT the Island *Guoton*, not far from the Island *dos Cavallos*, the South Wind is frequent on the *Chinese* Sea; whilst on the adjacent Seas the North Wind rages.

PROPOSITION VII.

Those Winds that blow for some Hours every Day, in some Places, at a certain Time of the Year, belong to the periodical or stated Winds.

THEY are found to be twofold; but only in some Places near the Sea. Some blow from the inland Parts to the Sea; others again from the Sea to the Land: the former is called a Land-Wind, the latter a Sea-Wind.

1. ON the *Malabar* Shore in the Summer-time, from *September* to *April*, the Land-Winds blow from twelve at Night to twelve at Noon, which are East Winds; nor are they sensible beyond ten Miles on the Sea; and from twelve at Day to twelve at Night the Sea-Wind blows from the West, but so weakly that Ships have little Benefit from it. The former East Winds I suppose come partly from the general Wind, and partly from the Clouds on the Mountains of the *Gate*: but the Cause of the latter is the dissolving of the Clouds by the western Sun; which Clouds were forced together by the East Winds. These are my Conjectures; but in other Months the North Wind rages there, as also

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the East, North-East; nor are the gentle Land and Sea-Winds sensible there, for the frequent Storms.

2. AT the Town of *Masulipatan*, on the Shore of *Coromandel*, the Land-Winds begin to blow on the first Day of *June*; they last only fourteen Days, and then it is the Ships go from thence. But these are rather to be referred to the *Monsoons*; for so far as I understand from Sailors Accounts, the Land Winds are constant on those Days; nor do the Sea-Winds come after them.

3. ON the *American* Shore of *New-Spain* the Land-Winds blow to the *Pacific* Sea at twelve at Night; but the Sea-Winds in the Day.

4. IN the Kingdom of *Congo*, and the Provinces of *Lopo Consalvo*, the Land-Winds blow from the Evening to the Morning, when the Sea-Winds begin to blow and mitigate the Heat of the Day.

5. AS to the East Winds which blow before and at Sun-rising, every Day, in all Places, especially at Sea, when other Winds blow not, particularly in *Brasil* where they blow every Day in the Morning; the Cause is plain: for either they are a Part of the general Wind, or else the Sun rarifies the gross Particles of the Air that were condensed by Night.

6. THE *Etesian* Winds of the *Grecians*, or their *Chelidonian* Winds, come among these *Quotidian* Winds.

7. ON the Shore of *Cambaya à Varella*, at *Pulo-Catte*, the Land and Sea Breezes succeed one another daily, from the twenty eighth of *July* to the fourth of *August*; for then the *Monsoons* cease, and there is a perfect Calm for a while. The Land Breezes are from the West and North-West. But the Sea Breezes are from the East, and the collateral Points which turn to the North; and then turn back to the South; when 'tis calm 'till the Land

Land Breezes come, which are not felt on the Sea above two Miles from the Shore. These Land and Sea Breezes are also found at *Havanna* in *America*.

PROPOSITION VIII.

The nearer we come to the Equator from the Arctic Pole, the northern Winds are the weaker; and beyond the Equator the South Winds are strong, and cold and dry, especially in Chili *and* Peru.

THE Cause of both is the same; because they come from the northern and southern Places: yet there are found South Winds in the northern, and North Winds in the southern Parts.

PROPOSITION IX.

It appears from what hath been said, that there are four different kinds of Winds.

1. THE Common, which blow in all Places, and all times; except hindered by others, as the General one.
2. THE proper, or such as blow at all times, but only in a certain Place or Tract of the Earth.
3. THOSE which blow in several Places, but not at all Times, as the *Monsoons*, or *Quotidian* Winds.
4. THOSE which blow neither at all Times, nor in very many Places.

PROPOSITION X.

Some Winds are sudden, and strong, but do not last long; such are Hurricanes, with, and without Lightening; Whirlwinds, Storms from the Water, and from the Air. These are in some Places anniversary: and some are only frequent in certain Places at Sea.

THE Wind called *Prester*; is a strong Wind that breaks out with Lightening and Flame. Such

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seldom happen, and scarce without the *Ecnephia*; *Seneca* calls *Prester* a Whirlwind with Lightening.

THE *Ecnephia* is a strong and sudden Wind that breaks out from some Cloud; which is frequent in the *Ethiopic* Sea, between *Brasil* and South *Africa*; especially at the Cape of *Good-Hope*, and on the other Side of *Africa*, at *Terra de Natal*, and at *Guinea*, under the Equator. The *Portuguese* call them *Travados*, the *Latins Procella*, but the *Greek* Word *Ecnephia* is best: they are most frequent in certain Places, and in certain Months of the Year.

A little Cloud, and sometimes several of them black or blackish, are plainly seen by Sailors to go together, and increase even in a clear Sky, before the Wind breaks out; and when they first see them, they should gather in their Sails, and prepare their Ship against the raging Wind that is at hand: but before the *Portuguese* knew this Prognostic of Wind they lost several Ships, being the first that had sailed the *Ethiopic* Ocean. For when *India* was made known by *Gamma*, the King of *Portugal* sent a greater Fleet of Ships, of large Bottoms, to the Number of thirteen, under *Caprali* in the Year 1500; which was the first Fleet sent to *Brasil*, with great Joy to the *Portuguese*.

WHEN they had waited there the Month of *April*, they sailed in *May* towards the Cape of *Good-Hope*, with raging Storms; and tho' they saw the Signs thereof, yet they knew not the Tempest that was to follow; which *Maffeus* thus describes.

'THEY made a long Run of almost two 'hundred Leagues from *Brazil* towards the Cape '(which is about one thousand *German* Miles) the 'Ocean and Winds all the while raging. Having 'entered that Voyage in *May*, with more Bold'ness than Success, a fiery Comet appeared con'tinually to the tenth Day, with a fearful Aspect; 'and the Sea and Heavens often changing; the 'black

'black and foul Clouds having gathered toge-
'ther in the North into a round Form, and the
'Wind ſeeming to come all againſt them as it were
'by Reflexion: the Sea being faint in deceitful
'Calms. The Sailors not knowing the Tempeſts
'that uſed to rage there, ſpread their Sails to ga-
'ther the Wind; when on a ſudden the Wind
'broke out from the Clouds in the North on four
'Ships whoſe Tackling was not in order to be
'handed, and overſet them in a Moment;
'and tho' the reſt were looking on, yet not one
'of a great many could be ſaved from death,
'except a few that had Oars or broken Pieces
'of Sails thrown to them. The North Wind
'continuing, the Sea roſe ſometimes high as it
'were to the Stars; and again fell low to the Bot-
'tom; the Sea looked black in the Day-time,
'and fiery in the Night, which Storm held them
'twenty Days.' So far *Maffeus*.

THE Cape of *Good-Hope* is diſaſtrous for ſuch Storms from the Clouds.

NOT far from the Shore there is a high Mountain, broad on the Top like a Table, from which great Storms often proceed; and this prognoſticates ſtrangely. For when the Sky is clear, and the Sea ſmooth, there is a little Cloud ſeen on the Top of the Hill, which appears at firſt no larger than a Hazel Nut, and then like a Walnut which the *Dutch* call the *Ox-eye*; and then covers the whole Plain above, and the *Dutch* compare it to a Table ſpread with all kinds of Meat on it: then the Storms begin to blow from the Top of the Mountain with ſuch Force that overwhelms all Ships that are not on their Guard, or have their Sails out; but Sailors are now more wary, and when they ſee the *Ox-eye*, they run immediately from the Shore as much as they can, and gather in their Sails, and do what is proper to de-

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send their Ships: nor does this Sign ever fail. The like Storm rages at *Terra de Natal*, having the *Ox-eye* there also; and by it several Ships have been lost; and likewise in the whole Tract between that and the Cape of *Good-Hope*. There is also in *Dauphiné* in *France*, not far from *Vienne*, a high Mountain, on whose Top there is a Lake, from which all the Storms thereabouts arise; on the Top of it there is a little Cloud or Exhalation, which portends Thunder and Rain.

ON the Sea under the Equator, between *America* and *Africa*, and near the Equator; there are frequently such Storms; especially in those Months in which there are few or no constant Winds blowing; and that almost thro' the whole Year, especially in *April*, *May*, and *June*, (in other Months 'tis more rare) and they are very remarkable on the Shores of *Guinea*. They break forth three or four times in a Day, and cease on a sudden, varying ordinarily every half Hour; but they are most vehement at first. They break out from the black and filthy Clouds that appear when the Sky is clear and the Sea calm, by which the Seamen know they are approaching. And with their help it is that Sailors get beyond the Equator; for other constant Winds are often wanting, especially in those three Months, for they do not hinder the Ships sailing except at the first breaking out.

BUT in that part of the Sea which is next the Kingdom of *Loango*, in *Africa*, the Storm is often in the Months of *January*, *February*, *March*, *April*, and in different Places of *Africa* at other times.

THUS likewise at a Promontory in *Africa*, called now *Guardafu*, not far from the Month of the *Red-Sea*, there rages in the Month of *May* every Year a North Wind, and the *Ecnephias* most vehemently.

FOR 'tis observable, that as some Winds less forcible blow yearly; so there are Storms and Tempests

pests anniversary in some Places: and with such a Storm, not far from that Cape, did *Sodreus*, the *Portuguese* Consul, perish in the Year 1505; and tho' he was admonished by the *Africans*, yet he would not hearken to it.

BUT in the Entrance of the *Arabian* Gulph, and in *Arabia*, and *Ethiopia*, there is a peculiar and wonderful Storm happens. A thick black Cloud, mixed with fiery little Clouds (which are terrible to behold), brings Darkness in the Day, and on a sudden there breaks out a Storm, which is soon over; but it throws such a quantity of red Sand on the Land and Sea, that the *Arabians* say it sometimes buries whole Companies of Merchants and Travellers, with their Camels, *viz.* the Caravans that pass there once or twice a Year, being gathered (out of all parts of *Asia*) in *Syria*, they arrive thence from *Aleppo* to *Arabia*, to the Number of six thousand Men, who dare not travel by themselves, because of the Robberies by the *Arabians*, and other Dangers, as they do from *India* to *China* and *Tartary*: and from hence 'tis they say the *Arabian* and *Egyptian* Mummy comes; their Bodies being dryed in the Sand with the Sun's Heat. This Storm comes from the North to which the *Red-Sea* is extended; and therefore 'tis likely, there being a great quantity of red Sand on that Shore, that 'tis carried up by the Wind, which causes a red Colour to appear among the Clouds, and afterwards falls down.

AND 'tis also probable, that there is such a Storm of Sand in *Libya*, because of the great Heaps of that Sand there; which the Antients knew when they wrote of the difficult access to the Temple of *Jupiter Hammon* in *Libya*: nor were they without the knowledge of the way how Mummy was made. In *Guzarat*, a Kingdom in *India*, Clouds of Sand, or a vast quantity of small Dust raised by the Sun's Heat,

Heat, doth often oppreſs Travellers; as is written by *Twiſt* a *Dutchman*, who lived long there.

AS to the Cauſe of theſe Storms, 'tis plain they come from the Clouds, and may be formed two ways. 1. If a Cloud falls down, by it's Weight it will move the Air under it, as a Sheet, or Sail, let fall; and hence 'tis the ſmaller the Cloud appears the Storm after it is the greater; for the Cloud, or *Ox-eye*, is then high, and appears ſmall, and falling down, moves the Air with greater force. 2. If ſulphureous Spirits incloſed in the Cloud, break out on a ſudden in one Place, other Parts being ſhut as the Wind breaks out of a Bottle, when the Liquor in it is heated; but the firſt Cauſe ſeems the truer.

PROPOSITION XI.

Exhydrias *is a Wind that breaks out of a Cloud with a great quantity of Water.*

THIS differs but little from an *Ecnephias*; only the Cloud, from which it ſeems to break out, is now condenſed to Water, and born up ſo long by the Clouds about it, and perhaps forced together by the Winds, 'till at laſt it falls down, and beats the Air below it, which cauſes the Wind: but theſe are rare, and the *Ecnephias* itſelf hath often Showers attending it, and therefore the Difference is only in Degree; except that the *Exhydrias* for the moſt part comes ſtrait down.

PROPOSITION XII.

A Typhon *is a ſtrong ſwift Wind that blows from all Points, wandring about all quarters and generally comes from above.*

THIS is frequent in the *Oriental* Sea, eſpecially in the Sea at *Siam*, *China*, and *Japan*, and between *Malacca* and *Japan*. It breaks out violently almoſt from the

the western Point, and turning round the Horizon with a rapid Force performs the Revolution in twenty Hours; still growing stronger and stronger; raising those Seas with it's strong whirling about, to a great Height, every tenth Wave rising above the rest, which dashing against one another with great force the Seamen lose all hopes of their Lives; for which, and other Storms, sailing from *India* to *Japan* is very dangerous; so that if one Ship of three get safe there, 'tis counted to be a prosperous Voyage. The *Typhon* rages most in Summer, and more than can be conceived by those who have not seen it; so that 'tis no wonder the Ribs of the strongest and largest Ships should be loosened: you would think the Heavens and Earth were turned to their antient *Chaos*.

IT rages not only at Sea, but on Land, and overturns Houses, and pulls up Trees by the Roots, and carries great Ships a quarter of a Mile from the Sea.

IT seldom lasts above six Hours. In the *Indian* Ocean the Sea is at first plain: but there come afterwards dreadful Waves. Thus about the Town of *Arbeil* in *Persia*, in the Months of *June* and *July*, it raises a great deal of Dust every Day at twelve of the Clock; and lasts one Hour.

THE Cause of it, no doubt, is that the Wind rushing to a certain Point, is obstructed, and returns on it self, and is thus turned round, as we see in Water that turns round about in a Vortex, when it meets with an Obstacle; or it may come from furious Winds meeting one another, which renders the Sea plain, and dashes against the Ships between them. If this Wind blow from above, 'tis called *Catægis*.

PROPOSITION XIII.

Whether some Winds came from the Earth, either from the Land or Water.

WE think this is very easy to conceive; for seeing there are in the Earth, and at the Sea Bottom, several

veral Cavities; there may be in them sulphureous Spirits, which may break out violently, especially if a little hindered at first: and if much hindered this causes an Earthquake, 'till at last they make way for themselves. Thus in the *Maurice* Isles there often breaks out a Smoak from the Earth; and also from some Caverns. In *Japan* there is a Fountain that breaks out at certain Hours of the Day, with great Force and Noise.

BUT I do not remember to have read of any Wind coming out of the Sea.

PROPOSITION XIV.

Whether any Wind arises from the Tides, or the flowing of Rivers.

EXPERIENCE testifies, that in those Places where the Tides are sensible, when the Sea flows, the Wind doth for the most part blow from the Sea, when other Winds cease; and therefore it seems the Air that is contiguous to the Water flows with it to the same Point: but 'tis to be considered, whether that happens constantly. And I believe there may be another cause given of that Wind, *viz.* That the Air is driven from it's Place by the Water that flows in on the Land: for a small matter moves the Air; and thus 'tis thought the Air moves with the Rivers that run swiftly, as the *Zaire* and *Rhine.*

PROPOSITION XV.

Why the fiery Appearances Castor, Pollux, *and* Helena, *and what they call* Jack in the Lantern, *appear amidst Storms.*

NOT one, but a great many, are seen on the Masts of Ships, wandring with an uncertain Motion, tho' they seem sometimes to cleave close to the Sails and Masts; but they frequently leap up and down, with intermission, affording an obscure Flame, like

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that of a Candle burning faintly. If five of them are seen together, which the *Portuguese* call the *Virgin Mary's Crown*, they take it for a sure Sign of the Storm being soon over. Their Cause is some sulphureous and bituminous Matter beat down by the Motion of the Air above, and gathering together is kindled by the Agitation of the Air; as Butter is gather'd together by the Agitation of the Cream. And from this Appearance we gather, that these Storms come from sulphureous Spirits that rarify the Air, and put it into a Motion.

PROPOSITION XVI.

***Why Calms are so frequent in the Sea near* Guinea, *and under the Equator, in the* Atlantic *Ocean between* America *and* Africa.**

THIS is a Phænomenon concerning the Winds, of no small difficulty; that at *Guinea*, which is two Degrees from the Equator, and under the Equator itself, there should be almost a constant Calm, especially in *April*, *May*, and *June*, where there are no *Monsoons*, and when the like is not found in other Places situated under the Equator. There is indeed an *Ecnephias* pretty frequent there sometimes; and is desired by Seamen, because by the help thereof they get beyond the Equator: for sometimes going from *Europe* to *India*, they are kept a whole Month under the *Equator*: but they take care to keep from the Coast of *Guinea*; and without loss of time sail towards the Coast of *Brazil*, to avoid being becalmed; which hath kept some Ships three Months near the Shore. I have not yet found the reason of it, except it may by said, that there is no Snow found on the Mountains of *Africa*, between *Guinea* and *Barbary*; which may cause a constant Wind.

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PROPOSITION XVII.

In ſome Countries the Storms are anniverſary.

WE gave Examples of this before, *viz.* 1. Concerning the changing of the *Monſoons*. 2. Of the *Ecnephias*. 3. Of the *Typhon*. 4. At the Cape of *Good-Hope*, in *June* and *July*. 5. In the Iſland of *Del Mayo* at the latter end of *Auguſt*; to which add, 6. The Storms at *Tercera*, in *Auguſt*. 7. In thirty five Degrees of the Meridian of *Triſtan de Cunha*. And in the Month of *May*, at New-Moon, the Weſt Wind rages, and ſwallows up Ships; but in thirty three Degrees on the ſame Meridian the North and North-Eaſt. 8. At *Pulon Timor*, in the *Chineſe* Sea the Weſt Winds rage in *June* and *July*, and are dangerous. 9. Between *China* and *Japan* there are ſeveral Storms from the New Moon in *July*, to the twelfth Day of the Moon. 10. If, in the ſame Place, other Winds beſides the *Monſoons* blow ſometimes from one Point, and ſometimes from another, 'till they ſettle in the North-Eaſt, a Storm certainly happens.

The End of the Firſt Volume.

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