

Physico-theology ; or, a demonstration of the being and attributes of God, from his works of creation / Being the substance of 16 sermons preached in St. Mary le Bow-Church, London, at the Honourable Mr. Boyle's lectures in the years 1711 and 1712. With large notes and many curious observations never before published by W. Derham.

Contributors

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PHYSICO-THEOLOGY:
OR, A
DEMONSTRATION
OF THE

BEING and ATTRIBUTES of GOD,
from his WORKS of CREATION.

Being the Substance of XVI SERMONS
Preached in St. Mary le Bow-Church, London,
at the Hon^{ble} Mr. BOYLE's LECTURES,
in the Years 1711 and 1712.

With large NOTES, and many curious OB-
SERVATIONS never before Published.

By W. DERHAM, Rector of Upminster in
Essex, and F. R. S.

*Mala & impia consuetudo est contra Deos disputare, sive
animo id fit, sive simulatè. Cicer. de Nat. Deor. L. 2. fine.*



L O N D O N:
Printed for W. INNYS, at the Princes Arms in
St. Paul's Church-Yard. MDCCXIII.

1713

PHYSICO-THEOLOGICAL
FOR A
DEMONSTRATION
OF THE

Being and Attributes of GOD
from the Works of CREATION

Being the Substance of XXI SERMONS
Preached in St. Mary's Church, London,
at the House of the BISHOP of London,
in the Year 1711 and 1712.

With two NOTES on the
SERMONS.

By W. DAVIES, M.A.
of the University of Oxford.

LONDON:
Printed by J. KNEELAND, at the Sign of the
Anchor, in St. Dunstons Church-yard.

MDCCLXIII.



LONDON:
Printed for W. Innys, at the Sign of the
Anchor, in St. Dunstons Church-yard.

MDCCLXIII.



T O T H E

Most Reverend Father in GOD,

THOMAS,

Lord ARCH-BISHOP of *Canterbury*, Pri-
mate of all *ENGLAND*, &c.

The surviving Trustee of the Honourable
Mr. *BOYLE*'s LECTURES.

May it please your Grace,



May justly put these *Lec-
tures* under Your Graces
Patronage, their Publica-
tion being wholly owing
to You. For having the
Honour to be a Member
of the *Royal Society*, as well as a *Divine*, I
was minded to try what I could do to-
wards the improvement of *Philosophical*
Matters to *Theological Uses*; and accord-
ingly laid a Scheme of what I have
here published a Part of, and when I
had little else to do, I drew up what I
had to say, making it rather the divert-

The DEDICATION.

ing Exercises of my *Leisure Hours*, than more serious *Theological Studies*. This Work, although I made a considerable Progress in at first, yet, having no Thoughts of Publishing, I laid aside; until your Grace, being informed of my Design by some of my Learned Friends both of the Clergy and Laity, was pleased to call me to the unexpected Honour of Preaching Mr. *Boyle's Lectures*: an Honour I was little aware of in my Country-Privacy, not much acquainted with Persons in high Stations, and not at all with your Grace particularly. So that therefore as it pleased your Grace, not only to confer so unlooked for an Honour upon me, a Stranger, and that too maugre the Opposition Your Grace at first met with in Your Choice of me, but also to continue that Honour and Benefit for Two Years, out of Your good Opinion of my Performance, in some measure, answering Mr. *Boyle's End*; so I can do no less than make this publick Acknowledgment of your Graces great and unexpected

The DEDICATION.

expected, undeserved Favour, and return you my hearty Thanks for the same.

But besides these particular Favours to my Self, the *Lecture* is indeed greatly indebted to Your Grace's Endeavours formerly, in promoting the Pious Design, and assisting in the Settlement of this Noble Charity in the Honourable Founder's time ; and more lately since his Death, in procuring (†) a more certain Salary to the *Lecturers*, more constantly and duly paid than it was before. These

(†) It may not only gratify the Reader's Curiosity, but also be of Use to give the following Account of Mr. *Boyle's Lectures*.

Mr. *Boyle*, by a Codicil dated July 28. 1691. and annexed to his Will, charged his Messuage or Dwelling-House in St. *Michael's Crooked-Lane*, London, with the Payment of the clear Yearly Rents and Profits thereof to some Learned Divine in London, or within the Bills of Mortality, to be Elected for a Term not exceeding Three Years, by his Grace the present Lord Arch-Bishop of Canterbury (then Dr. *Tenison*) Sir Henry *Ashurst*, Sir John *Rotherham*, and John *Evelyn*, Esq; The Business he appointed those Lecturers was, among others, to be ready to satisfy real Scruples, and to answer such new Objections and Difficulties, as might be started, to which good Answers had not been made. And also, to Preach Eight Sermons in the Year, the first Monday of January, February, March, April, and May,

The DEDICATION.

These Benefits as I my self have been a Sharer of, so I should be very ungrateful should I not duly acknowledge, and repay with my repeated Thanks and good Wishes. And that the infinite Rewarder of well-doing may give Your Grace a plentiful Reward of these, and Your many other, both Publick and Private Benefactions, is the hearty Wish of,

Your Grace's,

Most Humble and Thankful

Son and Servant,

W. DERHAM.

and of September, October and November. The Subject of these Sermons was to be, the Proof of the Christian Religion against notorious Infidels, viz. Atheists, Theists, Pagans, Jews, and Mahometans, not descending lower to any Controversies that are among Christians themselves. But by reason the Lecturers were seldom continued above a Year, and that the House sometimes stood empty, and Tenants brake, or failed in due Payment of their Rent, therefore the Salary sometimes remained long unpaid, or could not be gotten without some Difficulty. To remedy which Inconvenience, his present Grace of Canterbury procured a Yearly Stipend of 50 l. to be paid Quarterly for ever, charged upon a Farm in the Parish of Brill, in the County of Bucks: which Stipend is accordingly very duly paid when demanded, without Fee or Reward.

TO THE
READER.



AS the noble Founder of the Lectures I have had the Honour of Preaching, was a great Improver of Natural Knowledge, so in all probability he did it out of a pious End, as well as in Pursuit of his Genius. For it was his settled Opinion, that nothing tended more to cultivate true Religion and Piety in a man's Mind, than a thorough Skill in Philosophy. And such Effect it manifestly had in him, as is evident from divers of his publish'd Pieces; from his constant Deportment in never *Vid. Bp. Burnet's mentioning the Name of* *Funer. Serm pag. 24.* *G O D without a Pause, and visible Stop in his Discourse; and from the noble Foundation of his Lectures for the Honour of G O D, and the generous Stipend he allowed for the same.*

And forasmuch as his Lectures were appointed by him for the Proof of the Christian Religion against Atheists and other no-

To the READER.

torious Infidels, I thought, when I had the Honour to be made his Lecturer, that I could not better come up to his Intent, than to attempt a Demonstration of the Being and Attributes of God, in what I may call Mr. Boyle's own, that is a Physico-Theological, Way. And besides that it was for this very Service that I was called to this Honour, I was the more induced to follow this Method, by reason none of my learned and ingenious Predecessors, in these Lectures, have done it otherwise than in a transient, piece-meal Manner; they having made it their Business to prove the great Points of Christianity in another Way, which they have accordingly admirably done. But considering what our Honourable Founder's Opinion was of Natural Knowledge, and that his Intent was, that those Matters by passing through divers Hands, should be treated of in different Methods, I hope my Performance may be acceptable, although one of the meanest.

As for others who have before me done something of this kind, as Mersenne on Genesis; Dr. Cockburne in his Essays; Mr. Ray in his Wisdom of God, &c. and I
may

TO the READER.

may add the first of Mr. Boyle's Lecturers, the most learned Dr. Bently in his Boyle's Lectures; and I hear Monsieur Perrault hath something of this kind, but never saw it: I say, as to these learned and ingenious Authors, as the Creation is an ample Subject, so I industriously endeavoured to avoid doing over what they before had done; and for that reason did not, for many Years, read their Books until I had finished my own. But when I came to compare what each of us had done, I found my self in many things to have been anticipated by some or other of them, especially by my Friend, the late great Mr. Ray. And therefore in some Places I shortened my Discourse, and referred to them; and in a few others, where the Thread of my Discourse would have been interrupted, I have made use of their Authority, as the best Judges; as of Mr. Ray's, for instance, with relation to the Mountains and their Plants, and other Product. If then the Reader should meet with any thing mentioned before by others, and not accordingly acknowledged by me, I hope he will candidly think me no Plagiary, because I can assure him

To the READER.

I have all along (where I was aware of it) cited my Authors with their due Praise; and it is scarce possible, when Men write on the same, or a Subject near a-kin, and the Observations are obvious, but that they must often hit upon the same thing: and frequently it happens from Persons making Observations about one and the same thing, without knowing what each other have done; which indeed, since my Book hath been nearly printed off, I find to be my own Case, having (for want of Dr. Hook's Micrography being at hand, it being a very scarce Book) given Descriptions of two or three things, which I thought had not been tolerably well observed before, but are described well by that curious Gentleman.

One is a Feather, the Mechanism of which we in the main agree in, except in his Representation in Fig. 1. Scheme 22. which is somewhat different from what I have represented in my Fig. 18. &c. But I can stand by the Truth, tho' not the Elegance of my Figures. But as to other Differences, they are accidental, occasioned by our taking the Parts in a different View, or in a different
part

TO the READER.

part of the *Vane* ; and to say the Truth (not flattering my self, or detracting from the admirable Observations of that great Man) I have hit upon a few things that escaped him.

The other thing we have both of us figured and described, is The Sting of a Bee or Wasp ; in which we differ more than in the last. But by a critical Re-examination, I find, that although Dr. Hook's Observations are more critical than any were before, yet they are not so true as mine. For as to the Scabbard (as he calls it) I could never discover any Beards thereon, and I dare be confident there are none but what are on the two Spears. And as to the Point of the Scabbard, he hath represented it as tubular, or bluntish at the Top : but it really terminates in a sharp Point, and the two Spears and the Poyson came out at a Slit or longish Hole a little below the Top or Point. And as to the Spears he makes them to but one, and that the Point thereof lies always out of the Scabbard. But by a strict Examination, they will be found to be two, as I have said, and that they always lye within the Scabbard, except in stinging, as I have represented them

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in Fig. 21. from the transparent Sting of a Wasp. And as to the Spear being made of Joynts, and parted in two, as his Fig 2. Scheme 16. represents, I could never upon a Review, discover it to be so, but imagine that by seeing the Beards lying upon, or behind the Spears, he might take them for Joynts, and by seeing the Point of one Spear lie before the other, he might think the Spear was parted in two. But lest the Reader should think himself imposed upon both by Dr. Hook and my Self, it is necessary to be observed that the Beards (or Tenter-hooks as Dr. Hook calls them) lie only on one side of each Spear, not all round them; and are therefore not to be seen, unless they are laid in due Posture in the Microscope, viz. sideways, not under or a-top the Spear.

The last thing (which scarce deserves mention) is the Mechanism of the Hair, which Dr. Hook found to be solid, like a long Piece of Horn, not hollow, as Malpighi found it in some Animals. And I have found both those great Men to be in some measure in the right, the Hair of some Animals, or in some parts of the Body

TO the READER.

dy being very little, if at all tubular ; and in others, particularly Mice, Rats, and Cats, to be as I have represented it in my Fig. 14, &c.

And now if my Inadvertency in other things hath no worse Effect than it hath had in these, namely to confirm, correct, or clear others Observations, I hope the Reader will excuse it, if he meets with any more of the like kind. But not being conscious of any such thing (although probably there may be many such) I am more sollicitous to beg the Readers Candour and Favour, with Relation both to the Text and Notes: in the former of which, I fear he will think I have as much under-done, as in the latter over-done the matter: But for my Excuse here I desire it may be considered that the Textual Part being Sermons, to be delivered in the Pulpit, it was necessary to insist but briefly upon many of the Works of G O D, and to leave out many things that might have been admitted in a more free Discourse. So that I wish it may not be thought I have said too much rather than too little for such an Occasion and Place. And indeed I had no small Trouble
in

TO the READER.

in expunging some Things, altering many, and softning the most, and, in a Word, giving in some measure the Whole a different Dress than what I had at first drawn it up in, and what it now appears in.

And as for the Notes, which may be thought too large, I confess I might have shortned them, and had Thoughts of doing it, by casting some of them into the Text, as an ingenious learned Friend advised. But when I began to do this, I found it was in a manner to new-make all, and that I should be necessitated to transcribe the greatest part of the Book, which (having no Assistant) would have been too tedious for me. I then thought it best to pare off from some, and to leave out others, and accordingly did so in many Places, and would have done it in more, particularly, in many of the Citations of the Ancients, both Poets and others, as also in many of the Anatomical Observations, and many of my own and others Observations. But then I considered as to the First, that those Citations do, many of them, shew the Sense of Mankind about God's Works, and that the most of them may be
acceptable

TO THE READER.

acceptable to Young Gentlemen at the Universities, for whose Service these Lectures are greatly intended by me. And as to the Anatomical Notes, and some others of the like Nature, most of them serve either to the Confirmation, or the Illustration, or Explication of the Text, if not to the Learned, yet to the unskilful, less learned Reader; for whose sake, if I had added more, I believe he would forgive me. And lastly, as to the Observations of my self and some others, where it happens that they are long, it is commonly where a Necessity lay upon me of fully expressing the Author's Sense, or where the Thing was new, and never before Published; in which Case, it was necessary to be more Express and Particular, than in Matters better known, or where the Authors may be referred unto.

How acceptable this Piece may be, I am no Judge. Habent sua fata Libelli. But if I find Encouragement, I have another Part relating to the Heavens, that I can soon fit up to see the Light.

A

SURVEY

OF THE

Terraqueous Globe.

INTRODUCTION.

IN *Psal. III. 2.* The Psalmist asserts, That the (1) *Works of the Lord are great; sought out of all them that have Pleasure therein.* This is true of all God's Works, particularly of his Works of Creation: Which, when sought out, or, as the Hebrew Word (2) signifieth, when heedfully and deeply pried into, solicitously observ'd, and enquir'd out, especially when clearly discovered to us; in this

(1) It is not unlikely that the Psalmist might mean, at least have an Eye to, the *Works of the Creation* in this Text, the Word מְעֵשֵׂיוֹ being the same that in *Psal. 19. 1.* is translated *God's Handy-work*, which is manifestly applied to the Works of Creation, and properly signifieth *Factum, Opus, Opificium*, from עָשָׂה *Fecit, Paravit, Aptavit.* And saith Kircher, *significat talem effectiōnem, quā aliquid existit vel realiter, vel ornate, vel ut non sit in pristino statu quo fuit.* Concord. p. 2. col. 931.

(2) שָׁאַף *Quasivit, perquisivit, sciscitatus est, Buxtor. in verb. Et simul importat curam, & solitudinem.* Conrad. Kirch. ib. p. 1. col. 1174.

Case, I say, we find those Works of GOD abundantly to deserve the Psalmist's Character of being Great and Noble ; inasmuch as they are made with the most exquisite Art, (3) contrived with the utmost Sagacity, and ordered with plain wise Design, and ministering to admirable Ends. For which Reason St. Paul might well affirm of those Ποιήματα of God, (4) That the invisible Things of God, even his eternal Power and Godhead, are understood by them. And indeed they are the most easy and intelligible Demonstrations of the Being and Attributes of God ; (5) especially to such as are unacquainted with the

(3) Quod si omnes mundi partes ita constitutæ sunt, ut neque ad usum meliores potuerint esse, neque ad speciem pulchriores ; videamus utrum ea fortuita sint, an eo statu, quo coherere nullo modo potuerint, nisi sensu moderante, divinæque providentiæ. Si ergo meliora sunt ea, quæ Natura, quàm illa, quæ Arte perfectæ sunt : Nec Ars efficit quid sine ratione : Ne Natura quidem rationis expertis est habenda. Quæ igitur convenit, signum, aut tabulam pictam cum adspexeris, scire adhibitam esse artem ; cumque procul cursum navigii videris, non dubitare, quin id ratione atque arte moveatur : aut cum Solarium, &c. Mundum autem, qui & has ipsas artes, & earum artifices, & cuncta complectatur, consilii & rationis esse expertem putare ? Quod si in Scythiam, aut in Britanniam, Sphæram aliquis tulerit hanc, quam nuper familiaris nosser effecit Posidonius, cujus singulæ conversiones idem efficiunt in Sole, &c. — quod efficitur in cælo singulis diebus & noctibus ; quis in illâ barbarie dubitet, quin ea Sphæra sit perfectæ ratione ? Si autem dubitant de Mundo, ex quo & oriuntur, & fiunt omnia, casumne ipse sit effectus, — an ratione, an mente divinâ : Et Archimedes arbitrantur plus valuisse in imitandis Sphære conversionibus, quam Naturam in efficiendis, præsertim cum multis partibus sint illa perfectæ, quam hac simulata, solertius, &c. Cicer. de Nat. Deor. l. 2.

(4) And a little before he saith of Nature it self, Omnem ergo regit Naturam ipse [Deus,] &c.

(5) Mundus codex est Dei, in quo jugiter legere debemus. Bernard. Serm.

Arbitror nullam gentem, neque hominum societatem, apud quos ulla Deorum est religio, quidquam habere sacris Eleusiniis aut Samothraciis simile : Ea tamen obscure docent quæ profitentur : Naturæ vero opera in omnibus animantibus sunt perspicua. Galen. de Us. part l. 17. c. 1.

Subtilties of Reasoning and Argumentation ; as the greatest part of Mankind are.

—It may not therefore be unsuitable to the Nature and Design of Lectures (6) founded by one of the greatest Virtuoso's of the last Age, and instituted too on purpose for the Proof of the Christian Religion against Atheists and other Infidels, to improve this occasion in the Demonstration of the *Being* and *Attributes* of an infinitely wise and powerful Creator, from a cursory Survey of the Works of *Creation*, or (as often called) of *Nature*.

Which Works belong either to our *Terraqueous Globe*, or the *Heavens*.

I shall begin with our *own Globe*, being nearest, and falling most under our Senses. Which being a Subject very various and copious, for the more methodical and orderly Proceeding upon it, I shall distribute the Works therein,

I. Into such as are not properly Parts, but *Appendages* or *Out works* of the Globe.

II. The *Globe* it self.

(6) *Philosophia est Catechismus ad Fidem.* Cyril. 1. contra Jul.

B O O K I.

*Of the Out-works of the Terraqueous
Globe; the Atmosphere, Light, and
Gravity.*

C H A P. I.

Of the Atmosphere in general.

THE Atmosphere, or Mass of Air, Vapours and Clouds, which surrounds our Globe, will appear to be a matter of Design, and the infinitely wise Creator's Work, if we consider its *Nature* and *Make* (1), and its *Use* to the World (2).

1. Its Nature and Make, a Mass of Air, of subtile penetrating Matter, fit to pervade other Bodies, to penetrate into the inmost Recesses of Nature, to excite, animate, and spiritualize; and in short, to be the very Soul of this lower World. A thing consequently

2. Of greatest Use to the World; useful to the Life, the Health, the Comfort, the Pleasure, and Business of the whole Globe. It is the Air the

(1) *Mundi pars est Aer, & quidem necessaria: Hic est enim qui cælum terramque connectit, &c. Senec. Nat. Qu. l. 2. c. 4.*

(2) *Ipse Aer nobiscum videt, nobiscum audit, nobiscum sonat; nihil enim eorum sine eo fieri potest, &c. Cicer. de Nat. Deor. l. 2.*

whole Animal World breathes, and liveth by ; not
only the Animals inhabiting the Earth (||) and
B 3 Air,

(||) As the Air is of absolute Necessity to Animal Life, so it is necessary that it should be of a due Temperament or Consistence ; not foul, by reason that suffocateth ; nor too rare and thin, because that sufficeeth not : with Examples of each of which, I shall a little entertain the Reader. In one of Mr. *Hawkesbee's* Compressing Engines, I closely shut up a *Sparrow* without forcing any Air in ; and in less than an Hour the Bird began to pant, and be concerned ; and in less than an Hour and a Half to be sick, vomit, and more out of Breath ; and in two Hours time was nearly expiring.

Another I put in, and compressed the Air, but the Engine leaking, I frequently renewed the Compressure ; by which means, (although the Bird panted a little after the first Hour,) yet after such frequent Compressures, and immission of fresh Air, it was very little concerned, and taken out seemingly unhurt after three Hours.

After this I made two other Experiments in compressed Air, with the Weight of two Atmospheres injected, the Engine holding tight and well ; the one with the *great Titmouse*, the other with a *Sparrow*. For near an Hour they seem'd but little concerned ; but after that grew fainter, and in two Hours time sick, and in three Hours time died. Another thing I took notice of, was, that when the Birds were sick, and very restless, I fancied they were somewhat relieved for a short Space, with the Motion of the Air caused by their fluttering, and shaking their Wings, (a thing worth trying in the *Diving-Bell*.) I shall leave the ingenious Reader to judge what the cause was of both the Birds living longer in compressed, than uncompressed Air ; whether a lesser quantity of Air was not sooner fouled and rendered unfit for Respiration, than a greater.

From these Experiments, two Things are manifested ; one is, that Air, in some measure compressed, or rather heavy, is necessary to Animal Life. Of which by and by. The other, that fresh Air is also necessary. For pent up Air, when overcharged with the Vapours emitted out of the Animal's Body, becomes unfit for Respiration. For which Reason, in the *Diving-Bell*, after some time of stay under Water, they are forced to come up, and take in fresh Air. But the famous *Cornel Drebell* contrived not only a Vessel to be rowed under Water, but also a Liquor to be carried in that Vessel, that would supply the

want of fresh Air. The Vessel was made for King *James I.* It carried twelve Rowers, besides Passengers. It was tried in the River of *Thames*; and one of the Persons that was in that submarine Navigation was then alive, and told it one, that related the Matter to our famous Founder, the Honourable, and most Ingenious Mr. *Boyl*. As to the Liquor, Mr. *Boyl* saith, he discovered by a Doctor of Physick, who married *Drebell's* Daughter, that it was used from time to time when the Air in the submarine Boat was clogged by the Breath of the Company, and thereby made unfit for Respiration; at which time, by unstopping a Vessel full of this Liquor, he could speedily restore to the troubled Air such a proportion of vital Parts, as would make it again for a good while fit for Respiration. The Secret of this Liquor *Drebell* would never disclose to above one Person, who himself assured Mr. *Boyl* what it was. *Vid. Boyl Exp. Phys. Mech. of the Spring of the Air. Exp. 4th in the Digres.*

And as too gross, so too rare an Air is unfit for Respiration. Not to mention the forced Rarefactions made by the Air-pump, in the following Note; it is found, that even the extraordinary natural Rarefactions, upon the Tops of very high Hills, much affect Respiration. An Ecclesiastical Person, who had visited the high Mountains of *Armenia*, (on which some fancy the Ark rested,) told Mr. *Boyl*, that whilst he was on the upper part of them, he was forced to fetch his Breath oftener than he was wont. And taking notice of it when he came down, the People told him, that it was what happened to them when they were so high above the Plain, and that it was a common Observation among them. The like Observation the same Ecclesiastick made upon the Top of a Mountain in the *Cevennes*. So a learned Traveller, and curious Person, on one of the highest Ridges of the *Pyrenees*, called *Pic de Midi*, found the Air not so fit for Respiration, as the common Air, but he and his Company were fain to breathe shorter and oftener than in the lower Air. *Vid. Phil. Transact. No. 63, or Lowthorp's Abridg. Vol. 2. p. 226.*

Such another Relation the learned *Joseph Acosta* gives of himself and his Company, that, when they passed the high Mountains of *Peru*, which they call *Periacaca*, (to which he saith, the *Alps* themselves seemed to them but as ordinary Houses, in regard of high Towers,) He and his Companions were surprized with such extreme Pangs of Straining and Vomiting, (not without casting up of Blood too,) and with so violent a Distemper, that he concludes he should undoubtedly have died; but that this lasted not above three or four Hours, before they came into a more convenient and natural Temperature of the Air. All which he concludes proceeded from the too great subtilty and delicacy of the Air, which is not proportionable to hu-
mane

Air (4), but those of the Waters (5) too. Without it

B 4

most

mane Respiration, which requires a more gross and temperate Air. *Vid. Boyl, ubi supra.*

Thus it appears, that an Air too Subtile, Rare, and Light, is unfit for Respiration : But the Cause is not the Subtlety or too great Delicacy, as Mr. *Boyl* thinks, but the too great Lightness thereof, which renders it unable to be a Counterballance, or an Antagonist to the Heart, and all the Muscles ministering to Respiration, and the *Dia stole* of the Heart. Of which see Book 4. Chap. 7. Note 1.

And as our Inability to live in too rare and light an Air may discourage those vain Attempts of Flying, and Whimfies of passing to the Moon, &c. so our being able to bear an heavier State of the Air is an excellent Provision for Mens Occasions in Mines, and other great Depths of the Earth ; and those other greater Pressures made upon the Air, in the *Diving-Bell*, when we descend into great Depths of the Waters.

(4) That the Inhabitants of the Air, (Birds and Insects,) need the Air as well as Man, and other Animals, is manifest from their speedy dying in too feculent, or too much rarefied Air ; of which see the preceeding and following Note 6. But yet Birds and Insects (some Birds at least) can live in a rarer Air than Man. Thus Eagles, Kites, Herons, and divers other Birds, that delight in high Flights, are not affected with the rarity of the Medium, as those Persons were in the preceding Note. So Insects bear the Air-pump long, as in the following Note 6.

(5) Creatures inhabiting the Waters need the Air, as well as other Animals, yea, and fresh Air too. The *Hydrocanthari* of all Sorts, both great and small ; the *Notonekti*, *Squilla aquatica* of all Sorts, the *Nymphæ* of Gnats, and many other Water-Insects, have a singular Faculty, and an admirable Apparatus, to raise their back Parts to the Top of the Waters, to take in fresh Air. It is pretty to see, for Instance, the *Hydrocanthari* come and thrust their Tails out of the Water, and take in a bubble of Air, at the tip of their Vagina and Tail, and then nimbly carry it down with them into the Waters ; and, when that is spent, or fouled, to ascend again and recruit it.

So Fishes also are well known to use Respiration, by passing the Water through their Mouths and Gills. But *Carps* will live out of the Waters, only in the Air ; as is manifest by the Experiment of their way of Fattening them in *Holland*, and which hath been practised here in *England*, viz. they hang them up in a Cellar, or some cool Place, in wet Moss in a small Net, with

most Animals live scarce half a Minute (6) ; and others, that are the most accustomed to the want of it, live not without it many Days.

And

their Head out, and feed them with white Bread soaked in Milk for many Days. This was told me by a Man very curious, and of great Honour and Eminence, whose Word (if I might name him) no Body would question : And it being an Instance of the Respiration of Fishes very singular, and somewhat out of the way, I have for the Reader's Diversion taken notice of it.

(6) By Experiments I made my self in the Air-pump, in September and October, 1704 ; I observed that Animals whose Hearts have two *Ventricles*, and no *Foramen Ovale*, as Birds, Dogs, Cats, Rats, Mice, &c. die in less than half a Minute, counting from the very first Exsuction ; especially in a small Receiver.

A *Mole* (which I suspected might have born more than other Quadrupeds) died in one Minute (without Recovery) in a large Receiver ; and doubtless would hardly have survived half a Minute in a small Receiver. A *Bat* (although wounded) sustained the Pump two Minutes, and revived upon the re-admission of the Air. After that, he remained four Minutes and a half, and revived. Lastly, After he had been in five Minutes, he continued gasping for a time, and after twenty Minutes I re-admitted the Air, but the *Bat* never revived.

As for *Insects* : *Wasps*, *Bees*, *Hornets*, *Grashoppers*, and *Lady-Cows* seemed dead in appearance in two Minutes, but revived in the open Air in two or three Hours time, notwithstanding they had been in *Vacuo* twenty-four Hours.

The *Ear-wig*, the great *Staphylinus*, the great black lowly Beetle, and some other *Insects* would seem unconcerned at the Vacuum a good while, and lie as dead ; but revive in the Air, although some had lain sixteen Hours in the exhausted Receiver.

Snails bear the Air-pump prodigiously, especially those in Shells ; two of which lay above twenty-four Hours, and seemed not much affected. The same *Snails* I left in twenty-eight Hours more after a second Exhaustion, and found one of them quite dead, but the other revived.

Frogs and *Toads* bear the Pump long, especially the former. A large Toad, found in the House, died irrecoverably in less than six Hours. Another Toad and Frog I put in together, and the Toad was seemingly dead in two Hours, but the Frog just alive. After they had remained there eleven Hours, and seemingly dead, the Frog recovered in the open Air, only weak,

And not only Animals themselves, but even Trees and Plants, and the whole vegetable Race, owe their Vegetation and Life to this useful Element; as will appear when I come to speak of them, and as is manifest from their Glory and Verdure in a free Air, and their becoming Pale and Sickly, and Languishing and Dying, when by any means excluded from it (7).

Thus useful, thus necessary is the Air to the Life of the animated Creatures; and no less is it to the Motion and Conveyance of many of them. All the winged Tribes owe their Flight and Boyancy (8) hereunto, as shall be shewn in proper Place: And even the watery Inhabitants themselves cannot ascend

weak, but the Toad was quite dead. The same Frog being put in again for twenty-seven Hours, then quite died.

The Animalcules in *Pepper-Water* remained in *Vacuo* twenty-four Hours. And after they had been exposed a Day or two to the open Air, I found some of them dead, some alive.

(7) That the Air is the principal Cause of the Vegetation of Plants, *Borelli* proves in his excellent Book *de Mot. Animal.* Vol. 2. Prop. 181. And in the next Proposition, he asserteth, *In Plantis quoque peragi Aeris respirationem quandam imperfectam, à qua earum vita pendet, & conservatur.* But of this more, when I come to survey Vegetables.

Some Lettice-Seed being sown upon some Earth in the open Air, and some of the same Seed at the same time upon other Earth in a Glass-Receiver of the Pneumatick Engine, afterwards exhausted of Air: The Seed exposed to the Air was grown up an Inch and half high within eight Days; but that in the exhausted Receiver not at all. And Air being again admitted into the said emptied Receiver, to see whether any of the Seed would then come up, it was found, that in the space of one Week it was grown up to the Height of two or three Inches. Vid. *Phil. Trans.* Nr. 23. *Lowth. Abridg.* Vol. 2. p. 206.

(8) *In volucris pulmones perforati aerem inspiratum in totam ventris cavitatem admittunt. Hujus ratio, ut propter corporis truncum aere repletum, & quasi extensum, ipsa magis volatilia evadant, faciliusque ab aere externo, propter intimi penum, sustententur. Equidem pisces, quò levius in aquis natent, in Abdomine vesicæ*

ascend and descend in their Element, well without it (9).

But

vesicae aere inflatae gestant : pariter & volucres, propter corporis truncum aere impletum & quasi inflatum, nudo aeri incumbentes, minus gravantur, proindeque levius & expeditius volant. Willis de Anim. Brut. p. 1. c. 3.

(9) *Fishes, by reason of their Bladder of Air within them, can sustain, or keep themselves in any Depth of Water : For the Air in that Bladder being more or less compressed, according to the Depth the Fish swims at, takes up more or less Space ; and consequently, the Body of the Fish, part of whose Bulk this Bladder is, is greater or less according to the several Depths, and yet retains the same Weight. Now the Rule de Insidentibus humido is, that a Body, that is heavier than so much Water, as is equal in Quantity to the Bulk of it, will sink ; a Body that is lighter, will swim ; a Body of equal Weight will rest in any part of the Water. By this rule, if the Fish, in the middle Region of the Water, be of equal Weight to the Water, that is commensurate to the Bulk of it, the Fish will rest there without any Tendency upwards or downwards : And if the Fish be deeper in the Water, the Bulk of the Fish becoming less by the compression of the Bladder, and yet retaining the same Weight, it will sink, and rest at the Bottom. And on the other side, if the Fish be higher than the middle Region, the Air dilating it self, and the Bulk of the Fish consequently increasing, but not the Weight, the Fish will rise upwards, and rest at the Top of the Water. Perhaps the Fish by some Action can emit Air out of its Bladder, — and, when not enough, take in Air, — and then it will not be wondered, that there should be always a fit Proportion of Air in all Fishes to serve their Use, &c. Then follows a Method of Mr. Boyl to experiment the Truth of this. After which, in Mr. Lowthorp's Abbridgment, follow Mr. Ray's Observations, viz. I think, that — bath hit upon the true Use of the Swimming-Bladders in Fishes. For, 1. It hath been observed, that if the Swimming-Bladder of any Fish be pricked or broken, such a Fish sinks presently to the bottom, and can neither support or raise it self up in the Water. 2. Flat Fishes, as Soles, Plaïse, &c. which lie always grovelling at the bottom, have no Swimming-Bladders that ever I could find. 3. In most Fishes there is a manifest Channel leading from the Gullet — to the said Bladder, which without doubt serves for the conveying Air thereunto. — In the Coat of this Bladder is a musculous Power to contract it when the Fish lists. See more very curious Observations relating to this Matter,*

But it would be tedious to descend too far into Particulars, to reckon up the many Benefits of this noble Appendage of our Globe in many useful Engines (10); in many of the Functions and Operations of Nature (11); in the Conveyance of Sounds; and a thousand Things besides. And I shall but just

ter, of the great Mr. Ray, as also of the curious anonymous Gentleman in the ingenious Mr. Lowthorp's Abridgment, before cited, p. 845. from *Phil. Trans.* N. 114, 115.

(10) Among the Engines in which the Air is useful, Pumps may be accounted not contemptible ones, and divers other Hydraulical Engines, which need not to be particularly insisted on. In these the Water was imagined to rise by the Power of Suction, to avoid a *Vacuum*, and such unintelligible Stuff; but the justly famous Mr. Boyle was the first that solved these Phenomena by the Weight of the Atmosphere. His ingenious and curious Observations and Experiments relating hereto may be seen in his little Tract, *Of the Cause of Attraction by Suction*, and divers other of his Tracts.

(11) It would be endless to specify the Uses of the Air in Nature's Operations: I shall therefore, for a Sample only, name it's great Use to the World in conserving Animated Bodies, whether endowed with Animal or Vegetative-Life, and it's contrary quality of dissolving other Bodies; by which means many Bodies, that would prove Nuisances to the World, are put out of the way, by being reduced into their first Principles, (as we say,) and so embodied with the Earth again. Of it's faculty as a Menstruum, or it's power to dissolve Bodies; I may instance in Chrystal-Glasses, which, with long keeping, especially if not used, will in time be reduced into a Powder, as I have seen. So divers Minerals, Earths, Stones, Fossil-Shells, Wood, &c. which from Noah's Flood, at least for many Ages, have lain under Ground, so secure from Corruption, that, on the contrary, they have been thereby made much the stronger, have in the open Air soon mouldered away. Of which last, Mr. Boyle gives an Instance (from the *Dissertation de admirandis Hungar. aquis*) of a great Oak, like a huge Beam, dug out of a Salt Mine in Transilvania, so hard, that it would not easily be wrought upon by Iron Tools, yet, being exposed to the Air out of the Mine, it became so rotten, that in four Days it was easy to be broken, and crumbled between one's Fingers. Boyle's Suspicion about some hid. Qual. in the Air, p. 28. So the

Trees

just mention the admirable Use of our Atmosphere in ministering to the enlightening of the World, by it's reflecting the Light of the heavenly Bodies to us (12); and refracting the Sun-beams to our Eye, before it ever surmounteth our Horizon (13); by which means the Day is protracted throughout the whole Globe; and the long and dismal Nights are shortened in the frigid Zones, and Day sooner approacheth them; yea the Sun it self riseth in appearance (when really it is absent from them) to the great Comfort of those forlorn Places (14).

But

Trees turned out of the Earth by the Breaches at *West-Thurrock* and *Dagenham*, near me, although probably no other than *Alder*, and interred many Ages ago in a rotten oazy Mold, were exceedingly tough, hard, and sound at first; but, being exposed to the Air and Water, soon became so rotten as to be crumbled between the Fingers. See my Observations in *Philos. Transact.* Nr. 335.

(12) By *Reflecting the Light of the heavenly Bodies to us*, I mean that Whiteness, or Lightness which is in the Air in Day-time, caused by the Rays of Light striking upon the Particles of the Atmosphere, as well as upon the Clouds above, and the other Objects beneath upon the Earth. To the same Cause also we owe the Twilight, viz. to the Sun-beams touching the uppermost Particles of our Atmosphere, which they do when the Sun is about eighteen Degrees beneath the Horizon. And as the Beams reach more and more of the airy Particles, so Darkness goes off, and Day-light comes on, and encreaseth. For an Exemplification of this, the Experiment may serve of transmitting a few Rays of the Sun through a small Hole into a dark Room: By which means the Rays which meet with Dust, and other Particles flying in the Air, are rendered visible; or (which amounts to the same) those swimming small Bodies are rendered visible, by their reflecting the Light of the Sun-beams to the Eye, which, without such Reflection, would it self be invisible.

The Azure Colour of the Sky Sir *Isaac Newton* attributes to Vapours beginning to condense. and that are not able to reflect the other Colours. *V. Optic.* 1^o 2

(13) By the Refractive Power of the Air, the Sun, and the other heavenly Bodies seem higher than really they are, especially

But passing by all these Things with only a bare mention, and wholly omitting others that might have been named, I shall only insist upon the excellent Use of this noble circumambient Companion of

ally near the Horizon. What the Refractions amount unto, what Variations they have, and what Alterations in time they cause, may be briefly seen in a little Book called, *The Artificial Clock-maker*. Chap. 11.

Although this inflective Quality of the Air be a great Incumbrance and Confusion of Astronomical Observations ;—yet it is not without some considerable Benefit to Navigation ; and indeed in some Cases, the Benefit thereby obtained is much greater, than would be the Benefit of having the Ray proceed in an exact straight Line. [Then he mentions the Benefit hereof to the Polar Parts of the World.] But this by the by, (saith he.) The great advantage I consider therein, is the first discovery of Land upon the Sea ; for by means hereof, the Tops of Hills and high Lands are raised up into the Air, so as to be discoverable several Leagues farther off on the Sea, than they would be were there no such Refraction, which is of great Benefit to Navigators for steering their Course in the Night, when they approach near Land ; and likewise for directing them in the Day-time, much more certainly than the most exact Cælestial Observations could do by the help of an uninflected Ray, especially in such Places as they have no Soundings. [Then he proposes a Method to find by these means the distance of Objects at Sea.] V. Dr. Hook's Post. Works. Lect. of Navig. p. 466.

(14) Cum Belgæ in nova Zembla hybernarent, Sol illis apparuit 16 diebus citius, quam revera in Horizonte existeret, hoc est, cum adhuc infra Horizontem depressus esset quatuor circiter gradibus, & quidem aere sereno. Varen. Geog. c. 19. Pr. 22.

[These Hollanders] found, that the Night in that place shortened no less than a whole Month ; which must needs be a very great Comfort to all such Places, as lie very far towards the North and South Poles, where the length of Night, and want of seeing the Sun, cannot chuse but be very tedious and irksome. Hook. Ibid.

[By means of the Refractions,] we found the Sun to rise twenty Minutes before it should ; and in the Evening to remain above the Horizon twenty Minutes (or thereabouts) longer than it should. Captain James' Journ. in Boyl of Cold. Tit. 18. p. 190.

of our Globe, in respect of two of its Meteor's, the Winds, and the Clouds and Rain (15).

C H A P. II.

Of the Winds. (*)

TO pass by other Considerations, whereby I might demonstrate the Winds to be the infinite Creator's Work, I shall insist only upon their great usefulness to the World. And so great is their Use,

(15) *Aer* — in *Nubes* cogitur ; *humoremque colligens terram auget imbribus* : tum *effluens huc & illuc, ventos efficit*. Idem *annuus frigorum & calorum facit varietates* : idemque & *volatus Alitum sustinet, & spiritu ductus alit & sustentat animantes*. Cicer. de Nat. Deor. l. 2.

(1) *Ventus est aer fluens*, is Seneca's Definition, *Na. Qu. l. 5.* And as Wind is a Current of the Air, so that which excites or alters its Currents may be justly said to be the Cause of the Winds. An æquipoise of the Atmosphere produceth a Calm ; but if that æquipoise be more or less taken off, a Stream of Air, or Wind, is thereby accordingly produced either stronger or weaker, swifter or slower. And divers things there are that may make such Alterations in the æquipoise or ballance of the Atmosphere, viz. Eruptions of Vapours from Sea or Land ; Rarefactions and Condensations in one place more than another ; the falling of Rain, pressure of the Clouds, &c. Pliny, l. 2. c. 45. tells us of a certain Cavern in *Dalmatia*, called, *Senta*, in quem, saith he, *dejecto levi pondere, quamvis tranquillo die, turbini similis emicat procella*. But as to Caves it is observed, that they often emit Winds more or less. Dr. Conner, taking notice of this matter, specifies these, *In regno Neopolitano ex immani Cumane Sibyllæ antro tenuem ventum effluentem percepi*. The like he observed at the Caves at *Bais*, and in some of the Mines of Germany, and in the large Salt-Mines of *Cracow* in Poland. *Ubi, saith he, opifices, & ipse fodinæ dominus Andreas Morstin, Nob. Polonus, mihi asseruerunt, quod tanta aliquando Ventorum tempestas ex ambagiosis hujus fodinæ*

Use, and of such absolute Necessity are they to the Salubrity of the Atmosphere, that all the World would be poisoned without those Agitations thereof. We find how putrid, fætid, and unfit for Respiration, as well as Health and Pleasure, a stagnating, confined, pent-up Air is. And, if the whole Mass of Air and Vapours was always at Rest, and without Motion, instead of refreshing and animating, it would suffocate and poison all the World :
But

fodine recessibus surgere solebat, quod laborantes fossores humi prosternebat, nec non portas & domicilia (quæ sibi in hac fodinâ artifices exstruunt) penitus evertibat. Bern. Connor Dissert. Med. Phys. p. 33. Artic. 3.

And as great Caves, so great Lakes sometimes send forth Winds. So Gassendus saith the *Lacus Legnius* doth, *E quo dum exoritur fumus, nubes haud dubiè creanda est, quæ sit brevè in tempestatem sævissimam exoneranda.* Gassend. Vir. Peiresk. L. 5. p. 417.

But the most universal and constant Alterations of the Balance of the Atmosphere are from Heat and Cold. This is manifest in the General Trade-Winds, blowing all the Year between the Tropicks from East to West : The cause of which is doubtless the Sun's daily Progress round that part of the Globe, and by his Heat rarefying one part of the Air, whilst the cooler and heavier Air behind presseth after. So the Sea and Land Breezes in Note 4. And so in our own Climate, the Northerly and Southerly Winds (commonly esteemed the Causes of cold and warm Weather,) are really the Effects of the Cold or Warmth of the Atmosphere. Of which I have had so many Confirmations, that I have no doubt of it. As for Instance, it is not uncommon to see a warm Southerly Wind, suddenly changed to the North, by the fall of Snow or Hail ; to see the Wind in a frosty cold Morning North, and when the Sun hath well warmed the Earth and Air, to see it wheel about towards the Southerly quarters ; and again to turn Northerly or Easterly in the cold Evening. It is from hence also, that in Thunder-showers the Wind and Clouds are oftentimes contrary to one another, (especially if Hail falls,) the sultry Weather below directing the Wind one way ; and the Cold above the Clouds another Way. I took Notice last March the 10th 1717, (and divers such like Instances I have had before and since,)
that

But the perpetual Commotions it receives from the Gales, and Storms, keep it pure and healthful (2).

Neither are those Ventilations beneficial only to the Health, but to the Pleasure also of the Inhabitants of the Terraqueous Globe; witness the Gales which fan us in the Heat of Summer, without which, even in this our temperate Zone, Men are scarce able to perform the Labours of their Calling,
or

that the Morning was warm, and what Wind stirred was West-South-West, but the Clouds were thick and black, (as generally they are when Snow ensues :) A little before Noon the Wind veered about to North by West, and sometimes to other Points, the Clouds at the same time flying some North by West, some South West: About one of Clock it rained a-pace, the Clouds flying sometimes North-East, then North, and at last both Wind and Clouds settled North by West, at which time Sleet fell plentifully, and it grew very Cold. From all which I observe, 1. That although our Region below was warm, the Region of the Clouds was cold, as the black snowy Clouds shewed. 2. That the struggle between the warmth of ours and the cold of the cloudy Region stopped the airy Currents of both Regions. 3. That the falling of the Snow through our warmer Air melted it into Rain at first; but that it became Sleet after the superiour Cold had conquered the inferiour Warmth. 4. That, as that Cold prevailed by Degrees, so by Degrees it wheeled about both the Winds and Clouds fromwards the North towards the South.

Hippocrates, l. 2. De Vict. rat. omnes Ventos vel a nive, glacie, vehementi gelu, fluminibus, &c. spirare necesse judicat. Bartholin. de usu Nivis. c. 1.

(2) *It is well observed in my Lord Howard's Voyage to Constantinople, that at Vienna they have frequent Winds, which if they cease long in Summer, the Plague often ensues: So that it is now grown into a Proverb, that if Austria be not windy, it is subject to Contagion. Bohun of Wind. p. 213.*

From some such Commotions of the Air I imagine it is, that at Grand Cairo the Plague immediately ceases, as soon as the Nile begins to overflow; although Mr. Boyl attributes it to nutritious Corpuscles. *Determ. Nat. of Effluv. Chap. 4.*

or not without Danger of Health and Life : (3) But especially, witness the perpetual Gales which throughout the whole Year do fan the Torrid Zone, and make that Climate an healthful and pleasant

All this is more evident, from the Cause assigned to malignant, epidemical Diseases, particularly the Plague, by my ingenious learned Friend, Dr. Mead ; and that is, an hot and moist Temperament of the Air, which is observed by *Hippocrates*, *Galen*, and the general Histories of epidemical Diseases, to attend those Distempers. *Vid. Mead of Poysons, Essay 5. pag. 161.* But indeed, whether the Cause be this, or poisonous, malignant Exhalations, as others think, the Winds are however very Salutiferous in such Cases, in cooling the Air, and dispersing and driving away the moist, or pestiferous Vapours.

(3) *July 8. 1707*, (called for some time after the *Hot-Tuesday*,) was so excessively hot and suffocating, by reason there was no Wind stirring, that divers Persons died, or were in great danger of Death, in their Harvest-work. Particularly one who had formerly been my Servant, a healthy, lusty, young Man, was killed by the Heat : And several Horses on the Road, dropped down and died, the same Day.

In the foregoing Notes, having taken notice of some things relating to Heat, although it be somewhat out of the way, I hope the Reader will excuse me if I entertain him with some Observations I made about the Heat of the Air under the Line, compared with the Heat of our Bodies. *J. Patrick*, who, as he is very accurate in making Barometrical and Thermometrical Instruments, had the Curiosity for the nicer adjusting his Thermometers, to send two abroad under the care of two very sensible ingenious Men ; one to the northern Lat. of 81 ; the other to the parts under the *Æquinoctial* : In these two different Climates, the Places were marked where the Spirits stood at the severest Cold, and greatest Heat. And according to these Observations he graduates his Thermometers. With his Standard, I compared my standard Thermometer, from all the degrees of Cold, I could make with *Sal Armoniack*, &c. to the greatest degrees of Heat, our Thermometers would reach to. And with the same Thermometer (of mine) I experimented the greatest Heat of my Body, in *July 1709*. First in an hot Day without exercise, by putting the Ball of my Thermometer under my Armpits, and other hottest Parts of my Body. By which means the Spirits were raised 284 Tenths of an Inch above the Ball. After that,

pleasant Habitation, which would otherwise be scarce habitable.

To these I might add many other great Conveniencies of the Winds in various Engines, and various Buſineſſes. I might particularly inſiſt upon its great Uſe to tranſport Men to the fartheſt diſtant Regions of the World, and I might particularly ſpeak of the general and coaſting Trade-Winds, the Sea, and the Land-Breezes; (4) the one ſerving to carry the Mariner in long Voyages from Eaſt to Weſt; the other ſerving to waſt
him

that, in a much hotter Day, and indeed nearly as hot as any Day with us, and after I had heated my ſelf with ſtrong Exerciſe too, as much as I could well bear, I again tried the ſame Experiment, but could not get the Spirits above 288 Tenths; which I thought an inconfiderable Difference, for ſo ſeemingly a very different Heat of my Body. But from ſome Experiments I have made (although I have unfortunately forgotten it) in very cold Weather, I imagine the Heat of an healthy Body to be always much the ſame in the warmeſt Parts thereof, both in Summer and Winter. Now between thoſe very degrees of 284 and 288, the point of the equatorial Heat falleth. From which Obſervation it appears, that there is pretty nearly an equal Contemperament of the Warmth of our Bodies, to that of the hotteſt Part of the Atmosphere inhabited by us.

If the proportion of the degrees of Heat be deſired from the Freezing-point, to the Winter, Spring, and Summer Air, the Heat of Man's Body, of heated Water, melted Metals, and ſo to actual Fire; an account may be met with of it, by my moſt ingenious Friend, the great Sir Iſaac Newton, in *Phil. Tranſact.* Nr. 270.

(4) Sea-Breezes commonly riſe in the Morning about Nine a Clock. — They firſt approach the Shore ſo gently, as if they were afraid to come near it. — It comes in a fine, ſmall, black Curle upon the Water, whereas all the Sea between it, and the Shore (not yet reached by it) is as ſmooth and even as Glaſs in compariſon. In half an Hour's time after it has reach'd the Shore, it fans pretty briskly, and ſo increaſeth gradually till Twelve a Clock; then it is commonly ſtrongeſt, and laſts ſo till Two or Three a very brisk Gale. — After Three it begins to die away again, and gradually
withdraws

him to particular Places ; the one serving to carry him into his Harbour, the other to bring him out. But I should go too far to take notice of all Particulars (5). Leaving, therefore, the Winds, I proceed in the next place to the Clouds and Rain.

withdraws its force till all is spent ; and about Five a Clock — it is lulled asleep, and comes no more till next Morning.

And as the Sea-Breezes do blow in the Day, and rest in the Night ; so on the contrary [the Land-Breezes] blow in the Night, and rest in the Day, alternately succeeding each other. — They spring up between Six and Twelve at Night, and last till Six, Eight, or Ten in the Morning. Dampier's Disc. of Winds, ch. 4.

(5) One thing more I believe some of my Friends will expect from me is, that I shew the result of comparing my own Observations of the Winds, with others they know I have from *Ireland, Switzerland, Italy, France*, and some of our Parts of *England*. But the Observations being some of them but of one Year, and most of the rest of but a few Years, I have not been able to determine any great Matters. The chief of what I have observed is, that the Winds in all these places seldom agree, but when they most certainly do so, it is commonly when the Winds are strong, and of long continuance in the same Quarter : And more I think in the Northerly and Easterly, than other Points. Also a strong Wind in one place, is oftentimes a weak one in another place, or moderate, according as places have been nearer, or farther distant. *Vid. Phil. Transact. Nr. 297, & 321.* But to give a good and tolerable Account of this, or any other of the Weather, it is necessary to have good Histories thereof from all Parts : which, as yet we have but few of, and they imperfect, for want of longer and sufficient Observations.

C H A P. III.

Of the Clouds and Rain.

THE Clouds and Rain (1) we shall find to be no less useful Meteors than the last mentioned ; as is manifest in the refreshing pleasant Shades which the Clouds afford, and the fertile Dews and Showers which they pour down on the Trees and Plants,

(1) Clouds and Rain are made of Vapours raised from Water, or Moisture only. So that I utterly exclude the Notion of Dry, Terrene Exhalations, or Fumes, talked much of by most Philosophers ; Fumes being really no other than the humid Parts of Bodies respectively Dry.

These Vapours are demonstratively no other than small Bubbles, or Vesiculæ detatched from the Waters, by the power of the Solar, or Subterraneous Heat, or both. Of which see Chap. 5. following Note 2. And being lighter than the Atmosphere, are buoyed up thereby, until they become of an equal Weight therewith, in some of its Regions, aloft in the Air, or nearer the Earth ; in which those Vapours are formed into Clouds, Rain, Snow, Hail, Lightning, Dew, Mists, and other Meteors.

In which work the grand Agent is Cold ; which commonly, if not always, occupies the superior Regions of the Air ; as is manifest from those Mountains which exalt their lofty Tops into the upper and middle Regions, and are always covered with Snow and Ice.

This Cold, if it approaches near the Earth, presently precipitates the Vapours either in Dews : or if the Vapours more copiously ascend, and soon meet the Cold, they are then condensed into *Misting*, or else into Showers of *small Rain*, falling in numerous, thick, small Drops : But if those Vapours are not only copious, but also as heavy as our lower Air it self, (by means their Bladders are thick, and fuller of Water.) in this case they become visible, swim but a little Height above the Earth, and make what we call a *Mist* or *Fog*. But if they are a Degree lighter, so as to mount higher, but not any great Height, as also meet not with Cold enough to condense them, nor Wind to dissipate them, they then form an heavy, thick, *dark Sky*, lasting often times

Plants, which would languish and die with perpetual Drought, but are hereby made Verdant and Flourishing, Gay and Ornamental; so that (as the

times for several Weeks without either Sun or Rain. And in this case, I have scarce ever known it to rain, till it hath been *first Fair, and then Foul*. And Mr. *Clarke*, (an ingenious Clergyman of *Norfolk*, who in his Life-time, long before me, took notice of it, and kept a Register of the Weather for thirty Years, which his learned Grandson, Dr. *Samuel Clarke* put into my Hands, he, I say,) saith, he scarce ever observed the Rule to fail in all that time; only he adds, *If the Wind be in some of the easterly Points*. But I have observed the same to happen be the Wind where it will. And from what hath been said, the case is easily accounted for, *viz.* whilst the Vapours remain in the same State, the Weather doth so too. And such Weather is generally attended with moderate Warmth, little or no Wind to disturb the Vapours, and an heavy Atmosphere to support them, the Barometer being commonly high then. But when the Cold approacheth, and by condensing, drives the Vapours into Clouds or Drops, then is way made for the Sun-beams, till the same Vapours, being by further Condensation, formed into Rain, fall down in Drops.

The Cold's approaching the Vapours, and consequently the Alteration of such dark Weather I have before-hand perceived, by some few small Drops of Rain, Hail, or Snow, now and then falling, before any Alteration hath been in the Weather; which I take to be from the Cold meeting some of the straggling Vapours, or the uppermost of them, and condensing them into Drops, before it arrives unto, and exerts it self upon the main Body of Vapours below.

I have more largely than ordinary insisted upon this part of the Weather, partly, as being somewhat out of the way; but chiefly, because it gives light to many other Phænomena of the Weather. Particularly we may hence discover the Original of Clouds, Rain, Hail, and Snow; that they are Vapours carried aloft by the Gravity of the Air, which meeting together so as to make a Fog above, they thereby form a *Cloud*: If the Cold condenseth them into drops, they then fall in *Rain*, if the Cold be not intense enough to Freeze them: But if the Cold freezeth them in the Clouds, or in their fall through the Air, they then become *Hail*, or *Snow*.

As to *Lightening*, and other enkindled Vapours, I need say little in this place, and shall therefore only observe, that they

the Psalmist saith, *Psal. 65. 12, 13.*) *The little Hills rejoice on every side, and the Valleys shout for joy, they also sing.*

And,

owe also their rise to Vapours; but such Vapours as are detached from mineral Juices, or at least that are mingled with them.

Another *Phænomenon* resolvable from what hath been said is, why a *cold*, is always a *wet* Summer, *viz.* because the Vapours rising plentifully then, are by the Cold soon collected into Rain. A remarkable Instance of this we had in the Summer of 1708, part of which, especially about the *Solstice*, was much colder than usually. On *June 12.* it was so cold, that my Thermometer was near the point of Hoar-Frost, and in some places I heard there was an Hoar Frost; and during all the cool Weather of that Month, we had frequent, and large Rains, so that the whole Month's Rain amounted to above two Inches depth, which is a large quantity for *Upminster*, even in the wettest Months. And not only with us at *Upminster*, but in other places, particularly at *Zurich* in *Switzerland*, they seem to have had as unseasonable Cold and Wet, as we. *Fuit hic mensis — præter modum humidus, & magno quidem Vegetabilibus hominibusque damno. Multum computruit Fenum, &c.* complains the industrious and learned Dr. *J. J. Scheuchzer*. Of which, and other Particulars I have given a larger Account in *Philos. Trans.* Nr. 321.

In which *Transaction* I have observed farther, that about the Equinoxes we (at *Upminster* at least) have oftentimes more Rain, than at other Seasons. The reason of which is manifest from what hath been said, *viz.* in Spring, when the Earth and Waters are loosed from the brumal Constipations, the Vapours arise in great plenty: And the like they do in Autumn, when the Summer Heats, that both dissipated them, and warmed the superior Regions, are abated; and then the Cold of the superior Regions meeting them, condenseth them into Showers, more plentiful than at other Seasons, when either the Vapours are fewer, or the Cold that is to condense them is less.

The manner how Vapours are precipitated by the Cold, or reduced into Drops, I conceive to be thus: Vapours being, as I said, no other than inflated Vesiculæ of Water; when they meet with a colder Air, than what is contained in them, the contained Air is reduced into a lesser Space, and the watery Shell or Case rendered thicker by that means, so as to become heavier than the Air, by which they are buoyed up, and consequently must needs fall down.

And, if to these Uses, we should add the Origine of Fountains and Rivers, to Vapours and the Rains,

As to the Rain of different places, I have in some of our *Transactions* assigned the Quantities, particularly in the last cited *Transuction*, I have assigned these, viz. the depth of the Rain one Year with another, in *English* Measure, if it was to stagnate on the Earth, would amount unto, at *Townley* in *Lancashire* $42 \frac{1}{2}$ Inches; at *Upminster* in *Essex* $19 \frac{1}{2}$ Inches; at *Zurich* in *Switzerland* $32 \frac{1}{2}$ Inches; at *Pisa* in *Italy* $43 \frac{1}{2}$ Inches; at *Paris* in *France* 19 Inches, and at *Lisle* in *Flanders* 24 Inches.

It would be endless to reckon up the *Bloody* and other *prodigious* Rains, taken notice of by Historians, and other Authors, as *præternatural* and ominous Accidents; but, if strictly pried into, will be found owing to natural Causes. Of which, for the Reader's Satisfaction, I will give an instance or two. A bloody Rain was imagined to have fallen in *France*, which put the Country People into so great a fright, that they left their Work in the Fields, and in great haste flew to the neighbouring Houses. *Peiresc* (then in the Neighbourhood) strictly enquiring into the Cause, found it to be only red Drops coming from a sort of Butter-fly, that flew about in great Numbers at that time, as he concluded from seeing such red Drops come from them; and because these Drops were laid, *Non supra adificia, non in devexis lapidum superficibus, uti debuerat contingere, si e celo sanguine pluisset; sed in subcavis potius, ac in foraminibus.* — *Accessit, quod parietes iis tingebantur, non qui in mediis oppidis, sed qui agrorum vicini erant, neque secundum partes elatiores, sed ad mediocrem solum altitudinem, quantam volitare Papiliones solent.* Gassend. in Vit. Peiresk. L. 2. p. 156.

So Dr. Merret saith also, *Pluvia Sanguinis quam certissime constat esse tantum Insectorum excrementa: Pluvia Tritici quam nihil aliud esse quam Hederae bacciferae grana a Sturnis devorata excretaque comparanti liquidissime patet.* Pinax rerum, &c. pag. 220.

The curious Worm tells of the raining of Brimstone, An. 1646. Maii 16. *Hic Hafnia cum ingenti pluvia tota urbs, omnesque ita inundarentur plateae, ut gressus hominum impediret, Sulphureoque odore aerem inficeret, dilapsis aliquantulum aquis, quibusdam in locis colligere licuit Sulphureum pulverem, cujus portionem servo, colore, odore, & aliis verum Sulphur ferentem.* Mus. Worm. L. 1. c. 11. Sect. 1.

Together with the Rain we might take Notice of other Meteors, particularly Snow; which although an irksome Guest, yet hath its great Uses, if all be true, that the famous T. Bartholin

Rains, as some of the most eminent modern Philosophers

saith of it, who wrote a Book *de Nivis usu Medico*. In which he shews, of what great use Snow is in fructifying the Earth, preserving from the Plague, curing Feavers, Cholicks, Head-achs, Tooth-ach, Sore-eyes, Pleurisies, (for which Use, he saith his Country-women of Denmark keep Snow-water gathered in March,) also in prolonging Life, (of which he instanceth in the Alpine Inhabitants, that live to a great Age,) and preserving dead Bodies; instances of which he gives in Persons buried under the Snow in passing the *Alpes*, which are found uncorrupted in the Summer, when the Snow is melted, which sad Spectacle he himself was an Eye witness of. And at *Spitzberge* in *Greenland*, dead Bodies remain entire and uncorrupted for thirty Years. And lastly, concerning such as are so preserved when slain, he saith they remain in the same Posture and Figure. Of which he gives this odd Example, *Visum id extra Urbem nostram [Hafniam] quum, 11. Feb. 1659. oppugnantes hostes repellerentur, magnaque strage occumberent; alii enim rigidi iratum vultum ostendebant, alii oculos elatos, alii ore diducto ringentes, alii brachiis extensis gladium minari, alii alio situ prostrati jacebant.* Barthol. de usu Niv. c. 12.

Such an example is said to have happened some Years ago at *Paris*, in digging in a Cellar for supposed hidden Treasure; in which after digging some Hours, the Maid going to call her Master, found them all in their digging Postures, but dead. This being noised abroad, brought in, not only the People, but Magistrates also, who found them accordingly; *Ille qui ligone terram effoderat, & socius qui palâ effossam terram removerat, ambo pedibus stabant quasi suo quisque operi affixus incubisset; uxor unius quasi ab opere defessa in scamno, sollicito quodam vultu, sedebat, inclinato in palmam manûs genibus innitenti capite; puerulus laxatis braccis in margine excavatæ foveæ defixis in terram oculis alvum exonerabat; omnes in naturali situ, carnea tanquam statua rigidi, apertis oculis & vultu vitam quasi respirante, exanimés stabant.* Dr. Bern. Connor, Dissert. Med. Phys. p. 15.

The Doctor attributes all this to Cold; but I scarce think there could be Cold enough to do all this at *Paris*, and in a Cellar too. But his following Stories are not improbable, of Men and Cattle killed with Cold, that remain in the very same Posture in which they died; of which he gives this Instance from a Spanish Captain, that happened two Years before, of a Soldier that happened unluckily to straggle from his Company that were foraging, and was killed with the Cold, but was thought to have

losophers (2) have done, we should have a sufficient farther Instance of the great Use and Benefit of that Meteor.

And now, if we reflect upon this necessary Appendage of the Terraqueous Globe, the *Atmosphere*; and consider the absolute Necessity thereof to many Uses of our Globe, and its great Convenience to the whole: And in a Word, that it answereth all the Ends and Purposes that we can suppose there can be for such an Appendage: Who can but own this to be the Contrivance, the Work of the great Creator? Who would ever say or imagine such a Body, so different from the Globe it serves, could be made by Chance, or be adapted so exactly to all those fore-mentioned grand Ends, by any other Efficient, than by the Power and Wisdom of the infinite *GOD*! Who would not rather, from so noble a Work, readily acknowledge the Workman, (3) and as easily conclude the *Atmosphere* to be made

have fallen into the Enemies Hands. But soon after their return to their Quarters, they saw their Comrade returning sitting on Horseback, and coming to congratulate him, found him dead, and that he had been brought thither in the same Posture on Horseback, notwithstanding the jolting of the Horse. *Ibid.* p. 18.

(2) Of this Opinion was my late most ingenious and learned Friend, Mr. *Ray*, whose Reasons see in his *Physico Theolog. Discourses*, Disc. 2. p. 90, &c. So also my no less learned and ingenious Friends Dr. *Halley*, and the late Dr. *Hook*, many of the French Vertuoso's also, and divers other very considerable Men before them, too many to be specified here.

(3) *An Polycletum quidem admirabimur propter partium Statuæ—convenientiam ac proportionem? Naturam autem non modo non laudabimus, sed omni etiam arte privabimus, quæ partium proportionem non solum extrinsecus more Statuariorum, sed in profundo etiam servavit? Nonne &c Polycletus ipse Naturæ est imitator, in quibus saltem eam potuit imitari? Potuit autem in solis externis partibus, in quibus artem consideravit.* With much more to the like purpose. *Galen. de Us. Part. l. 17. c. 1.*

(1) It

made by GOD, as an Instrument wrought by its Power, any Pneumatick Engine, to be contrived and made by Man!

CH A P. IV.

Of Light.

THUS much for the first Thing ministering to the Terraqueous Globe, the Atmosphere, and its Meteors; the next Appendage is *Light*. (1) Concerning which, I have in another part of this Survey (2) shewed, what admirable Contrivances the infinitely wise Creator hath for the affording this noble, glorious, and comfortable Benefit to other Globes, as well as ours; the provision he hath made by Moons, as well as by the Sun, for the Communication of it.

And

(1) It is not worth while to enumerate the Opinions of the *Aristotelians*, *Cartesians*, and others about the Nature of Light; *Aristotle* making it a Quality; *Cartes* a Pulsion, or Motion of the Globules of the second Element. *Vid. Cartes Princip.* p. 3. §. 55, &c. But with the Moderns, I take *Light* to consist of material Particles, propagated from the Sun, and other luminous Bodies, not instantaneously, but in time, according to the Notes following in this Chapter. But not to insist upon other Arguments for the Proof of it, our noble Founder hath proved the Materiality of Light and Heat, from actual Experiments on Silver, Copper, Tin, Lead, Spelter, Iron, Tuttenag, and other Bodies, exposed (both naked, and closely shut up) to the Fire: All which were constantly found to receive an Increment of Weight. I wish he could have met with a favourable Season, to have tried his Experiments with the Sun-beams as he intended. *Vid. Boyl Exp. to make Fire and Flame ponderable.*

(2) In my Survey of the Heavens, not yet Published.

(3) Gen.

And now let us briefly consider the great Necessity and Use thereof to all our Animal World. And this we shall find to be little less than the very Life and Pleasure of all those Creatures. For what Benefit would Life be of, what Pleasure, what Comfort would it be for us to live in perpetual Darkness? How could we provide our selves with Food and Necessaries? How could we go about the least Business, correspond with one another, or be of any Use in the World, or any Creatures be the same to us, without Light, and those admirable Organs of the Body, which the great *Creator* hath adapted to the Perception of that great Benefit?

But now by the help of this admirable, this first-made, (3) because most necessary, Creature of God, by this, I say, all the Animal World is enabled to go here and there, as their occasions call; they can transact their Business by Day, and refresh and recruit themselves by Night, with Rest, and Sleep. They can with Admiration, and Pleasure, behold the glorious Works of God; they can view the Glories of the Heavens, and see the Beauties of the flowry Fields, the gay Attire of the feathered Tribe, the exquisite Garniture of many Quadrupeds, Insects, and other Creatures; they can take in the delightful Landscips of divers Countries, and Places; they can with admiration see the great Creator's wonderful Art and Contrivance in the Parts of Animals and Vegetables: And in a word, behold the Harmony of this lower World, and of the Globes above; and survey the exquisite Workmanship in every Creature.

To

(3) Gen. 1. 3. *And God said, Let there be Light, and there was Light.*

(4) It

To all which I might add the Improvements, which the Sagacity of Men have made of this noble Creature of God, by the Refractions and Reflections of Glasses. But it would be endless to enumerate all it's particular Uses and Benefits to our World.

But before I leave this Point, there are two things concerning Light, which will deserve an especial remark; and that is it's swift and almost instantaneous Motion; and it's vast Extension.

1. It is a very great Act of the Providence of God, that so great a Benefit as Light is, is not long in its passage from place to place. For was the Motion thereof no swifter than the Motion of the swiftest Bodies on Earth, such as of a Bullet out of a great Gun, or even of a Sound (4) (which is the swiftest Motion we have next Light) in this case Light would take up in it's Progress from the Sun to us, above thirty-two Years, at the rate of the first, and above seventeen Years, at the rate of the latter.

The

(4.) It may not be ungrateful to the Curious to take Notice of the Velocity of these two Things.

According to the Observations of *Mersennus*, a Bullet shot out of a great Gun, flies 92 Fathoms in a Second of Time, [*Bal-
list* ———] which is equal to $589\frac{1}{2}$ Feet *English*; and according to the Computation of Mr. *Huygens*, it would be 25 Years in passing from the Earth to the Sun. But according to my own Observations made with one of Her Majesties *Sakers*, and a very accurate Pendulum-Chronometer, a Bullet, at it's first discharge, flies 510 Yards in five Half-seconds, which is a Mile in a little above 17 Half-seconds. And allowing the Sun's Distance, as in the next Note, a Bullet would be $32\frac{1}{2}$ Years in flying with its utmost Velocity to the Sun.

As to the Velocity of Sound, see *Book 4. Chap. 3. Note 28.* according to which rate there mentioned, a Sound would be near $17\frac{1}{2}$ Years in flying as far as from the Earth to the Sun. Confer here the Experiments of the *Acad. del Ciment*, pag. 140, &c.

(5) Mr.

The Inconveniencies of which would be, it's Energy and Vigour would be greatly cooled and abated; it's Rays would be less penetrant; and Darkness would with greater difficulty, and much sluggishness, be dissipated, especially by the fainter Lights of our sublunary luminous Bodies. But passing with such prodigious Velocity, with nearly the instantaneous Swiftneſs of above two Hundred and ſixty Thouſand Engliſh Miles in one Second of time, (5) or (which is the ſame thing) being but about ſeven or eight Minutes of an Hour in coming
from

(5) Mr. Romer's ingenious Hypotheſis about the Velocity of Light, hath been eſtabliſhed by the *Royal Academy*, and in the *Obſervatory* for eight Years, as our *Phil. Tranſact.* Nr. 136. obſerve from the *Journ. des Scavans*: our moſt eminent Aſtronomers alſo in *England* admit it: But Dr. Hook thinks with *Monſieur Cartes*, the Motion of Light inſtantaneous. *Hook Poſt. Works.* pag. 77. And this he endeavours to explain, pag. 130, &c.

What Mr. Romer's Hypotheſis is, may be ſeen in the *Phil. Tranſact.* before-cited: As alſo in the before-mentioned Sir *Iſaac Newton's Opticks*: Light is propagated from luminous Bodies in time, and ſpends about ſeven or eight Minutes of an Hour in paſſing from the Sun to the Earth. This was firſt obſerved by Romer, and then by others, by means of the Eclipses of the Satellites of Jupiter. For theſe Eclipses, when the Earth is between the Sun and Jupiter, happen about ſeven or eight Minutes ſooner than they ought to do by the Tables; and when the Earth is beyond the ☉, they happen about ſeven or eight Minutes later than they ought to do: The reaſon being, that the Light of the Satellites hath farther to go in the latter Caſe than in the former, by the Diameter of the Earth's Orbit. *Newt. Opt. L. 2. Part 3. Prop. 11.*

Now, forasmuch as the Diſtance between the ☉ and ☉, is according to ſome 10000 Diameters of the Earth, according to others 20000; but according to our moſt ingenious Savilian Profeſſor, Dr. *Halley*, the middle between them, 15000, which (according to *Note 1. L. 2. c. 2.*) makes 119032125 Miles; therefore at the Rate of $7\frac{1}{2}$ Minutes, or 450 Seconds in paſſing from the ☉, Light will be found to fly 264516 Miles in one Second; which is vaſtly more than what Dr. *Hook* (no doubt by ſome Miſtake) hath it in his *Poſth. Works* before-cited.

(6) Dr.

from the Sun to us, therefore with all security and speed, we receive the kindly Effects and Influences of that noble and useful Creature of God.

2. Another thing of great consideration about Light is, it's vast Expansion, it's almost incomprehensible, and inconceivable Extension, which as a late ingenious Author (6) saith, "Is as boundless" and unlimited as the Universe it self, or the Expansum of all material Beings: The vastness of which is so great, that it exceeds the comprehensions of Man's understanding. Insomuch that very many have asserted it absolutely Infinite, and without any Limits or Bounds.

And that this noble Creature of God is of this extent, (7) is manifest from our seeing some of the farthest distant Objects, the heavenly Bodies, some with our naked Eye, some with the help of optical Instruments,

(6) Dr. Hook Post. Works. Lect. of Light. pag. 76.

(7) For the proof of this vast extent of Light, I shall take the Computation of the same great Man, pag. 77. If, saith he, we consider first the vast Distance between us and the Sun, which from the best and latest Observations in Astronomy, is judged to be about 10000 Diameters of the Earth, each of which is about 7925 English Miles; therefore, the Sun's distance is 79250000 Miles; and if we consider that according to the Observation, which I published to prove the Motion of the Earth, [which were Observations of the Parallax of some of the fixt Stars in the Head of Draco, made in 1669,) the whole Diameter of this Orb, viz. 20000 made the Subtense but of one Minute to one of the fixt Stars, which cannot therefore be less distant than 3438 Diameters of this Great-Orb, and consequently 68760000 Diameters of the Earth: And if this Star be one of the nearest, and that the Stars that are of one Degree lesser in Magnitude (I mean not of the Second Magnitude, because there may be many Degrees between the First and Second) be as much farther; and another sort yet smaller be three times as far; and a fourth, four times as far, and so onward, possibly to some 100 Degrees of Magnitude, such as may be discovered by longer and longer Telescopes, that they may be 100 times as far; then certainly this material Expansum, a part of which we are, must be

Instruments, and others in all probability farther and farther, with better and better Instruments : And had we Instruments of Power, equivalent to the extent of Light, the luminous Bodies of the utmost parts of the Universe, would for the same Reason be visible too.

Now as Light is of greatest Use to empower us to see Objects at all, so the Extension thereof is no less useful to enable us to see Objects afar off. By which means we are afforded a Ken of those many glorious Works of the infinite Creator, visible in the Heavens, and can improve them to some of the noblest Sciences, and most excellent Uses of our own Globe.

CHAP. V.

Of Gravity.

THE last thing subservient to our Globe, that I shall take notice of, is Gravity (1), or that Tendency which Bodies have to the Center of the Earth. If

so great, that 'twill infinitely exceed our shallow Conception to imagine. Now, by what I last mentioned, it is evident, that Light extends it self to the utmost imaginable Parts, and by the help of Telescopes, we collect the Rays, and make them sensible to the Eye, which are emitted from some of the almost inconceivably remote Objects, &c. — Nor is it only the great Body of the Sun, or the vast Bodies of the fixt Stars, that are thus able to disperse their Light through the vast Expansum of the Universe ; but the smallest Spark of a lucid Body must do the very same thing, even the smallest Globule, struck from a Steel by a Flint, &c.

(1) According to the principles of the Newtonian (the most rational of any) Philosophy, the cause of Gravity, is that universal Law of Matter, imprinted on it at it's Creation by the infinite Creator, namely Attraction: Which is congenial with all the

If by the kind Reception of this, I have encouragement to publish my *Survey of the Heavens*, I shall shew of what absolute Necessity, and what a noble

the Matter in the Universe ; to Bodies Simple and Compound, Solid and Fluid, in the Heavens, and the Earth ; to the largest Globes, and even to the minutest, component Particles of Bodies. These all *attract* one another in proportion to the quantity of their Matter, and to the square of their Distances. Which Attraction, or Tendency (particularly of the lesser Bodies to that greater, and most prevalent Attractor the Earth) is called their *Gravity*.

This Attraction, or Gravity, as its Force is in a certain proportion, so makes the descent of Bodies to be at a certain rate. And was it not for the Resistance of the Medium, all Bodies would descend to the Earth at the same rate ; the lightest down as swiftly as the heaviest Mineral : As is manifest in the *Air-pump*, in which the lightest Feather, Dust, &c. and a piece of Lead, drop down seemingly in the same time, from the top to the bottom of a tall exhausted Receiver.

The rate of the descent of heavy Bodies, according to *Gallileo*, Mr. *Huygens*, and Dr. *Halley* (after them) is 16 Feet 1 Inch in one Second of time ; and in more Seconds, as the Squares of those times. But in some accurate Experiments made in *St. Paul's Dome*, June 9. 1710, at the Height of 220 Feet, the Descent was scarcely 14 Feet in the first Second. The Experiments were made in the presence of some very considerable Members of the Royal Society, by Mr. *Hawksbee* their Operator, with glass hollow Balls, some empty, some filled with Quick-silver, the Barrometer at 29,7, the Thermometer 60 Degrees above Freezing. The weight of the Balls, their Diameters, and time of the Descents is in this Table.

Ball's filled with Ψ .			Empty Balls.			
Weight.	Diameter.	Time.	Weight.	Diameter.		Time.
Grains.	Tenth Inch.	$\frac{1}{2}$ Seconds.	Grains.	Inch.	Tenth.	$\frac{1}{2}$ Seconds.
908	8	8	510	5	1	17
993	8	8 less	642	5	2	16
866	8	8	599	5	1	16
747	$7 \frac{1}{2}$	8 more	515	5 nearly		$16 \frac{1}{2}$
808	$7 \frac{1}{2}$	8	483	5 nearly		17
784	$7 \frac{1}{2}$	8 more	641	5	2	16

For

noble Contrivance this is of keeping the several Globes of the Universe from shattering to pieces, as they evidently must do in a little time by their swift Rotation round their own Axes (2). The Terraqueous Globe particularly, which circum-

D

volves

The reason why the heavy, full Balls fell in half the time of the hollow ones, was the Resistance of the Air. Which Resistance is very ingeniously and accurately assigned by Dr. Wallis, in *Philos. Trans.* N. 186. And the cause of the Resistance of all Fluids, (as Sir Isaac Newton *Opt.* Q. 20.) is partly from the Friction of the parts of the Fluid, partly from the Inertia thereof. The Resistance a spherical Body meets with from Friction, is as the right Angle under the Diameter, and the Velocity of the moving Body : And the Resistance from the *Vis Inertiæ*, is as the Square of that Product.

For a farther account of the Properties and Proportions, &c. of Gravity in the fall or projection of Bodies, I shall refer to the larger Accounts of *Gallileus*, *Toricellius*, *Huygens*, Sir Isaac Newton, &c. or to the shorter Accounts of Dr. Halley, in *Philos. Trans.* abridged by Mr. Lowthorp, Vol. I. p. 561. or of Dr. Clarke in his Notes on *Robault. Phys.* p. 2. c. 28. §. 13, 16. And for the Resistance of Fluids, I refer to Dr. Wallis before-cited, and the *Act. Erudit Lips.* May 1693. where there is a way to find the Force of Mediums upon Bodies of different Figures.

(2) That the heavenly Bodies move round their own Axes is, beyond all doubt, manifest to our Eye, in some of them, from the Spots visible on them. The Spots on the Sun (easily visible with an ordinary Glass) do manifest him to revolve round his own Axis in about $25\frac{1}{4}$ Days. The Spots on Ψ and δ prove those two Planets to revolve also from East to West, as Dr. Hook discovered in 1664, and 1665. And ϱ also (although near the strong Rays of the Sun) hath, from some Spots, been discovered, by Mr. Castini, in 1666, and 1667, to have a manifest Rotation. *V. Lowth. Abridg.* Vol. I. p. 382, and 423, 425. And such uniformity hath God observed in the Works of Nature, that what is observable in one, is generally to be found in all others of the same kind. So that since 'tis manifest the Sun and three of his Planets whirl round, it is very reasonable to conclude all the rest do so too, yea, every Globe of the Universe.

D

(3) The

volved at the rate of above 1000 Miles an Hour (3), would by the centrifugal force of that Motion, be soon dissipated, and spirtled into the circumambient Space, was it not kept together by this noble Contrivance of the Creator, this natural inherent Power; namely, the power of Attraction, or Gravity.

And as by this Power our Globe is defended against Dissipation, so all its Parts are kept in their proper place and order. All material things do naturally gravitate thereto, and unite themselves therewith, and so preserve its Bulk intire (4). And the fleeting Waters, the most unruly of all its Parts, do by this means keep their constant æquipoise in the Globe (5), and remain in *that place which*, the Psalmist saith, *God had founded for them, a bound he had*

(3) The Earth's Circumference being 24930 Miles, (according to *Book II. Chap. 2. Note 1*) if we divide that into 24 Hours, we shall find the Motion of the Earth to be nearly 1039 Miles in an Hour. Which, by the bye, is a far more reasonable and less rapid Rate, than that of the Sun would be, if we suppose the Earth to stand still, and the Sun to move round the Earth. For according the Proportions in Note 5, of the preceding Chapter, the Circumference of the *Magnus Orbis* is 748201929 *English* Miles, which divided by 24 Hours, gives 31175080 Miles in an Hour. But what is this to the Rapidity of the fixt Stars, if we suppose them, not the Earth, to move? Which is a good Argument for the Earth's Motion.

(4) *Nihil majus, quam quod ita stabilis est Mundus, atque ita coheret ad permanendum, ut nihil ne excogitari quidem possit aptius. Omnes enim partes ejus undique medium locum capeffentes, nituntur æqualitèr: maximè autem corpora inter se juncta permanent, cum quodam quasi vinculo circumdata colligantur: quod facit ea natura, quæ per omnem mundum omnia mente, & ratione consiciens, funditur, & ad medium rapit, & convertit extrema. Cicer. de Nat. Deor. l. 2.*

(5) *Eadem ratione Mare, cum supra terram sit, medium tamen terra locum expetens, conglobatur undique æqualitèr, neque redundat unquam, neque effunditur. Id paulo post.*

(6) That

had set, which they might not pass; that they turn not again to cover the Earth, Psal. 104. 8, 9. So, that even in a natural way, by virtue of this excellent Contrivance of the Creator, the observation of the Psalmist is perpetually fulfilled, Psal. 89. 9. *Thou rulest the raging of the Sea; when the Waves thereof arise, thou stillest them.*

To these, and an Hundred other uses of Gravity that I might have named, I shall only just mention another thing owing to it, and that is *Levity* (6), that whereby, what we call light Bodies, swim; a thing no less useful to the World than its opposite, Gravity, is in many respects, to divers Tribes of Animals, but particularly serviceable to the raising up of Vapours (7), and to their conveyance about the World.

And

(6) That there is no such thing as *positive Levity*, but that *Levity* is only a lesser Gravity, is abundantly manifested by the acute, *Seigr Alph. Borelli de Mot. Nat. a Grav. pend. cap. 4.* See also the Annotations of the learned and ingenious Dr. *Clark on Robaulti Phys. p. 1. c. 16. Not. 3.* Also the *Exper. of the Acad. del Cimento. p. 118, &c.* Dr. *Wallis's Disc. of Gravity and Gravitation before the Royal Society, Nov. 12. 1674. p. 28, &c.*

(7) I have before in *Note 1. Chap. 3.* shewn what *Vapours* are, and how they are raised. That which I shall here note is their Quantity. Concerning which the before-commended, Dr. *Halley* hath given us some curious Experiments in our *Phil. Transact.* which may be met with together in Mr. *Lowthorp's Abridg. Vol. II. pag. 108, and 126.* Mr. *Sedileau* also at *Paris* observed it for near three Years. By all their Observations it appears, that in the Winter Months the Evaporations are least, and greatest in Summer, and most of all in windy Weather. And by *Monsieur Sedileau's* Observations it appears, that what is raised in Vapours, exceeds that which falleth in Rain. In the Seven last Months of the Year 1688, the Evaporations amounted to 22 Inches 5 Lines; but the Rain only to 11 Inches 6 $\frac{1}{2}$ Lines: In 1689, the Evaporations were 32 Inches 10 $\frac{1}{2}$ Lines; but the Rain 18 Inches 1 Line: In 1690, the Evaporations 30 Inches 11 Lines; the Rain 21 Inches $\frac{1}{2}$ of a Line. *Vid. Mem. de Math. Phys. Ann. 1692. pag. 25.*

And now from this transient View of no other than the Out-works, than the bare Appendages of the Terraqueous Globe, we have so manifest a Sample of the Wisdom, Power, and Goodness of the infinite Creator, that it is easy to imagine the whole Fabrick is of a piece, the Work of at least a skillful Artist. A Man that should meet with a Palace (8), beset with pleasant Gardens, adorned with stately Avenues, furnished with well-contrived Aqueducts, Cascades, and all other Appendages, conducing to Convenience or Pleasure, would easily imagine, that proportionable Architecture, and Magnificence were within : But we should conclude the Man was out of his Wits, that should assert and plead that all was the Work of Chance, or other than of some wise and skilful Hand. And so when we survey the bare Out-works of this our Globe, when we see so vast a Body, accouter'd with so noble a Furniture of Air, Light, and Gravity ; with every thing, in short, that is necessary to the Preservation and Security of the Globe it self, or that conduceth to the Life, Health, and Happiness, to the Propagation, and Increase of all the prodigious variety of Creatures the Globe is stocked with ; when we see nothing wanting, nothing redundant, or frivolous, nothing botching, or ill-made, but that every thing, even

If it be demanded, what becomes of the overplus of Exhalations that descend not in Rain ? I answer ; They are partly tumbled down and spent by the Winds, and partly descend in Dews, which amount to a greater quantity than is commonly imagined. Dr. Halley found the descent of Vapours in Dews so prodigious at St. Helena, that he makes no doubt to attribute the origine of Fountains thereto. And I my self have seen large thick Clouds hanging without any Motion in the Air, in two or three Hours time melted down by Degrees, by the cold of the Evening, that not any the least remains have been of them left.

(8) See Book II. Chap. 3. Note 3.

(1) Lice

even in the very Appendages alone, do exactly answer all their Ends, and Occasions: What else can be concluded, but that all was made with manifest Design, and that all the whole Structure is the Work of some intelligent Being; some Artist, of Power and Skill equivalent to such a Work?

B O O K II.

*Of the Terraqueous Globe it self,
in general.*

IN the foregoing Book having dispatched the Out-works, let us take a Survey of the Principal Fabrick, viz. the *Terraqueous Globe* it self. A most stupendous Work in every particular of it, which doth no less aggrandize it's Maker (1), than every

(1) *Licet* — oculis quodammodo contemplari pulchritudinem earum rerum, quas divina providentia dicimus constitutas. Ac principio Terra universa cernatur, locata in mediâ mundi sede, solida, & globosa — vestita floribus, herbis, arboribus, frugibus. Quorum omnium incredibilis multitudo, insatiabili varietate distinguitur. Adde huc Fontium gelidas perennitates, liquores perlucidos Amnium, Riparum vestitus viridissimos, Speluncarum concavas altitudines, Saxorum asperitates, impendentium Montium altitudines, immensitatesque Camporum: adde etiam reconditas Auri — venas — Quæ vero, & quam varia genera Bestiarum? — Qui volucrum lapsus, atque cantus? Qui Pecudum pastus? — Quid de Hominum genere dicam? Qui quasi cultores terræ constituti, &c. — Quæ si, ut animis, sic oculis videre possemus, nemo cunctam intuens terram, de divinâ ratione dubitaret. Cicer. de Nat. Deor. l. 2.

every curious compleat Work doth its Workman. Let us cast our Eyes here and there, let us ransack all the Globe, let us with the greatest accuracy inspect every Part thereof, search out the inmost Secrets of any of the Creatures; let us examine them with all our Gauges, measure them with our nicest Rules, pry into them with our Microscopes, and most exquisite Instruments (||), still we find them to bear testimony to their infinite Workman; and that they exceed all humane Skill so far, as that the most exquisite Copies and Imitations of the best Artists, are no other than rude bungling Pieces to them. And so far are we from being able to espy any defect or fault in them, that the better we know them, the more we admire them; and the farther we see into them, the more exquisite we see them to be.

And for a Demonstration of this; I shall,

I. Take a general Prospect of the Terraqueous Globe.

II. Survey it's Particulars.

I. The things which will fall under a general Prospect of the Globe, will be its *Figure, Bulk, Motion, Place, Distribution* into Earth and Waters, and the great *Variety* of all things upon it, and in it.

C H A P.

(||) I cannot here omit the Observations that have been made in these later Times, since we have had the Use and Improvement of the Microscope, concerning the great difference, which by the help of that, doth appear betwixt Natural and Artificial Things. Whatever is Natural, doth by that appear adorned with all imaginable Elegance and Beauty ——— Whereas the most curious Works of Art, the sharpest finest Needle, doth appear as a blunt rough Bar of Iron, coming from the Furnace or the Forge. The most accurate Engravings or Embosments seem such rude, bungling, deformed Works, as if they had been done with a Mattock, or a Trowel. So vast a difference is there betwixt the Skill of Nature, and the Rudeness and Imperfection of Art. Bp. Wilk. Nat. Rel. L. 1. Ch. 6.

(1) Although

C H A P. I.

Of the Figure of the Terraqueous Globe.

THIS I suppose I may take for granted to be spherical, or nearly so (1). And this must be allowed to be the most commodious, apt Figure for a World on many Accounts; as it is most capacious, as it's Surface is equi-distant from the Center, not

(1) Although the Terraqueous Globe be of an orbicular Figure, yet it is not strictly so, 1. On account of its Hills and Vallies. But these are so inconsiderable to the Earth's Semi-diameter, that they are but as the Dust upon a common Globe. But, 2. Our modern Astronomers assign a much greater Variation from a globous Form, namely, that of a prolate Sphaeroid, making the Polar about 34 Miles shorter than the Equatorial Diameter. The cause of which they make to be the centrifugal Force of the diurnal Rotation of the Globe.

This Figure they imagine is in *Jupiter*, his Polar being to his Equatorial Diameter, as $39\frac{1}{2}$ to $40\frac{1}{2}$. But whether it be so or no, I confess I could never perceive, although I have often viewed that Planet through very good, and long Glasses, particularly a tolerable good one of 72 Feet in my Hands: And although by reason of cloudy Weather, and (at present) *Jupiter's* proximity to the Sun, I have not yet been able to view that Planet; yet *Saturn*, (so far as his Ring would permit.) and *Mars* appear perfectly round through Mr. *Huygens's* long Glas of 126 Feet, which by Will he bequeathed, with its whole Apparatus, to our R. S. by whose Favour it is now in my Hands. And moreover, I believe it difficult, next to impossible, to measure the two Diameters to a 40th Part, by reason of the smallness of $\frac{1}{4}$ apparent Diameter, and by reason he is moving all the time of measuring him.

As to what is alledged from lengthening the Pendulums of Clocks, to make them keep the same time under the Equator, as they do in our Climes; I have shewn from the like Variations in the Air-pump, that this may arise from the rarity of the Air there, more than here. *V. Phil. Transf. N. 294.* But if the Degrees of a Meridian grow larger, the more we go towards

not only of the Globe, but (at least nearly) of Gravity and Motion too, and as some have thought, of the central Heat and Waters. But these, and divers other things I shall pass over, and insist only upon two or three other Benefits of this globous Figure of the Earth and Waters.

1. This Figure is the most commodious in regard of Light and Heat. For, by this means, those two great Benefits are uniformly and equally imparted to the World: They come harmoniously and gradually on, and as gradually go off again. So that the daily and yearly Returns of Light and Darknes, Cold and Heat, Moist and Dry, are Regular and Workman-like, (we may say,) which they would not be, if the Mass of Earth and Waters were (as some fancied (2) it) a large Plain; or as others, like

the Line, (as Mr. Castini affirms they do, by an 800th Part in every Degree, in *Phil. Trans.* N. 278.) then there is great reason to conclude in behalf of this Sphæroidal Form.

The natural Cause of this Sphericity of our Globe is (according to Sir Isaac Newton's Principles) that *Attraction*, which the infinite Creator hath stamp'd on all the Matter of the Universe, whereby all Bodies, and all the parts of Bodies mutually attract themselves and one another. By which means, as all the parts of Bodies tend naturally to their Center, so they all betake themselves to a globous Figure, unless some other more prevalent Cause interpose. Thus drops of Quick-silver put on a spherical Form, the parts thereof strongly attracting one another. So drops of Water have the same Form, when falling in the Air; but are Hemispherical only when they lie on an hard Body, by reason their Gravity doth so far over power their self attracting Power, as to take off one half of their Sphericity. This Figure is commonly attributed to the pressure of the circumambient Air: But that that can't be the cause, is manifest from the Air-pump; the case being the very same in an exhausted Receiver, as in the open Air, and not any the least Alteration of the Figure that I could perceive, in all the Trials that I have made.

(2) It would be frivolous, as well as endless, to reckon up the various Opinions of the Ancients about the Figure of the Ter-
raqueous

like a large Hill in the midst of the Ocean; or of a multangular Figure; or such like.

2. This Figure is admirably adapted to the commodious and equal Distribution of the Waters in the Globe. For since, by the Laws of Gravity, the Waters will possess the lowest place; therefore, if the Mass of Earth was cubick, prismatick, or any other angular Figure, it would follow that one (too vast a part) would be drowned; and another be too dry. But being thus orbicular, the Waters are equally and commodiously distributed here and there, according as the Divine Providence saw most fit; of which I shall take notice by and by.

3. The orbicular Figure of our Globe, is far the most beneficial to the Winds, and Motions of the Atmosphere. It is not to be doubted, if the Earth was of some other, or indeed any other Figure, but that the Currents of Air would be much retarded, if not wholly stopped. We find by Experience what influence large and high Mountains, Bays, Capes, and Head-lands have upon the Winds; how they stop some, retard many, and divert and change (near the Shores) even the *General and constant*

raqueous Globe; some of them may be seen in *Varen. Geogr. l. 1. c. 3. init.* or *Jonston's Thaumatochr. c. 1. Artic. 3* But among the variety of Opinions, one of the principal was, that the visible Horizon was the bounds of the Earth, and the Ocean the bounds of the Horizon, that the Heavens and Earth above this Ocean, was the whole visible Universe; and that all beneath the Ocean was *Hades*, or the *invisible World*. Hence, when the Sun set, he was said *tingere se Oceano*; and when any went to *Hades*, they must first pass the Ocean. Of this Opinion were not only the ancient Poets, and others among the Heathens, but some of the Christian Fathers too, particularly *Lactantius*, *St. Augustine*, and others, who thought their Opinion favoured by the Psalmist, in *Psal. 24. 2* and *136. 6*. See *Bp. Usher's Ans. to a Jes. Chall. p. 336, &c.*

stant Winds (3) that blow round the Globe in the Torrid Zone. And therefore, since this is the effect of such little Excrescences, which have but little proportion to our Globe; what would be the consequences of much vaster Angles, which would equal a Quarter, Tenth, or but an Hundredth Part of the Globe's Radius? Certainly these must be such a Barricade, as would greatly annoy, or rather absolutely stop the Currents of the Atmosphere, and thereby deprive the World of those salutiferous Gales, that I have said keep it sweet and clean.

Thus the Figure of our Globe doth manifest it to be a Work of contrivance, inasmuch as it is of the most commodious Figure; and all others would be liable to great and evident Inconveniences.

C H A P.

(3) Neither do these constant Trade-winds, usually blow near the Shore, but only in the Ocean, at least 30 or 40 Leagues off at Sea, clear from any Land; especially on the West Coast, or Side of any Continent: For indeed on the East side, the Easterly Wind being the true Trade-wind, blows almost home to the Shore; so near, as to receive a check from the Land-wind. Dampier's Winds. Ch. 1.

And not only the general Trade-winds, but also the constant coasting Trade-winds are in like manner affected by the Lands. Thus, for instance, on the Coast of Angola and Peru. But this, saith the curious Captain Dampier, the Reader must take notice of, That the Trade-winds that blow on any Coast, except the North Coast of Africa, whether they are constant, and blow all the Year, or whether they are shifting Winds, do never blow right in on the Shore, nor right along Shore, but go slanting, making an acute Angle of about 22 Degrees. Therefore, as the Land trends more East or West, from the North or South on these Coasts; so the Winds do alter accordingly. Ibid. Ch. 2.

C H A P. II.

Of the Bulk of the Terraqueous Globe.

THE next thing remarkable in the Terraqueous Globe, is the prodigious Bulk thereof (†): A Mass of above 260 Thousand Millions of Miles solid Content. A Work too grand for any thing less than a God to make. To which in the next place we may add,

C H A P. III.

The Motions of the Terraqueous Globe.

THE Motions the Terraqueous Globe hath, are round its own Axis, and round its Fountain of Light and Heat, the Sun (1). That so vast a body as the Earth and Waters should be moved at all,

(†) It is not difficult to make a pretty near Computation of the Bulk of the Terraqueous Globe, from those accurate Observations of a Degree, made by Mr. Norwood in England, and Mr. Picart, and others in France: Both whose Measures surprisingly agree, within about a quarter of a Mile. By the French Measure, the Diameter of our Globe appears to be 6538594 Parisian Toises, which are 41899310,352 English Feet, or 7935,475 English Miles. Its Ambit therefore is 24930 Miles, and (supposing it Spherical) its Surface is 197831392 Miles: Which multiplied into $\frac{1}{3}$ of its Semi-diameter, gives its solid Content, viz. 261631995920 Miles.

(1) With the Copernicans, I take it here for granted, that the Diurnal and Annual Revolutions are the Motions of the Terraqueous Globe, not of the Sun, &c. but the Proof thereof I shall reserve for my Survey of the Heavens. See Book I. Ch. 5. Note 3.

(2) Every

all (2), that it should undergo two such different Motions, as the Diurnal and Annual are, and that these Motions should be so constantly and regularly (3) performed for near 6000 Years, without any the least Alteration ever heard of (except some Hours which we read of in *Josb.* 10. 12, 13. and in *Hezekiah's* time, which, if they cannot be accounted for some other way, do greatly increase the

(2) Every thing that is moved, must of necessity be moved by something else ; and that thing is moved by something that is moved either by another thing, or not by another thing. If it be moved by that which is moved by another, we must of necessity come to some prime Mover, that is not moved by another. For it is impossible, that what moveth, and is moved by another, should proceed in infinitum. *Aristot. Phys. l. 8. c. 5.*

Solum quod seipsum movet, quia nunquam deseritur a se, nunquam ne moveri quidem desinit, quin etiam ceteris quæ moventur, hic fons ; hoc principium est movendi, Principii autem nulla origo : nam ex principio oriuntur omnia ; ipsum autem nulla ex re alia nasci potest : nec enim esset id principium, quod gigneretur aliunde. Cicer. Tusc. Quæst. L. 1.

Cogitemus quæ fieri possit, ut tanta magnitudo, ab aliqua possit natura, tanto tempore circumferri ? Ego igitur assero Deum causam esse, nec aliter posse fieri. *Plato in Epinom.*

(3) Among the Causes which *Cleanthes* is said in *Tully*, to assign for Mens Belief of a Deity, one of the chief is *Æquabilitatem motus, conversionem Cæli, Solis, Lunæ, Siderumque omnium distinctionem, varietatem, pulchritudinem, ordinem* : quarum rerum aspectus ipse satis indicaret, non esse fortuita. Ut si quis in domum aliquam, aut in gymnasium, aut in forum venerit ; cum videat omnium rerum rationem, modum, disciplinam, non possit ea sine causâ fieri judicare, sed esse aliquem intelligat, qui præsit, & cui pareatur : multo magis in tantis motibus, tantisque vicissitudinibus, tam multarum rerum, atque tantarum ordinibus, in quibus nihil unquam immensa, & infinita vetustas mentita sit, statuatur necesse est ab aliquâ mente tantos naturæ motus gubernari. *Cic. de Nat. Deor. L. 2.*

Homines ceperunt Deum agnoscere, cum viderent Stellas, tantam concinnitatem efficere ; ac dies, noctesque æstate, & hyeme, suos servare statos ortus, atque obitos. Plutarch de Placit. l. 1. c. 6.

the wonder (4); these things, I say,) do manifestly argue some divine infinite Power to be concerned therein (5): But especially, if to all this we add the wonderful Convenience, yea absolute Necessity of these Circumvolutions to the Inhabitants, yea all the Products of the Earth and Waters. For to one of these we owe the comfortable Changes of Day and Night; the one for Business, the other for Repose; (6) the one for Man, and most other Animals

(4) We need not be solicitous to elude the History of these Miracles, as if they were only poetical Strains, as *Maimonides*, and some others fancy *Joshua's* Day to have been, viz. only an ordinary Summer's Day; but such as had the work of many Days done in it, and therefore by a poetical Stretch made, as if the Day had been lengthened by the Sun standing still. But in the History they are seriously related, as real Matters of Fact, and with such Circumstances as manifest them to have been miraculous Works of the Almighty: And the Prophet *Habakkuk*, 3. 11. mentions that of *Joshua* as such. And therefore taking them to be miraculous Perversions of the Course of Nature, instead of being Objections, they are great Arguments of the Power of God. For in *Hezekiah's* Case, to wheel the Earth it self backward, or by some extraordinary Retractions to bring the Sun's shadow backward 10 Degrees: Or in *Joshua's* Case, to stop the diurnal Course of the Globe for some Hours, and then again give it the same Motion; to do, I say, these things, required the same infinite Power which at first gave the Terraqueous Globe its Motions.

(5) *Nam cum dispositi quassissem fœdera Mundi,
Præscriptosque Maris fines, Annique meatus,
Et Lucis, Noctisque vices: tunc omnia rebar
Consilio firmata Dei, qui lege moveri
Sidera, qui fruges diverso tempore nasci,
Qui variam Phœben alieno jussit igne
Compleri, Solemque suo: porrexerit undis
Lititora: Tellurem medio libraverit axe.*

Claudian in Rufin. L. 1. initio.

(6) *Diei noctisque vicissitudo conservat animantes, tribuens aliud agendi tempus, aliud quiescendi. Sic undique omni ratione concluditur, mente, consilioque divino omnia in hoc mundo ad salutem omnium, conservationemque admirabiliter administrari. Cicer. de Nat. Deor. L. 2.*

(7) The

imals to gather and provide Food, Habitation, and other Necessaries of Life; the other to rest, refresh, and recruit their Spirits (7), wasted with the Labours of the Day. To the other of those Motions we owe the Seasons of Summer and Winter, Spring and Autumn, together with the beneficial Influences and Effects which these have on the Bodies and State of Animals, Vegetables, and all other things both in the Torrid, Temperate, and Frigid Zones.

C H A P. IV.

Of the Place and Situation of the Terraqueous Globe, in respect of the Heavenly Bodies.

A Nother thing very considerable in our Globe, is its Place and Situation at a due distance from the Sun (†), its Fountain of Light and Heat, and

(7) The acute Dr. Cheyne in his ingenious *Philos. Princ. of Natural Religion*, among other uses of Day and Night saith, the Night is most proper for Sleep; because when the Sun is above the Horizon, Sleep is prejudicial, by reason the Perspirations are then too great. Also that Nutrition is mostly, if not altogether, performed in time of Rest; the Blood having too quick a Motion in the Day: For which Reason, weak Persons, Children, &c. are nourished most, and recruit best by Sleep.

(†) It is a manifest Sign of the Creator's Management and Care, in placing the Terraqueous Globe at that very Distance it is from the Sun, and contemperating our own Bodies, and all other things so duly to that Distance. For was the Earth farther from the Sun, the World would be starved, and frozen with Cold: And was it nigher, we should be burnt, at least the most combustible things would be so, and the World would be vexed with perpetual Conflagrations. For we see that a few of the Rays of the Sun, even no more than what fall within the compass of half an Inch, or an Inch in a Burning Glass, will fire combustible Bodies, even in our own Climate.

(1) The

and from its neighbouring Planets of the solar System, and from the fixt Stars. But these things I have spoken more largely of in my Survey of the Heavens, and therefore only barely mention them now, to insist more largely upon

CHAP. V.

The Distribution of the Earth and Waters.

THE Distribution of the Waters and the dry Land, although it may seem rude and undesign'd to a careless View, and is by some taxed as such (1), yet is admirably well adjusted to the Uses and Conveniences of our World.

For

(1) The most eminent Author I have met with, that finds fault with the Distribution of the Earth and Waters, and indeed with the whole present Structure of the Globe, is the learned and eloquent Theorist, Dr. Burnet, who frequently exclaims on this Point. *Tellus nostra, si totam simul complectamur, non est ordinata & venusta rerum compages — sed moles aggesta vario, incertoque situ partium, nullâ ordinis aut venustatis habitâ ratione.* Theor. Sacr. l. 1. c. 7. *Ecquis autem a Deo hæc ita facta? &c. ib. Quo autem Herculeo labore opus esset ad excavandam terram in tantum hiatum? — Si immediate a causâ primâ effectus fuisset hic alveus, aliquem saltem ordinem, mensuram, & proportionem notare licuisset in ipsius formâ, & partium dispositione; — sed confusa omnia, &c. ib. c. 8. Tellus nostra cum exigua sit, est etiam rudis: Et in illâ exiguitate multa sunt superflua, multa inelegantia. Dimidiam terræ superficiem inundat Oceanus; magnâ ex parte, ut mihi videtur, inutilis.* And then he goes on to shew how this Part of the Creation might be mended. *ib. c. 10.* All this is to me surprizing from an Author of great Ingenuity, who seems in his Book to have a just Opinion of, and due Veneration for God. But certainly such Notions are very inconsistent with the belief of God's creating, especially his governing and ordering the World. But suppose, the Terraqueous Globe was such a rude, confused, inconvenient Mass, as he pretends; yet

For in the first place, the Distribution is so well made, the Earth and Waters so handsomly, so Workman-like laid, every where all the World over, that there is a just æquipoise of the whole Globe. The *Northern* balanceth the *Southern Ocean*; the *Atlantick* the *Pacifick Sea*. The *American dry Land*, is a Counterpoise to the *European, Asiatick* and *African*.

In the next place, the Earth and the Waters are so admirably well placed about in the Globe, as to be helpful to one another, to minister to one another's Uses. The great Oceans, and the lesser Seas, and Lakes, are so admirably well distributed throughout the Globe, as to afford sufficient Vapours (2) for
Clouds

is it well enough for a sinful World. But besides, what others have long ago abundantly answered; the following Survey will, I hope, sufficiently manifest it to be the Work of a wise and beneficent, as well as omnipotent Creator.

(2) I took notice before in *Book I. Chap. 3. Note 1.* That the Vapours constituting Clouds and Rain, are *Vesiculæ* of Water detached by Heat. The manner of which I conceive to be thus; Heat being of an agile Nature, or the lightest of all Bodies, easily breaks loose from them; and if they are humid, in its Passage, carries along with it Particles, or little Cases of the Water: which being lighter than Air, are buoyed up thereby, and swim in it; until by knocking against one another, or being thickened by the Cold, (as in the Note before-cited,) they are reduced into Clouds, and Drops. Having mentioned the manner how Vapours are raised, and there being more room here than in the Note before-cited, I shall, for the Illustration of Nature's Process, take notice of three Things observable to our purpose, in Water over the Fire. 1. That the Evaporations are proportional to the Heat ascending out of the Water. A small Heat throws off but few Vapours, scarce visible: A greater Heat, and ascending in greater Quantities, carries off grosser, larger, and more numerous *Vesiculæ*, which we call a *Steam*: And if the Heat breaks through the Water with such fury, as to lacerate, and lift up great quantities or bubbles of Water, too heavy for the Air to carry or buoy up, it causeth what we call *Boyling*. And the Particles of Water thus mounted up by the
Heat,

Clouds and Rains, to temperate the Cold (3) of the Northern frozen Air, to cool and mitigate the Heats

Heat, are visibly Sphærules of Water, if viewed with a Microscope, as they swim about in a Ray of the Sun let into a dark Room, with warm Water underneath; where some of the Vapours appear large, some smaller Sphærules, according (no doubt) to the larger or lesser Quantities of Heat blowing them up, and carrying them off. 2. If these Vapours be intercepted in their ascent by any Context, especially cold Body, as Glass, Marble, &c. they are thereby reduced into Drops, and Masses of Water, like those of Rain, &c. 3. These Vapours in their ascent from the Water, may be observed in cold, frosty Weather, either to rise but a little above the Water, and there to hang, or to glide on a little above its Surface: or if the Weather be very Cold, after a little ascent, they may be seen to fall back again into the Water; in their ascent and descent describing a curve somewhat like that of an Arrow from a Bow. But in a warmer Air, and Still, the Vapours ascend more nimbly and copiously, mounting up aloft, till they are out of sight. But if the Air be warm and windy too, the Vapours are sooner carried out of sight, and make way for others. And accordingly I have often observed, that hot Liquors, if not set too thin, and not frequently stirred, cool slower in the greatest Frosts, than in temperate Weather, especially if Windy. And it is manifest by good Experiments, that the Evaporations are less at those times, than these: less by far in the Winter, than the warmer Months.

(3) As our Northern Islands are observed to be more temperate than our Continents, (of which we had a notable Instance in the great Frost, in 1708. which *Ireland* and *Scotland* felt less of, than most parts of *Europe* besides; of which see *Book IV. Chap. 12. Note 3.*) so this Temperature is owing to the warm Vapours afforded chiefly by the Sea: which, by the preceding Note, must necessarily be warm, as they are Vapours, or Water inflated by Heat.

The cause of this Heat, I take to be partly that of the Sun, and partly Subterraneous. That it is not wholly that of the Sun, is manifest from Vapours, being as, or more, copiously raised when the Sun-beams are weakest, as when strongest; there being greater Rains and Winds at the one time than the other. And that there is such a thing as *Subterraneous Heat*, (whether Central, or from the meeting of mineral Juices; or congenial, or connatural to our Globe, I have not time to enquire, but, I

Heats (4) of the torrid Zone, and to refresh the Earth with fertile Showers, yea in some measure to minister fresh Waters to the Fountains and Rivers. Nay, so abundant is this great Blessing, which the most indulgent Creator hath afforded us by means of this distribution of the Waters I am speaking of, that there is more than a scanty, bare provision, a mere sufficiency; even a plenty, a surplussage of this useful Creature of God, the fresh Waters afforded to the World; and they so well ordered, as not to drown the Nations of the Earth, nor to stagnate, stink, and poison, or annoy them; but to be gently carried through convenient Channels back again to their grand Fountain (5) the Sea; and many of them

say, that such a thing is,) is evident not only from the Hot Baths, many fiery Eruptions and Explosions, &c. but also from the ordinary warmth of Cellars, and Places under Ground, which are not barely comparatively warm, but of sufficient Heat to raise Vapours also: As is manifest from the smoking of perennial Fountains in frosty Weather, and Water drawn out of Pumps and open Wells. Yea even Animals themselves are sensible of it, as particularly Moles, who dig before a Thaw, and against some other Alterations of the Weather; excited, no doubt, thereunto by the same warm Vapours arising in the Earth, which animate them, as well as produce the succeeding Changes of the Weather.

(4) Besides the Trade-Winds, which serve to mitigate the excessive Heats in the torrid Zone; the Clouds are a good Screen against the scorching Sun-beams, especially when the Sun passeth their Zenith; at which time is their Winter, or coolest Season, by reason they have then most Clouds and Rain. For which service, that which Varenæ takes notice of, is a great Providence of God, viz. *Pleraque loca Zone Torridæ vicinum habent mare, ut India, Insulæ Indiæ, lingua Africa, Guinea, Brasilia, Peruvia, Mexicana Hispania: Pauca loca Zone Torridæ sunt Mediterraneæ.* Varenii Geograph. L. 2. C. 26 Prop. 10. §. 7.

(5) That Springs have their Origine from the Sea, and not from Rains and Vapours, among many other strong Reasons, I conclude from the perennity of divers Springs; which always afford the same quantity of Water. Of this sort there are many

them through such large Tracts of Land, and to such prodigious Distances, that it is a great wonder the

to be found every where. But I shall, for an Instance, single out one in the Parish of *Upminster*, where I live, as being very proper for my purpose, and one that I have had better opportunities of making Remarks upon above twenty Years. This in the greatest Droughts is little, if at all diminished, that I could perceive by my Eye, although the Ponds all over the Country, and an adjoining Brook have been dry for many Months together; as particularly in the dry Summer Months of the Year 1705. And in the wettest Seasons, such as the Summer and other Months were preceding the violent Storm in *November*, 1703. (*Vid. Philos. Trans. Nr. 289.*) I say in such wet Seasons I have not observed any Increment of its Stream, excepting only for violent Rains falling therein, or running down from the higher Lands into it; which discoloureth the Waters oftentimes, and makes an increase of only a Day's, or sometimes but a few Hours continuance. But now, if this Spring had its Origine from Rain and Vapours, there would be an increase and decrease of the one, as there should happen to be of the other: As actually it is in such temporary Springs, as have undoubtedly their Source from Rain and Vapours.

But besides this, another considerable thing in this *Upminster* Spring (and Thousands of others) is, that it breaks out of so inconsiderable an Hillock, or Eminence of Ground, that can have no more influence in the Condensation of the Vapours, or stopping the Clouds, (which the Maintainers of this Hypothesis suppose,) than the lower Lands about it have. By some critical Observations I made with a very nice portable Barometer, my House stands between 80 and 90 Feet higher than the Low-water Mark in the River of *Thames*, nearest me, and that part of the River being scarce thirty Miles from the Sea; I guess, (and am more confirmed from some later Experiments,) that we cannot be much above 100 Feet above the Sea. The Spring I judge nearly level with, or but little higher than where my House stands; and the Lands from whence it immediately issues, I guess about 15 or 20 Feet higher than the Spring; and the Lands above that, of no very remarkable Height. And indeed, by actual Measure, one of the highest Hills I have met with in *Essex*, is but 363 Feet high, (*Vid. Phil. Trans. Nr. 313. p. 16.*) and I guess by some very late Experiments I made, neither that, nor any other Land in *Essex*, to be above 400 Feet above the Sea. Now what is so inconsiderable a rise of Land, to a peren-

the Fountains should be high enough (6), or the Seas low enough. ever to afford so long a Conveyance. Witness the *Danube* (7) and *Volga* of Europe, the *Nile* (8) and

nial Condensation of Vapours, fit to maintain even so inconsiderable a Fountain, as what I have mentioned is? Or indeed the High-lands of the whole large County of *Essex*, to the maintaining all its Fountains and Rivulets?

But I shall no farther prosecute this Argument, but refer to the late learned, curious, and industrious Dr. *Plot's Tentamen Phil. de Orig. Font.* in which he hath fully discussed this Matter.

As to the manner how the Waters are raised up into the Mountains, and higher Lands, an easy and natural Representation may be made of it, by putting a little heap of Sand, Ashes, or a little Loaf of Bread, &c. in a bason of Water; where the Sand will represent the dry Land, or an Island, and the Bason of Water the Sea about it. And as the Water in the Bason riseth to, or near to the top of the Heap in it, so doth the Waters of the Sea, Lakes, &c. rise in the Hills. Which case I take to be the same with the ascent of Liquids in capillary Tubes, or between contiguous Planes, or in a Tube filled with Ashes: Of which the industrious and compleat Artificer in Air-pumps Mr. *Hawksbee*, hath given us some not contemptible Experiments, in his *Phys. Mech. Exp.* pag. 139, &c.

Among the many Causes assigned for this Ascent of Liquors, there are two that bid the fairest for it, viz. the Pressure of the Atmosphere, and the Newtonian Attraction. That it is not the former appears from the Experiments succeeding as well, or better in *Vacuo*, than in the open Air, the Ascent being rather swifter in *Vacuo*. This then being not the Cause, I shall suppose the other is; but for the Proof thereof, I shall refer to some of our late English Authors, especially some very late Experiments made before our most famous R. S. which will be so well improved by some of that illustrious Body, as to go near to put the Matter out of doubt.

(6) See Book III. Chap. 4.

(7) The *Danube* in a sober account performs a Course of above 1500 Miles, (i. e. in a straight Line,) from it's rise to it's fall. *Bohun's Geogr. Dict.*

(8) *Tractus s. Longitudo [Nili] est milliarius circiter 6300 Germ. sive Ital. 2520, pro quibus ponere licet 3000 propter curvaturas.* *Varen. Geogr. l. 1. c. 16. p. 27.*

(9) *Varen.*

and the *Niger* (9) of *Africk*, the *Ganges* (10) and *Euphrates* of *Asia*, and the *Amazons River* (11) and *Rio de la Plata* of *America*, and many others which might be named; some of which are said to run above 5000 Miles, and some no less than 6000 from their Fountains to the Sea. And indeed such prodigious Conveyances of the Waters make it manifest, that no accidental Currents and Atterrations of the Waters themselves, no art, or power of Man, nothing less than the Fiat of the Almighty could ever have made or found so long and commodious Declivities and Channels for the passage of the Waters.

C H A P. VI.

The great Variety and Quantity of all things upon, and in the Terraqueous Globe, provided for the Uses of the World.

THE last Remark I shall make about the Terraqueous Globe in general is, the great variety of Kinds, or Tribes, as well as prodigious Number of Individuals of each various Tribe there is of all Creatures.

(9) *Varene* reckons the Course of the *Niger*, at a middle Computation, 600 German Miles, that is 2400 *Italian*.

(10) That of the *Ganges*, he computes at 300 German Miles. But if we add the Curvatures to these Rivers, their Channels are of a prodigious Length.

(11) *Oritur flumen (quod plerumque Amazonum, &c.) haud procul Quito in montibus—Cum per Leucas Hispanicas 1356 cursum ab occidente in orientem continuerit, ostio 84 leucas lato—in Oceanum præcipitatur.* Chr. D' Acugna Relatio de fluamine Amaz. in Act. Erud. Aug. 1683.

Creatures (1). There are so many Beasts, so many Birds, so many Insects, so many Reptiles, so many Trees, so many Plants upon the Land; so many Fishes, Sea-Plants, and other Creatures in the Waters; so many Minerals, Metals, and Fossiles in the Subterraneous Regions; so many *Species* of these *Genera*, so many *Individuals* of those *Species*, that there is nothing wanting to the Use of Man, or any other Creature of this lower World. If every Age doth change its Food, its way of Cloathing, its way of Building; if every Age (2) hath its variety of Diseases; nay, if Men, or any other Animal was minded to change these things every Day, still the Creation would not be exhausted, still nothing would be wanting for Food, nothing for Physick, nothing for Building and Habitation, nothing for

(1) *Non dat Deus beneficia? Unde ergo ista quæ possides? — Unde hæc innumerabilia, oculos, aures & animum mulcentia? Unde illa luxuriam quoque instruens copia? Neque enim necessitatibus tantummodo nostris provisum est: usque in delicias amamur. Tot arbusta, non uno modo frugifera, tot herbæ salutare, tot varietates ciborum, per totum annum digestæ, ut inertibus quoque fortuita terræ alimenta præberent. Jam animalia omnis generis, alia in sicco, &c. — ut omnis rerum naturæ pars tributum aliquod nobis conferret. Senec. de Benef. l. 4. c. 5. ubi plura vide.*

Hic, ubi habitamus non intermittit suo tempore Cælum nitescere, arbores frondescere — tum multitudinem pecudum partim ad vescendum, partim ad cultus agrorum, partim ad vehendum, partim ad corpora vestienda: hominemque ipsum quasi contemplatorem cæli ac deorum, ipsorumque cultorem. — Hæc igitur, & alia innumerabilia cum cernimus, possumusne dubitare, quin his præsit aliquis ve, effector, si hæc nata sunt, ut Platoni videtur: vel, si semper fuerint, ut Aristoteli placet, Moderator tanti operis & muneris? Cicer. Tusc. Quæst. L. I.

(2) *Sunt & gentium differentie non mediocres — quæ contemplatio aufert rursus nos ad ipsorum animalium naturas ingenitasque iis vel certiores morborum omnium medicinas. Enimvero rerum omnium Parens, nullum animal ad hoc tantum ut pasceret, aut alia satiare nasci voluit: artesque salutare iis inseruit. Plin. N. H. l. 27. c. 13.*

(3) This

for Cleanliness and Refreshment, yea even for Recreation and Pleasure. But the Munificence of the Creator is such, that there is abundantly enough to supply the wants, the conveniences, yea almost the extravagancies of all the Creatures, in all Places, all Ages, and upon all Occasions.

And this may serve to answer an Objection against the Excellency of, and Wisdom shewed in the Creation; namely, What need of so many Creatures (3), particularly of so many Insects, so many Plants, and so many other things; and especially of some of them, that are so far from being useful, that they are very noxious; some by their Ferity, and others by their poisonous Nature? &c.

To which I might answer, that in greater Variety, the greater Art is seen; that the fierce, poisonous, and noxious Creatures serve as Rods and Scourges

(3) This was no very easy Question to be answered by such, as held, that *all things were made for Man*, as most of the Ancients did; as *Aristotle, Seneca, Cicero and Pliny*, (to name only some of the chief.) And *Cicero* cites it as the celebrated *Chrysippus's* Opinion, *Præclarè enim Chrysippus, Cætera nata esse Hominum causâ, & Deorum.* De fin. bon. & mal. L. 3. And in his *De Nat. Deor.* L. 2. fin. he seriously proves the World it self to have been made for the Gods and Man, and all things in the World to have been made and contrived for the benefit of Man, (*parata & inventa ad fructum Hominum*, are his Words.) So *Pliny* in his Preface to his 7th Book saith, Nature made all things for Man; but then he makes a doubt, whether she shewed herself a more indulgent Parent, or cruel Step-Mother, as in *Book IV. Chap. 12. Note 2.* But since the Works of God have been more discovered, and the Limits of the Universe have been found to be of infinitely greater Extent than the Ancients supposed them; this narrow Opinion hath been exploded. And the Answer is easy to these Questions, Why so many useless Creatures? In the Heavens, why so many fixt Stars, and the greatest part of them scarce visible? Why such Systems of Planets, as in *Jupiter, Saturn, &c.* In the Earth and Waters, why so many Creatures of no use to Man?

Scourges to chastise us (4), as means to excite our Wisdom, Care, and Industry, with more to the same purpose. But these things have been sufficiently

(4) *Nec minus clara exitii documenta sunt etiam ex contemnendis animalibus. M. Varro auctor est, a cuniculis suffossam in Hispaniâ oppidum, a talpis in Thessaliâ: ab ranis civitatem in Galliâ pulsam, ab locustis in Africâ: ex Gyaro, Cycladum insulâ, incolas a muribus fugatos; in Italiâ Amy myclas a serpentibus deletas. Citra Cynamolgos Æthiopas latè deserta regio est, a scorpionibus & felpugis gente sublata: & a scolopendris abactos Trierienses, auctor est Theophrastus. Plin. Nat. Hist. l. 8. c. 29.*

To these Instances may be added, the Plague they sometimes suffer from a kind of Mice, (they call *Leming*, *Leminger*, *Lemmus*, &c.) in Norway, which eat up every green thing. They come in such prodigious Numbers, that they fancy them to fall from the Clouds; but *Ol-Magnus*, rather thinks they come from some of the Islands. *Hist. l. 8. c. 20.* If the Reader hath a mind to see a large Account of them, with a dispute about their Generation, a handsom Cut of them, with the Prayers, and an Exorcism against them used in the Church of Rome, I shall refer him (it being too tedious to recite in these Notes) to *Museum Wormian. l. 3. c. 23.*

Quare patimur multa mala a creaturâ quam fecit Deus, nisi quia offendimus Deum? — De pœnâ tuâ peccatum tuum accusas, non judicem. Nam propter Superbiam instituit Deus creaturam istam minimam & abjectissimam, ut ipsa nos torqueret, ut cum superbus fuerit homo, & se jactaverit adversus Deum, — cum se erexerit, Pulicibus subdatur. Quid est, quod te inflas humana subergia? — Pulicibus resiste, ut dormias. Cognosce qui sis. Nam propter Superbiam nostram domandam — creata illa quæ molesta sunt: populum Pharaonis superbum potuit Deus domare de Ursis, de, &c. Muscas & Ranas illis immisit, ut rebus vilissimis subergia domaretur. Omnia ergo per ipsum — facta sunt; & sine ipso factum est nihil. August. Tract. 1. in S. Johan.

But although the infinitely wise Creator hath put it in the power of such vile Animals to chastise us, yet hath he shewed no less Wisdom and Kindness in ordering many, if not most of them so, as that it shall be in the power of Man, and other Creatures to obviate or escape their Evils. For, besides the noble Antidotes afforded by Minerals, Vegetables, &c. many, if not most of our European venomous Animals carry their Cure, as well as Poison in their own Bodies. The Oil, and I doubt not, the Bo-

ently urged by others; and it is sufficient to say, that this great Variety is a most wise Provision for all the Uses of the World in all Ages, and all Places. Some for Food, some for Physick (5), some for Habitation, some for Utensils, some for Tools and Instruments of Work, and some for Recreation and Pleasure,

dy of *Scorpions* too, is a certain Remedy against its Stroke. A *Bee*, *Wasp*, or *Hornet* crushed, and rubbed, or bound upon the place, I have always found to be a certain Cure for the sting of those Creatures. And I question not, but the *Flesh*, especially the Head of *Vipers*, would be found a Remedy for their Bites.

Our *Viper-Catchers* have a Remedy, in which they place so great Confidence, as to be no more afraid of the Bite [of a *Viper*,] than of a common *Puncture*, immediately curing themselves by the Application of their *Specifick*. This, though they keep as a great Secret, I have upon strict enquiry found to be no other than *Axungia Viperina*, presently rubbed into the Wound. This Remedy, the learned Doctor tried himself with good Success in a young Dog, that was bitten in the Nose. *Vid. Mead of Poysons*, pag. 29.

And as to the Means to escape the Mischiefs of such noxious Animals, besides what may be effected by the Care, Industry, and Sagacity of Man; some of them are so contrived and made, as to give warning, or time to Creatures in dangers from them. Thus, for instance, the *Rattle-Snake*, the most poisonous of any Serpent, who darts its poisonous Vapours to some Distance, and in all probability was the *Basilisk* of the Ancients, said to kill with its Eyes; this involuntarily gives warning by the Rattle in it's Tail. So the *Shark*, the most repacious Animal of the Waters, is forced to turn himself on his Back, (and thereby gives an opportunity of escape,) before he can catch his prey.

(5) *Hæc sola Natura placuerat esse remedia parata vulgo, inventu facilia, ac sine impendio, ex quibus vivimus. Postea fraudes hominum & ingeniorum captivæ officinas invenire istas, in quibus sua cuique homini vœnalis promittitur vita. Statim compositiones & mixturæ inexplicabiles decantantur. Arabia atque India in mediæ æstimantur, ulcerique parvo medicina a Rubro mari imputatur, cum remedia vera quotidie pauperrimus quisque cœnet. Plin. l. 24. c. 1.*

Non sponte sua ex tellure germinant Herbæ, quæ contra quoscunque morbos accommodæ sunt; sed ea, voluntate Opificis, ad nostram utilitatem productæ sunt. Basil. Ascet. Tom. 2.

Consult here, *Book X. Note 23, 24, 25.*

(6) Among

Pleasure, either to Man, or to some of the inferiour Creatures themselves; even for which inferiour Creatures, the liberal Creator hath provided all things necessary, or any ways conducing to their happy, comfortable living in this World, as well as for Man.

And it is manifest, that all the Creatures of God, Beasts, Birds, Insects, Plants, and every other Genus have, or may have, their several Uses even among Men. For although in one place many things may lie neglected, and out of Use, yet in other places they may be of great Use. So what hath seemed useless in one Age, hath been received in another; as all the new Discoveries in Physick, and all the Alterations in Diet do sufficiently witness. Many things also there are which in one Form may be pernicious to Man; but in another of great Use. There are many Plants (6), many Animals, many Minerals, which in one form destroy, in another heal.

The

(6) Among poisonous Vegetables, none more famous of old than *Hemlock*, accounted at this Day also very dangerous to Man, of which there are some dismal Examples in our *Philos. Transact.*, *Wepfer*, &c. But yet this Plant is Food to *Goats*, and its Seeds to *Bustards*; and as *Galen* saith, to *Starlings* also. Neither is this so pernicious a Plant, only Food, but also Physick to some Animals. An Horse troubled with the *Farcy*, and could not be cured with the most famed Remedies, cured himself of it in a short time by eating *Hemlock*, of which he eat greedily. *Vid. Phil. Trans. Nr. 231.* And a Woman cured of the *Plague*, and wanting Sleep, did with very good Effect, eat *Hemlock* for some time; till falling ill again of a Fever, and having left off the Use of this Remedy, he [*Nic. Fontanus*] endeavoured to procure rest by repeated Doses of *Opium*, which had no Operation; till the help of *Cicuta*, was again called in with desired Success. *Mead of Poiss. p. 144.*

The *Cassada-Plant* unprepared poisoneth, but prepared, is the very Bread of the *West-Indies* (7); *Vipers* and *Scorpions*, and many Minerals as destructive as they are to Man, yet afford him some of his best Medicines.

Or if there be many things of little immediate Use to Man, in this, or any other Age; yet to other Creatures they may afford Food or Physick, or be of some necessary Use. How many Trees, and Plants, nay, even the very Carcasses of Animals, yea, the very Dust of the Earth (8), and the most refuse, contemptible things to be met with; I say, how many such things are either Food, or probably Medicine to many Creatures, afford them Retreat, are places of Habitation, or Matrixes for their Generation, as shall be shewed in proper place? The prodigious swarms of Insects in the Air, and in the Waters, (many of which may be perhaps at present of no great Use to Man,) yet are Food to Birds, Fishes, Reptiles, Insects themselves, and other Creatures (9): for whose happy and comfortable Subsistence, I have said the bountiful Creator hath liberally provided, as well as for that of Man.

(7) *It is of the most general Use of any Provision, all over the West-Indies; especially the hotter Parts, and is used to victual Ships. Dr. Sloan's Nat. Hist. of Jamaica, Vol. 1. Chap. 5, §. 12.*

(8) I have shewn in the *Philos. Transactions*, that the *Pediculus fatidicus*, *Mortisaga*, *Pulsatorius*, or *Death-watch* there described, feedeth upon Dust; but that this Dust they eat, is poudered Bread, Fruits, or such like Dust, not poudered Earth; as is manifest from their great Diligence and Curiosity in Hunting among the Dust. See more in *Phil. Transf. Nr. 291.*

(9) *Vid. Book IV. Chap. 11.*

B O O K III.

Of the Terraqueous Globe in particular, more especially the Earth,

HAVING thus taken a general Prospect of our Terraqueous Globe; I shall in this Book come to its Particulars. But here we have such an immense Variety presenteth it self to our Senses, and such amazing Strokes of Power and Wisdom, that it is impossible not to be at a stand, and very difficult to know where to begin, how to proceed, or where to end. But we must however attempt.

And for the more clear and regular proceeding on this copious Subject; I shall distribute the Globe into its two grand constituent Parts.

I. The *Earth* and its Appurtenances.

II. The *Waters* and Theirs.

The first of these only, is what at present I shall be able to take into this Survey.

And in Surveying the *Earth*; I intend,

1. To consider its constituent Parts, or Things peculiar to it self.

2. The Inhabitants thereof, or the several kinds of Creatures that have their Habitation, Growth, or Subsistence thereon.

I. As to the *Earth* it self; the most remarkable things that present themselves to our View, are,

I. Its

1. Its various Moulds and Soils.
 2. Its several Strata, or Beds.
 3. Its very Subterraneous Passages, Grotto's, and Caverns.
 4. Its Mountains and Vallies.
-

C H A P. I.

Of the Soils and Moulds in the Earth.

THE various Soils and Moulds are an admirable and manifest Contrivance of the All-wise Creator, in making this Provision for the various Vegetables (1), and divers other Uses of the Creatures. For, as some Trees, some Plants, some Grains dwindle and die in a disagreeable Soil, but thrive

(1) It is not to be doubted, that although Vegetables delight in peculiar Soils, yet they owe not their Life and Growth to the Earth it self, but to some agreeable Juices, or Salts, &c. residing in the Earth. Of this the great Mr. *Boyl* hath given us some good Experiments. He ordered his Gardiner to dig up and dry in an Oven, some Earth fit for the purpose, to weigh it, and to set therein some *Squash-Seeds*, (a kind of *Indian Pompion*.) The Seeds when sown, were watered with Rain or Spring-water only. But although a Plant was produced in one Experiment of near 3 *l.* and in another of above 14 *l.* yet the Earth when dried, and weighed again, was scarce diminished at all in its Weight.

Another Experiment he alledges is of *Helmont's*, who dried 200 *l.* of Earth, and therein planted a Willow weighing 5 *l.* which he watered with Rain or distilled Water: And to secure it from any other Earth getting in, he covered it with a perforated Tin Cover. After five Years, weighing the Tree with all the Leaves it had born in that time, he found it to weigh 169 *l.* 3 Ounces; but the Earth to be diminished only about 2 Ounces in its Weight. *Vid. Boyl's Scept. Chym. Part 2. pag. 114.*

thrive and flourish in others ; so the All-wise Creator hath amply provided for every Kind a proper Bed.

If some delight in a warm, some a cold Soil ; some in a lax or sandy, some a heavy or clayie Soil ; some in a mixture of both, some in this, and that, and the other mould, some in moist, some in dry Places (2) ; still we find provision enough for all these Purposes : Every Country abounding with its proper Trees and Plants (3), and every Vegetable flourishing, and gay, somewhere or other about the Globe, and abundantly answering the Almighty Command of the Creator, when the Earth and Waters were ordered to their peculiar place, *Gen. I. 11. And God said, let the Earth bring forth Grass, the Herb yielding Seed, and the Tree yielding Fruit after his Kind.* All which we actually see is so.

To this convenience which the various Soils that coat the Earth are of to the Vegetables ; we may add their great Use, and Benefit to divers Animals, to many Kinds of Quadrupeds, Fowls, Insects, and Reptiles ;

(2) Τὲς δὲ τόποις ζητεῖ τὰς οἰκίας, ἢ μόνον τὰ περὶ τὰ — τῶν δένδρων, &c. Τὰ μὲν γὰρ φιλεῖ ξηρὰς, τὰ δὲ ἐνυδρὰς, τὰ δὲ χειμαρύνους, τὰ δὲ περὶ πηλῶν, τὰ δὲ παλαιοῦς, καὶ ὅλως, τὰ μὲν ὀρεῖνους, τὰ δὲ ἐλαίους. — Ζητεῖ γὰρ τὰ πρὸς ποταμοῖς κατὰ τὴν κρᾶσιν, ἐπὶ δὲ ἀδενῇ, καὶ ἰσχυρῇ, καὶ βαθυρρίζῃ, καὶ ἐπὶ πολλὰ ὀρρίζῃ, καὶ ἔτις ἄλλη διαφορὰ κατὰ τὰ μέρη. — Πάντα γὰρ ταῦτα, ἐπὶ δὲ τὸ ὅμοιον ζητεῖ τὸ ὅμοιον, καὶ τὰ ἀνόμοια μὴ τὸ αὐτὸν, ὅταν ἢ τις παρεκκλᾷ τῆς φύσεως. *Theophrast. de Caus. Plant. l. 2. c. 9.*

(3) *Nec vero terra ferre omnes omnia possunt.
Fluminibus Salices, crassisque paludibus Alni
Nascuntur ; steriles saxosis montibus Orni :
Littora myrtetis latissima : denique apertos
Bacchus amat colles : Aquilonem & frigora Taxi.
Aspice & extremis domitum cultoribus orbem,
Easque domos Arabum, pictosque Gelonos :
Divisa arboribus patria, &c. Virgil. Georg. L. 2.*

(1) Although

Reptiles; who make in the Earth their places of Repose and Rest, their Retreat in Winter, their Security from their Enemies, and their Nests to repose their Young; some delighting in a lax and pervious Mould, admitting them an easy passage; and others delighting in a firmer and more Solid Earth, that will better secure them against Injuries from without.

C H A P. II.

Of the various Strata or Beds observable in the Earth.

THE various *Strata* or *Beds*, although but little different from the last, yet will deserve a distinct consideration.

By the *Strata* or *Beds*, I mean those Layers of Minerals (1), Metals (2), Earth, and Stone (3),

(1) Although Minerals, Metals, and Stones lie in Beds, and have done so ever since *Noah's Flood*, if not from the Creation; yet it is greatly probable that they have a power of growing in their respective Beds: That as the Beds are robbed, and emptied by Miners, so after a while they Recruit again. Thus *Vitriol*, Mr. *Boyl* thinks will grow by the help of the Air. So *Alum* doth the same. We are assured, (he saith,) by the experienced *Agricola*, that the Earth or Ore of *Alum*, being robbed of its Salt, will in tract of time recover it by being exposed to the Air. *Boyl's Suspicion*, about some Hidd. Qual. in the Air, pag. 18.

(2) As to the Growth of *Metals*, there is great Reason to suspect that also, from what Mr. *Boyl* hath alledged in his *Observations about the Growth of Metals*: And in his *Scept. Chym. Part. 6. pag. 362*. Compare also *Hakewill's Apol. pag. 164*.

And particularly as to the Growth of *Iron*, to the instances he gives from *Pliny*, *Fallopins*, *Cesalpinus*, and others; we may add, what is well known in the Forest of *Deane* in *Glocestershire*: That the

(3), lying under that upper Stratum, or Tegument of the Earth last spoken of, all of prodigious Use to Mankind: Some being of great Use for Building; some

the best Iron, and most in Quantity, that is found there, is in the old Cinders, which they melt over again. This the Author of the *Additions to Gloucestershire, in Cambd-Brit.* of the last Edition, pag. 245. attributes to the remissness of the former Melters, in not exhausting the Ore: But in all probability it is rather to be attributed to the new Impregnations of the old Ore, or Cinders, from the Air, or from some seminal Principle, or plastick Quality in the Ore it self.

(3) As for the Growth of Stone, Mr. Boyl gives two Instances. One is that famous place in France, called *Les Caves Goutieres*: where the Water falling from the upper Parts of the Cave to the Ground, doth presently there condense into little Stones, of such Figures as the Drops falling either severally, or upon one another, and conglutating presently into Stones, chance to exhibit. Vid. Scept. Chym. pag. 360.

Such like Caves as these, I have my self met with in England; particularly on the very Top of *Bredon-Hill* in *Worcestershire*, near the *Precipice*, facing *Pershore*, in or near the old Fortrefs, called *Bembsbury Camp*; I saw some Years ago such a Cave, which (if I misremember not) was lined with those *Stalactical-Stones*, on the Top and Sides. On the Top, they hung like Icicles great and small, and many lay on the Ground. They seemed manifestly to be made by an Exsudation, or Exstillation of some petrifying Juices out of the rocky Earth there. On the spot, I thought it might be from the Rains soaking through, and carrying with it Impregnations from the Stone, the Hill being there all Rocky. Hard by the Cave is one or more vast Stones, which (if I mistake not) are incrustated with this Sparry, Stalactical Substance, if not wholly made of it. But it is so many Years ago since I was at the place, and not being able to find my Notes about it, I cannot say, whether the whole Stone is (in all probability) Spar, (as I think it is,) or whether I found it only cascd over with it, notwithstanding I was very nice in examining it then, and have now some of the Fragments by me, consisting, among other shining Parts, of some transparent angular Ones.

The other Instance of Mr. Boyl, is from *Linschoten*, who saith, that in the *East-Indies*, when they have cleared the Diamond Mines of all the Diamonds; In a few Years time they find in the same place new Diamonds produced. Boyl. Ibid.

some serving for Ornament; some furnishing us with commodious Machines, and Tools to prepare our Food, and for Vessels and Utensils, and for multitudes of other Uses; some serving for Firing to dress our Food, and to guard us against the insults of Cold, and Weather; some being of great Use in Physick, in Exchange and Commerce, in Manuring and Fertilizing our Lands, in Dying and Colouring, and ten Thousand other Conveniences, too many to be particularly spoken of: Only there is one grand Use of one of these Strata or Beds, that cannot easily be omitted, and that is those subterraneous Strata of Sand, Gravel, and laxer Earth that admit of, and facilitate the passage of the sweet Waters (4), and may probably be the Colanders whereby they are sweetened, and then at
the

(4) It is not only agreeable to Reason, but I am told by Persons conversant in digging of Wells throughout this County of *Essex*, where I live, that the surest Beds in which they find Water, are *Gravel*, and a coarse dark coloured *Sand*; which Beds seldom fail to yield plenty of sweet Water: But for *Clay*, they never find Water therein, if it be a strong, stiff Clay; but if it be lax and sandy, sometimes Springs are found in it; but so weak, that they will scarcely serve the Uses of the smallest Family. And sometimes they meet with those Beds lying next under a loose black Mould, (which, by their Description, I judged to be a sort of oazy, or to have the resemblance of an ancient rushy Ground,) and in that case the Water is always naught and stinks. And lastly, another sort of Bed they find in *Essex*, in the clayey Lands, particularly that part called the *Rodings*, which yields plenty of sweet Water, and that is a Bed of white Earth, as though made of Chalk and white Sand. This they find, after they have dug through forty or more Feet of Clay; and it is so tender and moist, that it will not lie upon the Spade, but they are forced to throw it into their Bucker with their Hands, or with Bowls; but when it comes up into the Air, it soon becomes an hard white Stone.

Thus much for the variety of Beds wherein the Waters are found. That it is in these Beds only, or chiefly the Springs run, is farther manifest from the forcible Eruption of the Wa-

the same time also conveyed to all Parts of the habitable World, not only through the temperate and torrid Zones, but even the farthest Regions of the frozen Poles.

That these Strata are the *principal Passages* of the sweet, fountain Waters, is, I think, not to be doubted, considering that in them the Waters are well known to pass, and in them the Springs are found by those that seek for them. I say, the principal Passages, because there are other Subterraneous Guts and Channels, Fissures and Passages, through which many times the Waters make their way.

Now that which in a particular manner doth seem to me to manifest a special Providence of God in the repositing these watery Beds is, that they should be dispersed all the World over, into all Countries, and almost all Tracts of Land: That they should so entirely, or for the most part, consist of lax, incohering Earth, and be so seldom blended with other impervious Moulds, and that often, but accidentally: And that they are interposed between the other impervious Beds, and so are as a Prop and Pillar to guard them off, and to prevent their sinking in, and shutting up the Passages of the Waters.

The time when those Strata were laid, was doubtless at the Creation, when God said, (Gen. 1. 9.) *let the Waters under the Heaven be gathered together unto one place, and let the dry Land appear*; or else at the Deluge, if, with some sagacious Naturalists, we

ters sometimes out of those watery Beds. Of which see Chap. 4. Note 10. This Eruption shews, that the Waters come from some Eminence or other, lying at a distance, and being closely pent up within the *watery Stratum*, by the claiy Strata, the Waters with force mount up, when the Strata above are opened.

we suppose the Globe of Earth to have been dissolved by the Flood (5). At that time (whatever it was) when the Terraqueous Globe was in a chaotick State, and the earthy Particles subsided, then those several Beds were in all probability repositied in the Earth, in that commodious Order in which they now are found; and that, as is asserted, according to the Laws (6) of Gravity.

C H A P.

(5) V. Dr. Woodward's Essay, Part 2.

(6) Id. Ib. pag. 28, and pag. 74. But Dr. Leigh in his *Nat. History of Lancashire*, speaking of the Coal-pits, denies the Strata to lie according to the Laws of Gravitation, saying, the Strata are a Bed of *Marle*, afterwards *Free-Stone*, next *Iron-Stone*, then *Coal*, or *Kennel-Mine*, than some other Strata, and again *Coal*, &c.

But upon a stricter enquiry into the matter, finding I had reason to suspect that few, if any, actually had tried the Experiment, I was minded to bring the thing to the Test of Experiment my self; and having an opportunity, on April. 11. 1712. I caused divers places to be bored, laying the several Strata by themselves; which afterwards I weighed with all strictness, first in Air, then in Water, taking care that no Air-bubbles, &c. might obstruct the accuracy of the Experiment. The result was, that in my Yard, the Strata were gradually specifically heavier and heavier, the lower and lower they went; and the upper which was Clay, was considerably specifically lighter than the lower Stratum; which was first a loose Sand, then a Gravel. In which Stratum principally the Springs run that supply my Well.

But in my Fields, where three places were bored (to no great Depth) I found below the upper, superficial Stratum, a deep Bed of Sand only, which was of different Colours and Consistence, which I weighed as before, together with the Virgin-mold; But they were all of the same, or nearly the same specific Gravity, both out of the same Hole, and out of different Holes, although the Sand was at last so gravelly, that hindered our boring any deeper.

Upon this, fearing lest some error might be in the former Experiments, I tried them over again; and that with the same Success.

C H A P. III.

Of the Subterraneous Caverns, and the Vulcano's.

I Shall take notice of the Subterraneous Caverns, Grotto's, and Vulcano's, because they are made an Objection (1) against the present Contrivance and Structure of the Globe. But, if well considered, they will be found to be wise Contrivances of the Creator, serving great Uses of the Globe, and Ends of God's Government. Besides many secret grand Functions and Operations of Nature in the Bowels of the Earth, that in all probability these things may minister unto, they are of great Use to the Countries where they are (2). To instance in the very worst of all the things named, *viz.* the *Vulcano's*

After this, I made some Experiments in some deep Chalk-Pits, with the Flints, Chalk, &c. above and below; but the Success was not so uniform as before.

Acquainting our justly renowned R. S. with these Experiments, they ordered their Operator to experiment the *Strata* of a Coal-Pit; the Success whereof may be seen in *Philos. Transf. Nr. 336.*

(1) *Nemo dixerit terram pulchriorem esse quod cavernosa sit, quod dehiscat in multis locis, quod disrupta caveis & spatiis inanibus; iisque nullo ordine dispositis, nullâ formâ: nec quæ aliud contineant quam tenebras & sordes; unde graves & pestifera exhalationes, terræ motus, &c.* Burnet ubi supr. c. 7.

(2) The Zirchnitzer Sea in Carniola, is of great Use to the Inhabitants of that Country, by affording them Fish, Fowls, Fodder, Seeds, Deer, Swine and other Beasts, Carriage for their Goods, &c. *Vid. Phil. Transf. Nr. 191, &c. or Lowth. abridg. Vol. 2. p. 306, &c.* where you have put together into one View, what is dispersed in divers of the *Transactions.* This Sea or Lake proceeds from some Subterraneous Grotto, or Lake, as is made highly probable by Mr. *Valvasor. Ibid.*

Vulcano's and Ignivomous Mountains; although they are some of the most terrible Shocks of the Globe, and dreadful Scourges of the sinful Inhabitants thereof, and may serve them as Emblems, and Pre-sages of Hell it self; yet even these have their great Uses too, being as Spiracles or Tunnels (3) to the Countries where they are, to vent the Fire and Vapours that would make dismal Havock, and oftentimes actually do so, by dreadful Succussions and Convulsions of the Earth. Nay, if the Hypothesis of a central Fire and Waters be true, these Out lets seem to be of greatest Use to the peace and quiet of the Terraqueous Globe, in venting the Subterraneous Heat and Vapours; which, if pent up, would make dreadful and dangerous Commotions of the Earth and Waters.

It may be then accounted as a special Favour of the Divine Providence, as is observed by the Author before praised (4), "That there are scarcely any Countries, that are much annoyed with Earth-quakes, that have not one of these fiery Vents. And these, (saith he,) are constantly all in Flames whenever any Earthquake happens; they disgorging that Fire, which whilst underneath, was the cause of the Disaster. Indeed, (saith he,) were it not for these *Diverticula*, whereby it thus gaineth an *Exit*, 'twould rage in the Bowels

The *Grotto Podpetchio* may be another Instance, that the very Subterraneous Lakes may be of use even to the Inhabitants of the Surface above: Of which see *Lowth. ubi supr. pag. 317. Sturmius* also may be consulted here in his *Philos. Eclect. Exercit. 11. de Terræ mot.* particularly in *Chap. 3.* some of the most eminent Specuses are enumerated, and some of their Uses.

(3) *Crebri specus [remedium] præbent. Præconceptum enim spiritum exhalant: quod in certis notatur oppidis, quæ minus quatiuntur, crebris ad eluvium cuniculis cavata.* Plin. Hist. Nat. l. 2, c. 82.

(4) *Woodward's Essay, Part 3, Consect. 13.*

“ of the Earth much more furiously, and make
 “ greater Havock than now it doth. So, that
 “ though those Countries, where there are such
 “ *Vulcano's*, are usually more or less troubled with
 “ Earthquakes ; yet, were these *Vulcano's* wanting,
 “ they would be much more annoyed with them
 “ than now they are; yea in all probability to that
 “ Degree, as to render the Earth, for a vast Space
 “ around them, perfectly uninhabitable. In one
 “ word, (saith he) so beneficial are these to the
 “ Territories where they are, that there do not
 “ want Instances of some which have been rescued,
 “ and wholly delivered from Earthquakes by the
 “ breaking forth of a new *Vulcano* there; this con-
 “ tinually discharging that matter, which being till
 “ then barricaded up, and imprisoned in the Bowels
 “ of the Earth, was the occasion of very great and
 “ frequent Calamities”. . Thus far that ingenious
 Author.

C H A P. IV.

Of the Mountains and Valleys,

THE last thing I shall take notice of relating to the Earth, shall be the *Hills* and *Valleys*. These the eloquent *Theorist* owns to, “ contain somewhat
 “ august and stately in the beholding of them, that
 “ inspireth the Mind with great Thoughts and Pas-
 “ sions; that we naturally on such occasions think
 “ of God, and his Greatness”. But then, at the same
 time, he saith, “ The Hills are the greatest exam-
 “ ples of Ruin and Confusion; that they have nei-
 “ their Form nor Beauty, nor Shape, nor Order,
 “ any more than the Clouds in the Air; that they
 “ consist not of any proportion of Parts, referrable
 “ to

“ to any Design, nor have the least Footsteps of
 “ Art or Counsel”. Consequently one grand part
 of this lower Creation, even the whole present Face
 of our Terraqueous Globe, according to this ingeni-
 ous Author, is a Work of mere Chance, a Structure
 in which the Creator did not concern himself.

Part of this Charge I have already briefly answered, and my Survey now leads me to shew, that the Mountains are so far from being a Blunder of Chance, a Work without Design, that they are a noble, useful, yea, a necessary Part of our Globe (1).

And in the first place, as to the business of Ornament, Beauty, and Pleasure, I may appeal to all Mens Senses, whether the grateful Variety of Hills and Dales, be not more pleasing than the largest continued Plains. Let those who make it their business to visit the Globe, to divert their Sight with the various Prospects of the Earth; let these, I say, judge whether the far distant Parts of the Earth

(1) *Though there are some that think Mountains to be a deformity to the Earth, &c. yet, if well considered, they will be found as much to conduce to the Beauty and Conveniency of the Universe, as any of the other Parts. Nature, (saith Pliny,) purposely framed them for many excellent Uses; partly to tame the violence of greater Rivers, to strengthen certain Joints within the Veins and Bowels of the Earth, to break the force of the Sea's Inundation, and for the safety of the Earth's Inhabitants, whether Beasts, or Men. That they make much for the protection of Beasts, the Psalmist testifies, The highest Hills are a Refuge for the Wild-Goats, and the Rocks for Conies. The kingly Prophet had likewise learnt the safety of those by his own Experience, when he also was fain to make a Mountain his Refuge from the fury of his Master Saul, who persecuted him in the Wilderness. True indeed, such places as these keep their Neighbour's Poor, as being most barren, but yet they preserve them safe, as being most strong; witness our unconquered Wales and Scotland. — Wherefore a good Author doth rightly call them Nature's Bulwarks, cast up at God Almighty's charges, the Scorns and Curbs of Victorious Armies. Which made the Barbarians in Curtius so confident of their own safety, &c. Bishop Wilkin's World in the Moon, pag. 114.*

would be so well worth visiting, if the Earth was every where of an even, level, globous Surface, or one large Plain of many 1000 Miles; and not rather, as now it is, whether it be not far more pleasing to the Eye, to view from the Tops of the Mountains the subjacent Vales and Streams, and the far distant Hills; and again from the Vales to behold the surrounding Mountains. The elegant Strains, and lofty Flights, both of the ancient and modern Poets on these Occasions, are Testimonies of the Sense of Mankind on this Configuration of the Earth.

But be the case as it will as to Beauty, which is the least valuable Consideration, we shall find as to Convenience, this Configuration of the Earth far the most commodious on several Accounts.

1. As it is the most Salubrious, of great Use to the Preservation, or Restoration of the Health of Man. Some Constitutions are indeed of so happy a Strength, and so confirmed an Health, as to be indifferent to almost any Place, or Temperature of the Air. But then others are so weakly and feeble, as not to be able to bear one, but can live comfortably in another place. With some, the finer and more subtile Air of the Hills doth best agree, who are languishing and dying in the feculent, and grosser Air of great Towns, or even the warmer and vaporous Air of the Valleys and Waters. But contrariwise, others languish on the Hills, and grow lusty and strong in the warmer Air of the Valleys.

So that this opportunity of shifting our Abode from the warmer and more vaporous Air of the Valleys, to the colder and more subtile Air of the Hills, or from the Hills to the Vales, is an admirable Easement, Refreshment, and great Benefit to the Valetudinarian, feeble Part of Mankind; affording those an easy and comfortable Life, who would otherwise

otherwise live miserably, languish, and pine away.

2. To this salutary Conformation of the Earth, we may add another great Convenience of the Hills, and that is in affording commodious Places for Habitation; “serving (as an eminent Author (2) wordeth it) “as Skreens to keep off the cold and nipping Blasts of the Northen and Easterly Winds, “and reflecting the benign and cherishing Sun-Beams, and so rendering our Habitations both “more comfortable, and more chearly in Winter; “and promoting the growth of Herbs and Fruit-Trees, and the Maturation of their Fruits in “Summer.

3. Another benefit of the Hills is, that they serve for the Production of great Varieties of Herbs and Trees (3). And as there was not a better Judge of those Matters, so I cannot give a better Account of this Convenience, than in the Words of the last cited famous Author, the late most eminent and learned Mr. Ray (4), (who hath so fully discussed this Subject I am upon, that it is scarce possible to tread out of his Steps therein.) His Observation is, “That the Mountains do especially abound with “different Species of Vegetables, because of the “great Diversity of Soils that are found there, even
“ 1y

(2) Ray's *Wisdom of God*, &c. pag. 251. *Dissolution of the World*, pag. 36.

(3) *Theophrastus* having reckoned up the Trees that delight most in the Hills, and others in the Valleys, observeth, “*Ἀπαντα δὲ ὅσα κοινὰ τῷ ὄρει καὶ τῷ πεδίῳ, μείζων μὲν καὶ καλλίω τῇ ὄρει τὰ ἐν τοῖς πεδίοις γίνονται· κρείττω δὲ τῇ τε χρήσει τῶν ξύλων καὶ τῶν καρπῶν, τὰ ὄρεα.* *Theoph. Hist. Pl. l. 3. c. 4.* “*Ἀπαντα δὲ ἐν τοῖς οἰκείοις τόποις καλλίω γίνονται, καὶ πολλὸν εὐθρανεῖ.* — *Τὰ μὲν γὰρ φιλεῖ τὰς ἐρύδρας καὶ ἐλάδας.* — *Τὰ δὲ, τὰς εὐσεπείας καὶ εὐηλίας.* *Ib. l. 4. c. 1.*

(4) *Wisdom of God*, p. 252.

(5) *Ubi*

“ ry *Vertex*, or Eminency, almost affording new
 “ Kinds. Now these Plants, (saith he,) serve part-
 “ ly for the Food and Sustainance of such Animals
 “ as are proper to the Mountains, partly for medi-
 “ cinal Uses; the chief Physick Herbs and Roots,
 “ and the best in their kinds growing there: It be-
 “ ing remarkable, that the greatest and most luxu-
 “ riant Species in most Genera of Plants are native
 “ of the Mountains.

4. Another Convenience which my last named
 learned Friend observes (5) is, that the Mountains
 “ serve for the Harbour, Entertainment, and Main-
 “ tenance of various Animals; Birds, Beasts, and
 “ Insects, that breed, feed, and frequent there.
 “ For, (saith he,) the highest Tops and Pikes of
 “ the *Alps* themselves are not destitute of their In-
 “ habitants, the *Ibex*, or *Stein-buck*, the *Rupicapra*,
 “ or *Chamois*, among Quadrupeds; the *Lagopus*
 “ among Birds. And I my self, (saith he,) have
 “ observed beautiful *Papilio*'s, and Store of other
 “ Insects upon the Tops of some of the *Alpine* Moun-
 “ tains. Nay, the highest Ridges of many of these
 “ Mountains, serve for the maintenance of Cattle,
 “ for the service of the Inhabitants of the Valleys.
 5. Another thing he observes is, “ That those
 “ long Ridges and Chains of lofty and topping
 “ Mountains, which run through whole Continent's
 “ East and West (6), serve to stop the Evagation of
 “ the Vapours to the North and South in hot Coun-
 “ tries,

(5) *Ubi supra.*

(6) Many have taken notice that some of the greatest Emini-
 nences of the World run generally East and West, of which
 take the late ingenious and learned Dr. *Nichols's* Account, [*Con-
 fer. with a Theist.* Part 2. pag. 191.] To go no farther than our
 own Country, all our great Ridges of Hills in *England*, run East
 and West; so do the *Alps*, in *Italy*, and in some measure the *Py-
 renees*; so do the Mountains of the *D* in *Africk*, and so do Mount
 Taurus

“ tries, condensing them like Alembick Heads into
 “ Water, and so (according to his Opinion) by a
 “ kind of external Distillation giving original to
 “ Springs and Rivers; and likewise by amassing,
 “ cooling, and constipating of them, turn them in-
 “ to Rain by those means rendering the fervid Re-
 “ gions of the torrid Zone habitable.

To these might be added some other Uses and Conveniences (7); as that the Hills serve to the Generation of Minerals and Metals (8), and that in them principally are the most useful Fossils found; or if not found and generated only in them, yet at least all these Subterraneous Treasures are most easily

Taurus and Caucasus. This he saith is a wise Contrivance to prevent the Vapours, which would all run Northwards, and leave no Rains in the Mediterranean Countries.

(7) The Generation of many of the Clouds is owing to the Hills, appears from the Observations of the ingenious and learned Dr. Joh. Jam. Scheuchzer of Zurich, and M. Joach. Frid. Creitlovius cited by him. They observed at Sun-rising divers Clouds detached by the heat of the Sun from some of the tops of the Alps, &c. upon all which their Observations, the Conclusion is, *Mirati summam Creatoris sapientiam, qui & id, quod paulo antè nulli nobis usui esse videbatur, maximis rebus destinaverat, adeoque ex illo tempore dubitare cœpi num Nubes essent futurae, si istiusmodi Montes & Petrae non darentur. Hypothesi hæc stante, elucesceret permagna utilitas, imò necessitas, quam Helveticæ Alpes non nobis tantum accolis, sed & vicinis aliis regionibus præstant, dispensando, quas gignunt Nubes, Ventos, Aquas.* Scheuch, *Iter Alpin.* 2. p. 20.

(8) Let us take here Ol-Mag, Observation of his Northern Mountains, *Montes excelsi sunt, sed pro majori parte steriles, & aridi; in quibus fere nil aliud pro incolarum commoditate & conservatione gignitur, quam inexhausta pretiosorum Metallorum ubertas, qua satis opulenti, fertilesque sunt in omnibus vitæ necessariis, forsitan & superfluis aliunde si libet conquirendis, unanimique robore, ac viribus, ubi vis contra hæc naturæ dona intentata fuerit, defendendis. Acre enim genus hominum est, &c.* Ol-Mag. *Hist. L. 6. Præf.* See also Sir Rob. Sibbald's *Prodr. Nat. Hist. Scot.* pag. 47.

(9) See

easily come at in them : Also their Use to several Nations of the Earth in being Boundaries and Bullwarks to them. But there is only one Use more that I shall insist on, and that is,

6thly, and lastly, That it is to the Hills that the Fountains owe their Rise, and the Rivers their Conveyance. As it is not proper, so neither shall I here enter into any dispute about the Origine of Springs, commonly assigned by curious and learned Philosophers. But whether their Origine be from condensed Vapours, as some think (9); or from Rains falling, as others; or whether they are derived from the Sea by way of Attraction, Percolation, or Distillation; or whether all these Causes concur, or only some, still the Hills are the grand Agent in this prodigious Benefit to all the Earth: Those vast Masses and Ridges of Earth serving as so many huge *Alembicks*, or *Cola* in this noble Work of Nature.

But be the *Modus*, or the method Nature takes in this great Work as it will; it is sufficient to my purpose, that the Hills are a grand Agent in this so noble and necessary a Work. And consequently, that those vast Masses, and lofty Piles are not, as they are charged, such rude and useless Excrescences of our ill-formed Globe; but the admirable Tools of Nature, contrived and ordered by the infinite Creator, to do one of its most useful Works; and to dispense this great Blessing to all Parts of the Earth; without which neither Animals could live, nor Vegetables scarcely grow, nor perhaps Minerals, Metals, or Fossils receive any Increase. For was the Surface of the Earth even and level, and the middle Parts of its Islands and Continents not

Moun-

(9) See Book I. Chap. 3. Note 2.

(10) *Monsieur*

Mountainous and High, (as now it is,) it is most certain there could be no descent for the Rivers, no conveyance for the Waters; but instead of gliding along those gentle Declivities which the higher Lands now afford them quite down to the Sea, they would stagnate, and perhaps stink, and also drown large Tracts of Land.

But indeed, without Hills as there could be no Rivers, so neither could there be any Fountains or Springs about the Earth; because, if we could suppose a Land could be well watered (which I think not possible) without the higher Lands, the Waters could find no descent, no passage through any commodious Out-lets, by vertue of their own Gravity, and therefore could not break out into those commodious Passages and Currents, which we every where almost find in, or near the Hills, and seldom, or never in large and spacious Plains; and when in them, at great and inconvenient Depths of the Earth; nay, those very Subterraneous Waters that are any where met with by digging in the Plains, are in all probability owing to the Hills, either near or far distant. As among other instances may be made out from the forceable Eruption of the Subterraneous Waters in digging Wells in the *lower Austria*, and the Territories of *Modena* and *Bologna* in *Italy*, mentioned by my fore-named learned Friend Mr. Ray (10). Or if there be any such place found throughout the Earth, that is devoid of Mountains, and yet well watered, as perhaps

(10) Monsieur Blundel related to the Parisian Academy, what device the Inhabitants of the lower Austria, (which is encompassed with the Mountains of Stiria,) are wont to use to fill their Wells with Water. They dig in the Earth to the depth of 25 and 20 Feet, till they come to an Argilla [clammy Earth]—which they bore

haps some small Islands may ; yet in this very case that whole Mass of Land is no other than as one Mountain, descending (though unperceivedly) gently down from the mid-land Parts to the Sea, as most other Lands do ; as is manifest from the descent of their Rivers, the principal of which in most Countries have generally their Rise in the more lofty mid-land Parts.

And now considering what hath been said concerning this last Use of the Hills, there are two or three Acts of the Divine Providence observable therein. One is, that all Countries throughout the whole World should enjoy this great Benefit, of Mountains, placed here and there, at due and proper Distances, to afford the several Nations this excellent, and most necessary Element the Waters. For according to Nature's Tendency, when the Earth and Waters were separated, and ordered to their several Places, the Earth must have been of an
even

bore through so deep, till the Waters break forcibly out : which Water it is probable comes from the neighbouring Mountains in Subterraneous Channels. And Cassinus observed, that in many places of the Territory of Modena and Bologna in Italy, they make themselves Wells by the like Artifice, &c. By this means the same Seigr Cassini made a Fountain at the Castle of Urbin, that cast up the Water five Foot high above the level of the Ground. Ray's Disc. i. pag. 40. ubi plura.

Upon enquiry of some skilful Workmen, whose business it is to dig Wells, &c. whether they had ever met with the like case, as these in this Note, they told me they had met with it in Essex, where after they had dug to 30 Foot depth, the Man in the Well observed the clayie bottom to swell and begin to send out Water, and stamping with his Foot to stop the Water, he made way for so suddain and forceable a Flux of Water, that before he could get into his Bucket, he was above his Waste in Water ; which soon ascended to 17 Feet height, and there stayed : And although they often with great labour endeavoured to empty the Well, in order to finish their Work, yet they could never do it, but were forced to leave it as it was.

even Surface, or nearly so. The several component Parts of the Earth must have subsided according to their several specifick Gravities, and at last have ended in a large even spherical Surface, every where equi-distant from the Center of the Globe. But that instead of this Form, so incommodious for the conveyance of the Waters, it should be jetted out every where into Hills and Dales so necessary for that purpose, is a manifest sign of an especial Providence of the wise Creator.

So another plain sign of the same especial Providence of God in this matter is, that generally throughout the whole World, the Earth is so disposed, so ordered, so well laid, I may say, that the mid-land Parts, or Parts farthest from the Sea, are commonly the highest. Which is manifest, I have said, from the descent of the Rivers. Now this is an admirable Provision the wise Creator hath made for the commodious Passages of the Rivers, and for draining the several Countries, and carrying off the superfluous Waters from the whole Earth, which would be as great an Annoyance, as now they are a Convenience.

Another providential Benefit of the Hills supplying the Earth with Water is, that they are not only Instrumental thereby to the fertility of the Valleys; but to their own also (11), to the Verdure of the Vegetables without, and to the Increment and Vigour of the Treasures within them.

Thus

(11) As the Hills being higher, are naturally disposed to be drier than the Valleys; so kind Nature hath provided the greater supplies of Moisture for them, such at least of them, as do not ascend above the Clouds and Vapours. For, besides the Fountains continually watering them, they have more Dews and Rains commonly than the Valleys. They are more frequently covered with Fogs; and by retarding, stopping, or compressing the

Thus having vindicated the present Form and Fabrick of the Earth, as distributed into Mountains and Valleys, and thereby shewn in some measure the Use thereof, particularly of the Mountains, which are chiefly found fault with: I have, I hope, made it in some measure evident, that God was no idle Spectator (12), nor unconcerned in the ordering of the Terraqueous Globe, as the former bold Charges against it do infer; that he did not suffer so grand a Work, as the Earth, to go unfinished out of his Almighty Hand; or leave it to be ordered by Chance, by natural Gravity, by casual Earthquakes, &c. but that the noble Strokes, and plain Remains of Wisdom and Power therein do manifest it to be his Work. That particularly the Hills and Vales, though to a peevish weary Traveller, they may seem incommodious and troublesome, yet are a noble Work of the great Creator, and wisely appointed by him for the good of our sublunary World.

And so for all the other parts of our Terraqueous Globe, that are presumed to be found fault with by some, as if carelessly ordered, and made without any Design or End; particularly the Distribution of

the Clouds, or by their greater Cold condensing them, they have larger quantities of Rain fall upon them. As I have found by actual Experience, in comparing my Observations with those of my late very curious and ingenious Correspondent, *Richard Townley, Esq; of Lancashire*, and some others, to be met with before, *Chap. 2. Note 1.* From which it appears, that above double the quantity of Rain falleth in *Lancashire*, than at *Uppingham*. The reason of which is, because *Lancashire* hath more, and much higher Hills than *Essex* hath. See *Book II Chap. 5. Note 5.*

(12) *Accusandi sanè meâ sententiâ hîc sunt Sophistæ, qui cùm nondum invenire, neque exponere opera Naturæ queant, eam tamen inertîâ atque inscitiâ condemnant, &c.* Galen de Us. Part 1. l. 107 c. 9.

(11) *Vide*

of the dry Land and Waters ; the laying the several Strata, or Beds of Earth, Stone, and other Layers before spoken of ; the Creation of noxious Animals, and poisonous Substances ; the boisterous Winds ; the Vulcano's, and many other things which some are angry with, and will pretend to amend : I have before shewn, that an infinitely wise Providence, an Almighty Hand was concerned even in them, that they all have their admirable Ends, and Uses, and are highly instrumental and beneficial to the Being, or Well-being of this our Globe, or to the Creatures residing thereon.

So also for Humane Bodies, it hath been an ancient (||) as well as modern Complaint, that our Bodies are not as big as those of other Animals, that we cannot run as swift as Deer, fly like Birds, and that we are out-done by many Creatures in the accuracy of the Senses, with more to the same purpose. But these Objections are well answered by Seneca (†), and will receive a fuller Solution from what I shall observe of Animal Bodies hereafter.

But

(||) *Vide quam iniqui sint divinatorum munerum aestimatores, etiam quidam professi sapientiam. Queruntur quod non magnitudine corporis æquemus Elephantes, velocitate Cervos, levitate Aves, impetu Tauros ; quod solidior sit cutis Belluis, decentior Damis, densior Ursis, mollior Fibris ; quod sagacitate nos narium Canes vincant, quod acie luminum Aquilæ, spatio ætatis Corvi, multa animalia nandi facilitate. Et cum quedam ne coire quidem in idem Natura patiatur, ut velocitatem corporis & vires pares animalibus habeamus ; ex diversis & dissidentibus bonis Hominem non esse compositum, injuriam vocant ; & in negligentes nostri Deos querimoniam faciunt, quod non bona valetudo, & vitia inexpugnabilis data sit, quod non futuri scientia. Vix sibi temperant quin eoque impudentiæ provehantur, ut Naturam oderint, quod infra Deos sumus, quod non in æquo illis stetimus. Seneca de Benef. l. 2. c. 29.*

(†) *Quanto satius est ad contemplationem tot tantorumque beneficiorum reverti, & agere gratias, quod nos in hoc pulcherrimo domicilio voluerunt [Dii] secundos sortiri, quod terrenis præfecerunt.*

But indeed after all, it is only for want of our knowing these things better, that we do not admire (13) them enough; it is our own Ignorance, Dulness, or Prejudice, that makes us charge those noble Works of the Almighty, as Defects or Blunders, as Ill-contrived, or Ill-made.

It is therefore fitter for such finite, weak, ignorant Beings, as we, to be humble and meek, and conscious of our Ignorance, and jealous of our own Judgment, when it thus confronteth infinite Wisdom. Let us remember how few things we know, how many we err about, and how many we are ignorant of: and those, many of them, the most familiar, obvious things; things that we see and handle at Pleasure, yea our own very Bodies, and that very part of us whereby we understand at all, our Soul. And should we therefore pretend to censure what God doth! Should we pretend to amend his Work! Or to advise infinite Wisdom! Or to know the Ends and Purposes of his infinite Will, as if we were of his Council! No, let us bear in mind, that these Objections are the Products, not of Reason, but of Peevishness. They have been incommoded by Storms and Tempests; they have been terrified with the burning Mountains, and Earthquakes; they have been annoyed by the noxious Animals, and fatigued by the Hills; and therefore are angry, and will pretend to amend these Works of the Almighty. But in the Words of St. Paul,

Then having reckoned up many of the Priviledges and Benefits which the Gods, he saith, have conferred upon us, he concludes, *Ita est: carissimos nos habuerunt Dii immortales, habentque. Et qui maximus tribui bonos potuit, ab ipsis proximos collocaverunt. Magna accepimus, majora non cepimus.* Senec. ibid.

(13) *Naturam maxime admiraberis, si omnia ejus opera perlustraris.* Galen. de Us. Part I. 11. conclus.

(14) Rom.

Paul (14), we may say, *Nay, but, O Man, who art thou that repliest against God? Shall the thing formed say to him that formed it; Why hast thou made me thus? Hath not the Potter power over the Clay, of the same lump to make one Vessel to honour, and another to dishonour?* If the Almighty Lord of the World had for his own Pleasure made this our World more inconvenient for Man; it would better become us to sit still, and be quiet, to lament our own great infirmities and failings, which deserve a worser place, a more incommodious Habitation, than we meet with in this elegant, this well-contrived, well-formed World; in which we find every thing necessary for the Sustainment, Use and Pleasure both of Man, and every other Creature here below; as well as some Whips, some Rods to scourge us for our Sins (15). But yet so admirably well tempered is our State, such an accord, such an harmony is there throughout the Creation, that if we will but pursue the ways of Piety and Virtue, which God hath appointed, if we will form our Lives according to the Creator's Laws, we may escape the Evils

(14) Rom. 9. 20, 21.

(15) *Neither are they [noxious Creatures] of less Use to amend our Minds: by teaching us Care, and Diligence, and more Wit. And so much the more, the worse the things are, we see, and should avoid. Weesles, Kites, and other mischievous Animals, induce us to Watchfulness: Thistles and Moles, to good Husbandry. Lice oblige us to Cleanliness in our Bodies; Spiders in our Houses; and the Moth in our Clothes. The deformity and filthiness of Swine, make them the Beauty-spot of the Animal Creation, and the Emblems of all Vice.—The Truth is, things are hurtful to us, only by Accident; that is, not of Necessity, but through our own Negligence, or Mistake. Houses decay, Corn is blasted, and the Weevle breeds in Mault, soonest towards the South. Be it so, it is then our own fault, if we use not the means, which Nature and Art have provided against these Inconveniences. Grew's Cosmol. c. 2. §. 49, 50.*

Evils of this our frail State, and find sufficient means to make us happy whilst we are in the Body. The natural Force and Tendency of our Vertue will prevent many of the Harms (16), and the watchful Providence of our Almighty Benefactor will be a Guard against others; and then nothing is wanting to make us happy as long as we are in this World, there being abundantly enough to entertain the Minds of the most contemplative; Glories enough to please the Eye of the most curious and inquisitive; Harmonies and Consorts of Natures own; as well as Man's making, sufficient to delight the Ear of the most harmonious; all sorts of pleasant Gasts to gratify the Taste and Appetite even of the most luxurious; and fragrant Odours to please the nicest and tenderest Smell; and in a word, enough to make us love and delight in this World rather too much, than too little, considering how nearly we are allied to another World, as well as this.

(16) *Non est gemendus, nec gravi urgendus nece,
Virtute quisquis abstulit fati iter.*

Senec. Hercul. Oct. Act. 5. Car. 1833.

Nunquam Stygias fertur ad umbras

Incluta Virtus. Id. Ibid. Car. 1982.

B O O K

BOOK IV.

Of Animals in general.

IN the last Book having surveyed the Earth it self in particular, I shall next take a view of the Inhabitants thereof; or the several kinds of Creatures (1) that have their Habitation, Growth, or Subsistence thereon.

These Creatures are either sensitive, or insensitive Creatures.

In speaking of those endowed with Sense, I shall consider,

1. Some things common to them all.

2. Things peculiar to their Tribes.

1. The things in common, which I intend to take notice of, are these Ten.

1. The five *Senses*, and their Organs.

2. The great Instrument of Vitality, *Respiration*.

3. The *Motion*, or Loco-motive Faculty of Animals.

4. The

(1) *Principio cælum, ac terras, camposque liquentes,
Lucentemque globum Luna, Titaniaque astra
Spiritus intus alit, totamque infusa per artus
Mens agitat molem, & magno se corpore miscet.
Inde hominum, pecudumque genus, vitæque volantum
Et quæ marmoreo fert monstra sub æquore pontus.
Igneus est illis vigor, & cælestis origo
Seminibus.* Virgil. *Æneid.* L. 6.

4. The *Place*, in which they live and act.
 5. The *Balance* of their Numbers.
 6. Their *Food*.
 7. Their *Cloathing*.
 8. Their *Houses, Nests, or Habitations*.
 9. Their Methods of *Self-Preservation*.
 10. Their *Generation, and Conservation* of their Species by that means.
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C H A P. I.

Of the five Senses in general.

THE first thing to be considered in common to all the sensitive Creatures, is their faculty of *Seeing, Hearing, Smelling, Tasting, and Feeling*; and the *Organs* ministering to these five *Senses*, together with the exact Accommodation of those Senses and their Organs to the State and Make of every Tribe of Animals (2). The consideration of which Particulars alone, was there no other demonstrations of God, is abundantly sufficient to evince the infinite Wisdom, Power and Goodness of the great Creator. For who can but stand amazed at the Glories of these Works; at the admirable Artifice of them, and at their noble Use and Performances! For suppose an Animal, as such, had Breath and Life, and could move it self hither and thither; yet how could it know whither to go, what it was about, where to find its Food, how to avoid

(2) *Ex Sensibus ante cetera Homini Tactus, deinde Gustatus: reliquis superatur a multis. Aquilæ clarius cernunt: Vultures sagacius odorantur: liquidius audiunt Talpæ obruta terra, tam denso atque surdo naturæ elemento. Plin. Nat. Hist. l. 10. c. 69.*

(3) *Oculi,*

avoid thousands of Dangers (3), without Sight ! How could Man particularly, view the Glories of the Heavens, survey the Beauties of the Fields, and enjoy the Pleasure of beholding the noble Variety of diverting Objects, that do above us in the Heavens, and here in this lower World, present themselves to our view every where ; how enjoy this, I say, without that admirable sense of *Sight* (4) ! How could also the Animal without *Smell* and *Taste* distinguish its Food, and discern between wholesome and unwholesome ; besides the Pleasures of delightful Odours, and relishing Gusto's ! How without that other Sense of *Hearing*, could it discern many Dangers that are at a distance, understand the mind of others, perceive the harmonious Sounds of Musick, and be delighted with the Melodies of the winged Choir, and all the rest of the Harmonies the Creator hath provided for the Delight and Pleasure of his Creatures ! And lastly, how could Man, or any other Creature distinguish Pleasure from Pain, Health from Sicknes, and consequently be able to keep their Body sound and entire, without the sense of *Feeling* ! Here, therefore, we have a glorious Oeconomy in every Animal, that commandeth Admiration, and deserveth our Contemplation : as will better appear by coming to Particulars, and distinctly considering the Provision which the Creator hath made for each of these Senses.

C H A P.

(3) *Oculi, pars corporis pretiosissima, & qui lucis usu vitam distinguant a morte.* Plin. Nat. Hist. l. 11. c. 37.

(4) *Feminae aliquae Megarenses solis oculis discernere valebant inter Ova quæ ex Gallinâ nigrâ, & quæ ex albâ nata sunt.* Grimald. de Lumin. & Color. Pr. 43. §. 60.

C H A P. II.

Of the Eye.

FOR our clearer proceeding in the consideration of this noble Part (1), and understanding its Oeconomy, I shall consider,

1. The *Form* of the Eye.
2. Its *Situation* in the Body.
3. Its *Motions*.
4. Its *Size*.
5. Its *Number*.
6. Its *Parts*.
7. The *Guard* and *Security* Nature hath provided for this so useful a part.

As this eminent part hath not been pretermitted by Authors, that have made it their particular Design and Business to speak of the Works of God ; so divers of the aforesaid Particulars have been touched upon by them. And therefore I shall take in as little as possible of what they have said, and as near
as

(1) In Dissectionibus anatomicis vix aliquid admirabilius aut artificiosius, structura Oculi humani, meo quidem judicio, occurrit : ut merito per excellentiam Creatoris appelletur Miraculum. Gul. Fabr. Hildan. Cent. 2. Observ. 1.

So likewise that accurate Surveyor of the Eye, Dr. Briggs, whose *Ophthalmography* I have met with since my penning this part of my Survey. His Character of this curious Piece of God's Work is, *Inter præcipuas corporis animati partes, quæ magni Conditoris nostri sapientiam ostendunt nulla sane reperitur, quæ majori pompâ elucet quam ipse Oculus, aut quæ elegantiori formâ concinnatur. Dum enim aliæ partes vel minori satellitio stipantur, vel in tantam venustatem haud assurgunt ; Ocelli peculiarem honorem & decus a supremo Numine afflatum referunt, & nunquam non stupendæ suæ Potentiæ characteres repræsentant.* Nulla sanè pars tam divino artificio & ordine, &c. Cap. I. §. 1.

as I can, mention chiefly what they have omitted. And,

1. For the *Form* of the Eye; which is for the most part Globous, or somewhat of the sphaeroidal Form: Which is far the most commodious optical Form, as being fittest to contain the Humours within, and to receive the Images of Objects from without (2). Was it a Cube, or of any multangular Form, some of its Parts would lie too far off (3), and some too nigh those lenticular Humours, which by their Refractions cause Vision. But by means of the Form before-mentioned, the Humours of the Eye

(2) It is a good reason *Frier Bacon* assigns for the Sphaericity of the Eye: *Nam si esset plana figura, species rei majoris oculo non posset cadere perpendiculariter super eum. — Cum ergo Oculus videt magna corpora, ut ferè quartam cæli uno aspectu, manifestum est, quod non potest esse plana figura, nec alicujus nisi sphaerica, quoniam super Sphæram parvam possunt cadere perpendiculares infinitæ, quæ a magno corpore veniunt, & tendunt in centrum Sphære: Et sic magnum corpus potest ab Oculo parvo videri.* For the Demonstration of which he hath given us a Figure. *Rog. Bacon Perspect.*

• Distinct. 4. Cap. 4.

Dr. Briggs saith, *Pars antica, (five Cornea,) convexior est pesticâ: hâc enim ratione radii melius in pupillam detorquentur, & Oculi fundus ex alterâ parte in majorem (propter imagines rerum ibidem delineandos) expanditur.* Ibid. §. 2.

(3) Suppose the Eye had the Retina, or back-part flat for the Reception of the Images, as in *Fig. 1.* ABA it is manifest, that if the extremes of the Image AA were at a due focal Distance, the middle B would be too nigh the Crystalline, and consequently appear confused and dim; but all parts of the Retina lying at a due focal Distance from the Crystalline, as at ACA, therefore the Image painted thereon is seen distinct and clear. Thus in a dark Room, with a Lens at a hole in the Window, (which *Sturmius* calls his Artificial Eye, in his *Exercit. Acad.* one of which he had made for his Pupils, to run any where on Wheels. In this Room, I say,) if the Paper that receives the Images be too nigh, or too far off the Lens, the Image will be confused and dim; but in the Focus of the Glass, distinct, clear, and a pleasant Sight.

(4) *Blemmies*

Eye are commodiously laid together, to perform their Office of Refraction; and the *Retina*, and every other part of that little darkened Cell, is neatly adapted regularly to receive the Images from without, and to convey them accordingly to the common Sensory in the Brain.

To this we may add the Aptitude of this Figure to the Motion of the Eye. For as it is necessary for the Eye to move this way, and that way to adjust it self to the Objects it would view, so by this Figure it is well prepared for such Motions, so that it can with great facility and dexterity direct it self as Occasion requires.

And as the Figure, so no less commodious is,

2. The *Situation* of the Eye, namely in the Head (4), the most erect, eminent Part of the Body, near the most sensible, vital Part, the Brain. By its eminence in the Body, it is prepared to take in the more (5) Objects. And by its Situation in the Head, besides its Proximity to the Brain, it is in the most convenient place for Defence and Security. In the Hands, it might indeed (in Man) be rendered more eminent than the Head, and be turned about here and there at Pleasure. But then it would be exposed to many injuries in that active Part, and the Hands (6) rendered a less active and useful

(4) *Blemmyis traduntur capita abesse, Ore & Oculis pectori affixis.* Plin. Nat. Hist. l. 5. c. 8. *Occidentem versus quosdam sine cervice Oculos in humeris habentes.* Ib. l. 7. c. 2. From these, and other such like Fables, in this last cited Chapter, no doubt our famous Romancer Sir *J. Mandeville*, had his Romanick Stories, related in his Travels.

(5) See Book V. Chap. 2. Note 5.

(6) *Galen* deserves to be here consulted, who in his Book *De Usu Partium*, from many considerations of the Hand, such as what is here mentioned, as also its Structure, Site, and Use, largely proves and reflects upon the Wisdom and Providence of the Contriver and Maker of that Part.

(7) Thus

useful Part. And the like may be said to its Site in any other part of the Body, but where it is. But in the Head, both of Man, and other Animals, it is placed in a Part that seems to be contrived and made chiefly for the action of the principal Senses.

Another thing observable in the Site of the Eye, is the manner of its Situation in the Head, in the Fore-part, or Side-part thereof, according to the particular Occasions of particular Animals. In Man, and some other Creatures, it is placed to look directly forward chiefly, but withal it is so ordered, as to take in near the Hemisphere before it. In Birds, and some other Creatures, the Eyes are so seated, as to take in near a whole Sphere, that they may the better seek their Food, and escape Dangers. And in some Creatures they are seated, so as to see best behind them (7), or on each side, whereby they are enabled to see their Enemy that pursues them that way, and so make their escape.

And for the Assistance of the Eyes, and some of the other Senses in their Actions; the Head is generally made to turn here and there, and move as Occasion requires. Which leads me to the

3. Thing to be remarked upon, the *Motions* of the Eye it self. And this is generally upwards, downwards, backwards, forwards, and every way (8), for the better, more easy, and distinct Reception of the visual Rays.

But

(7) Thus in *Hares*, and *Coneys*, their Eyes are very protuberant, and placed so much towards the sides of their Head, that their two Eyes take in nearly a whole Sphere: whereas in *Dogs*, (that pursue them,) the Eyes are set more forward in the Head, to look that way, more than backward.

(8) *Sed lubricos Oculos fecit [Natura] & mobiles, ut & declinarent siquid noceret; & aspectum, quo vellent, facile converterent.* Cicer. de Nat. Deor. L. 2.

(9) The

But where Nature any way deviateth from this Method, either by denying Motion to the Eyes, or the Head (9), it is a very wonderful Provision she hath made in the Case. Thus for a remedy of this Inconvenience, in some Creatures their Eyes are sent out at a Distance (10) from the Head, to be circumvolved here and there, or one this, the other that

(9) *The Eyes of Spiders, (in some four, in some six, and in some eight,) are placed all in the fore front of their Head, (which is round, and without any Neck,) all diaphanous and transparent, like a Locket of Diamonds, &c. neither wonder why Providence should be so anomalous in this Animal, more than in any other we know of. For, 1. Since they wanting a Neck cannot move their Head, it is requisite that defect should be supplied by the multiplicity of Eyes. 2. Since they were to live by catching so nimble a Prey as a Fly is, they ought to see her every way, and to take her per saltum (as they do) without any Motion of the Head to discover her: which Motion would have scared away so timorous an Insect. Power's Microsc. Observ. pag. 11.*

The Eyes of the Camaleon resemble a Lens, or Convex Glass, set in a versatile globular Socket, which she turned backward, or any way, without moving her Head; and ordinarily the one a contrary, or quite different way from the other. Dr. Goddard in Phil. Trans. Nr. 137.

But what is more extraordinary in this Motion [of the Camaleon's Eye] is to see one of the Eyes move, whilst the other remains immoveable; and the one to turn forward, at the same time that the other looketh behind; the one to look up to the Sky, when the other is fixed on the Ground. And all these Motions to be so extreme, that they do carry the Pupilla under the Crest, which makes the Eye-brow, and so far into the Canthi, or Corners of the Eyes, that the Sight can discern whatever is done justly behind it, and directly before, without turning the Head which is fastened to the Shoulders. Mem. for a Nat. Hist. in Anatom. dissect. at Paris. Diff. of Camel. pag. 22.

(10) *Snails send out their Eyes at a Distance, they being contained in their four Horns, like atramentous Spots, fixed to the end of their Horns; or rather to the ends of those black Filaments or optick Nerves, which are sheathed in her Horns, as Dr. Power wordeth it. Obs. 31. pag. 36. So the ingenious Dr. Lister Exercit. Anat. Cochli. and Limac.*

(11) *Vid.*

that way, at Pleasure. And in Creatures, whose Eyes are without Motion, as in divers Insects, in this Case either they have more than two Eyes, or their Eyes are nearly two protuberant Hemispheres, and each Hemisphere often consisting of a prodigious Number of other little Segments of a Sphere (11). By which means those Creatures are so far from being denied any Benefit of that noble and most necessary Sense, of Sight, that they have probably more of it than other Creatures, answerable to the Rapidity of their Flight, and brisk Motion; and to their Inquests after Food, Habitation, or Repositories of Generation, or such other necessity of the Animal.

4. Another admirable Provision in the Eye is, its Size; in some Animals large, in some little. It would be endless here to enumerate Particulars; as those of Quadrupeds, Birds, Insects, and other Terrestrial Animals. And as for Fishes, they will fall under another part of my Survey.

I shall, therefore, only take notice of its Size in one Creature, the *Mole* (12). As the Habitation of that uncouth Animal is wholly Subterraneous, its Lodging,

(11) *Vid. l. 8. c. 3. Note I.*

(12) *Severinus* is of *Aristotle's*, *Pliny's*, and *Alb. Magnus's* Opinion, that the *Mole* hath no Sight; *G. Seger* denies any humour to be therein, but thinks they may probably see, because Nature made nothing in vain. But *Borrichius* saith, their Eyes have *appendiculam nerveam in cerebrum euntem* cujus beneficio globi illi [the little Eyes] *extra pellem facile poterant exseri, retrahique pro arbitrio.* — *In illis oculorum globulis humor aqueus copiose satis natabat; ceterorum non nisi tenue vestigium.* Blas. Anat. Anim. c. 35.

Et quoniam Natura hoc vitæ genus ipsi destinavit, etiam perquam exiguos Oculos — dedit eo consilio, ut ii, præciosissima corporis pars, a terræ pulvere ne affligerentur. Iti insuper pilis testæ, &c. Humores illis oculis insunt, & tunica nigra, uvea, se prodit. Ad hos tramite aliò nervus venit. Schneider in Blas. ibid.

Lodging, its Food, its Exercifes, nay, even all its Paftimes and Pleasures are in those Subterraneous Recesses and Passages, which its own Industry hath made for it self; so it is an admirable Provision made in the Size of the Eye of that little Creature, to answer all its Occasions, and at the same time to prevent Inconveniences. For as a little Light will suffice an Animal living always under Ground; so the smallest Eye will abundantly supply that Occasion. And as a large protuberant Eye, like that of other Animals, would much annoy this Creature in its principal Business, of digging for its Food and Passage; so it is endowed with a very small one, commodiously seated in the Head, and well fenced and guarded against the Annoyances of the Earth.

5. Another thing remarkable in this noble part of Animals is, its *Numbers*; not less than two (13) in
in

Some time since I made divers accurate Dissections of the *Eyes* of *Moles*, with the help of Microscopes, having a doubt whether what we take to be Eyes, were such or no. But upon a strict Scrutiny I plainly could distinguish the *Vitreous*, and *Crystalline* Humours, yea, the *Ligamentum Ciliare*, and the atramentaceous *Mucus*. The *Pupil* I could manifestly discern to be round, and the *Cornea* copped, or conical: The Eye is at a great Distance from the Brain, the Optick-Nerve very slender, and long, reaching from the Eye through the intermediate Flesh, and so passeth to the Brain, along with the pair of Nerves reaching to the Nose, which are much the largest in all the Animal. These Creatures, I imagine, have the faculty of withdrawing their Eyes, if not quite into the Head, as *Snails*, yet more or less within the Hair, as they have more or less occasion to use, or guard their Eyes.

Galen saith, *Moles* have Eyes, the *Crystalline* and *Vitreous* Humours, encompassed with *Tunicks*. *De Us. Part. l. 14. c. 6.* So accurate an Anatomist was he for his time.

(13) *Pliny* tells us of a sort of *Heron* with but one Eye, but 'twas only by hearsay. *Inter Aves Ardeolarum genere, quos Leu-*

in any instance, that I know of ; and in some Animals more, as I have already hinted (14.)

Now this is an admirable Provision ; first, for the Convenience of taking in the larger Angle or Space : And in the next place, the Animal is by this Provision, in some Measure, prepared for the Misfortune of the loss of one of these noble, and necessary Organs of its Body.

But then besides all this, there is another thing considerable in this multiplycate Number of the Eye ; and that is, that the Object seen is not multiplied as well as the Organ, but appears but one, though seen with two, or more Eyes (15). A manifest Sign of the infinite skill of the Contriver of this so noble a Part, and of the exquisite Art he employed

cos vocant, altero oculo carere tradunt. Nat. Hist. l. 11. c. 37. So the King of the *Nigra*, that hath but one Eye, and that in his Forehead. l. 6. c. 30.

(14) *Supra*, Note 9.

(15) The most celebrated Anatomists differ greatly about the reason why we see not double with two Eyes. This *Galen*, and others after him, generally thought to be from a Coalition or Decussation of the Optick Nerves, behind the *Os Sphænoides*. But whether they decussate, coalesce, or only touch one another, they do not well agree. The *Bartholines* expressly assert they are united, *non per simplicem contactum vel intersectionem in homine, sed totalem substantiæ confusionem.* Anat. l. 3. c. 2. And whereas *Vesalius*, and some others had found some Instances of their being disunited ; they say, *Sed in plerisque ordinariè confunditur interior substantia, ut accuratâ disquisitione deprehendi.*

But our learned Dr. Gibson, (*Anat. l. 3. c. 10.*) saith, they are united by the closest Conjunction, but not Confusion of their Fibres.

But others think the reason is not from any coalescence, contact, or crossing of the Optick-Nerves, but from a Sympathy between them. Thus Monsieur *Cartes* is of Opinion, that the *Fibrillæ* constituting the medullary Part of those Nerves, being spread in the *Retina* of each Eye, have each of them corresponding Parts in the Brain ; so that when any of those *Fibrillæ* are struck by any part of an Image, the corresponding Parts of the Brain

employed in the formation thereof. But the Design and Skill of the infinite Workman, will best be set forth by

6. Surveying the *Parts* and *Mechanism* of this admirable Organ the Eye. And here indeed we cannot but stand amazed, when we view its admirable Fabrick, and consider the prodigious exactness, and the exquisite Skill employed in every part ministering to this noble and necessary Sense.
To

Brain are thereby affected, and the Soul thereby informed, &c. but see more hereafter under Note (38), from *Cartes* himself.

Somewhat like this is the Notion of our judicious Dr. Briggs, who thinks the Optick-Nerves of each Eye consist of *Homologous Fibres*, having their rise in the *Thalamus Nervorum Opticorum*, and thence continued to both the *Retinae*, which are made of them: And farther, that those *Fibrillae* have the same Parallelism, Tension, &c. in both Eyes; and consequently when an Image is painted on the same corresponding, sympathizing Parts of each *Retina*, the same Effects are produced, the same Notice or Information is carried to the *Thalamus*, and so imparted to the Soul, or judging Faculty. That there is such an *Ὀμοιοπιδεία* between the *Retinae*, &c. he makes very probable from the ensuing of double Vision upon the Interruption of the Parallelism of the Eyes; as when one Eye is depressed with the Finger, or their Symphony interrupted by Disease, Drunkenness, &c. And lastly, that simple Vision is not made in the former way, viz. by a Decussation or Conjunction of the Optick-Nerves, he proves, because those Nerves are but in few Subjects decussated, and in none conjoined otherwise than by a bare Contact, which is particularly manifest in Fishes; and in some Instances it hath been found, that they have been separated without any double Vision ensuing thereupon. Vid. Brig. *Ophthalmogr.* cap. 11. & 5. and *Nov. Vis. Theor.* passim.

After the same manner our justly eminent Sir Isaac Newton, Are not the Species of Objects seen with both Eyes united where the Optick-Nerves meet before they come into the Brain, the Fibres on the right side of both Nerves uniting there, &c. For the Optick-Nerves of such Animals as look the same way with both Eyes, (as of Men, Dogs, Sheep, Oxen, &c.) meet before they come into the Brain; but the Optick-Nerves of such Animals as do not look the same way with both Eyes, (as of Fishes, and of the Chameleon,) do not meet, if I am rightly informed. Newt. Opt. Q. 15.

(16) Nigra

To pass by its Arteries and Veins, and such other parts common to the rest of the Body, let us cast our Eye on its *Muscles*. These we shall find exactly and neatly placed for every Motion of the Eye. Let us view its *Tunicks*; and these we shall find so admirably seated, so well adapted, and of so firm a texture, as to fit every place, to answer every occasion, and to be proof against all common Inconveniences, and Annoyances. Let us examine its three *Humours*; and these we shall find all of exquisite Clearness and Transparency, for an easy admission of the Rays; well placed for the refracting of them, and formed (particularly the *Crystalline Humour*) by the nicest Laws of Opticks, to collect the wandering Rays into a point. And to name no more, let us look into its darkned Cell, where those curious Humours lie, and into which the glories of the Heavens and the Earth are brought, and exquisitely Pictured; and this Cell we shall find, without, well prepared by means of its Texture, Aperture, and Colour, to fence off all the useless, or noxious Rays; and within, as well coated with a dark Tegument, that it may not reflect, dissipate, or any way confuse, or disturb the beneficial Rays (16).

But to descend to Particulars, although it would be a great Demonstration of the Glory of God, yet would take up too much time, and hath been in some Measure done by others, that have written of God's Works. Passing over therefore what they have

(16) *Nigra est [Uvea] ut radios (ab Oculi fundo ad anteriorem ejus partem reflectos) obumbret; ne hi (ut ait clar. Cartesius) ad Oculi fundum retorti ibidem confusam visionem efficerent. Alia forsitan ratio hujus nigredinis statuatur, quod radii in visione superflui, qui ab objectis lateralibus proveniunt hoc ritu obsterbeantur. Ita enim e loco obscuro interdum objecta optime intuemur, quia radii tunc temporis circumfuso lumine non diluuntur.* Brigg's Opthal. c. 3.

have observed, I shall under each principal Part take a transient Notice of some things they have omitted, or but slightly spoken of.

And my first Remark shall be concerning the *Muscles* of the Eye, and their *Æquilibration*. Nothing can be more manifestly an act of Contrivance and Design, than the *Muscles* of the Eye, admirably adapted to move it any, and every way; upwards, downwards, to this side, or that, or howsoever we please, or there is occasion for, so as to always keep that Parallelism of the Eye which is necessary to true Vision. For the performance of which Service, the Form, the Position, and the due Strength of each Muscle is admirable. And here I might instance in the peculiar and artificial Structure of the *Trochlearis*, and the Augmentation of its Power by the *Trochlea* (17); the Magnitude and Strength of the *Attollent Muscle*, somewhat exceeding that of its Antagonist; the peculiar Muscle called the *Seventh*, or *Suspensory Muscle* (18), given to Brutes, by reason of the prone Posture of their Bodies, and frequent Occasions

(17) *Admirandum Dei artificium ex diversorum animalium comparatione indies evadit manifestius. Mirantur omnes Trochlearem in oculis Hominum & Quadrupedum, & quidem jure: sed admirationem omnem superat, quod sine Trochlea oculum movens in Avibus novum genus Trochleæ longè artificiosius Nititandi Membrana dederit.* Blas. Anat. Animal. p. 2. c. 4. ex Stenon.

[Musculum Trochlearem] per intermediam trochleam traductum, nunquam intueor, quin admirabundus mecum, Ὁ Θεός, exclamem, ὃ μόνον αἰεὶ γεωμετρεῖ, ἀλλὰ καὶ αἰεὶ μηχανᾶται. I. C. Sturmii Exercit. Acad. 9. de Vis. Org. & Rat. c. 3. §. 4. pag. 446.

(18) *Observare est quod Quadrupedes, qui oculos in terram pronos, ac pendulos gerunt, Musculum peculiarem habent, quo Oculi globus suspenditur. — Hoc Musculo Bos, Equus, Ovis, Lepus, Porcus, &c. prædita sunt: hoc etiam Canis instruitur, sed alio modo conformatum habet.* Willis de An. Brut. p. 1. c. 13.

Of this Opinion also was Bartholine, Anat. l. 3. c. 8. and divers other eminent Anatomists.

Occasions to hang down their Heads : and I might speak also of the peculiar Origine, and Insertion of the *lower oblique Muscle* (19), which is very notable, and many other things relating to these Parts : but it would be tedious to descend too much to those admirable Particulars. And therefore to close up these Remarks, all I shall farther take Notice of, shall be only the exquisite Equilibration of all these *Opposite and Antagonist Muscles*, effected partly by the equality of their Strength ; which is the case of the *Adducent and Abducent Muscles* : partly by their peculiar Origine, or the addition of the *Trochlea* ; which is the case of the *Oblique Muscles* (20) : and partly by the natural Posture of the Body, and the Eye ; which is the case of the *Attollent and Depri-*
ment

But Dr. Briggs is of Opinion that the *Adnata*, and the Muscles sufficiently answer all those Ends ascribed to that Muscle by former Anatomists, and thinks *Probabilis itaque esse hunc Musculum nervi Optici actionem (per vices) confirmare, ne a prono Brutorum incessu & copioso affluxu humorum debilitetur.* Opthal. c. 2. §. 2.

The *Musculus Suspensorius* being in the *Porpeß*, as well as Brutes, Dr. Tyson thinks the Use of it is not to suspend the bulk of the Eye ; but rather by its equal Contraction of the *Sclerotis*, to render the Ball of the Eye more or less Spherical, and so fitter for Vision. *Tyson's Anat. of the Porpeß*, pag. 39.

(19) *Musculus obliquus inferior* oritur a peculiari quodam foramine in latere Orbitæ ocularis facto (contra quam in cæteris, &c.) quo fit ut ex unâ parte a Musculo trochleari, ex alterâ verò ab hujus Musculi commodissimâ positione, Oculus in æquilibrio quodam constitutus, irretorto obtutu versus objecta feratur, nec plus justo accedat versus internum externumve canthum ; quæ quidem Libratio omnino nulla fuisset, absque hujus Musculi peculiari originatione (cujus ratio omnes huc usque Anatomicos latuit.) And so this curious Anatomist goes on to shew farther the stupendous Artifice of the great Creator in this Position of the *Oblique Muscles*. *Brigg's Nova Vis. Theor.* pag. 11. meo libro.

(20) Besides those particular Motions which the Eye receives from the *Oblique Muscles*, and its Libration also in some Measure, some Anatomists ascribe another no less considerable Use to them ; namely, to lengthen and shorten the Eye (by squeezing

ment Muscles. By this so curious and exact a Libration, not only unseemly Contortions, and incommodious Vagations of the Eye are prevented, but also it is able with great readiness, and exactness to apply it self to every Object.

As to the *Tunicks* of the Eye, many things might be taken Notice of, the prodigious fineness of the *Arachnoeides*, the acute Sense of the *Retina*, the delicate Transparency of the *Cornea* (21), and the firm and strong Texture of that, and the *Sclerotica* too; and each of them in these, and every other respect in the most accurate manner adapted to the place in which it is, and the business it is there to perform. But for a Sample, I shall only take Notice of that part of the *Uvea* which makes the *Pupil*. It hath been observed by others, particularly by our Honourable Founder (22), That as we are forced to use various Apertures to our optick Glasses, so Nature hath made a far more compleat Provision in the Eyes of Animals, to shut out too much, and to admit sufficient Light, by the Dilatation and Contraction of the *Pupil* (23). But it deserveth our especial Remark, that these Pupils are in divers
Animals

and compressing it) to make it correspond to the Distances of all Objects, according as they are nigh, or far off. Thus the ingenious Dr. Keil; *The Aqueous Humour being the thinnest, and most liquid, easily changeth its Figure, when either the Ligamentum ciliare contracts, or both the Oblique Muscles squeeze the middle of the Ball of the Eye, to render it Oblong when Objects are too near us.* Keil's Anat. Chap. 4. Sect. 4. See Note 22.

(21) *Quis vero Opifex præter Naturam, quâ nihil potest esse callidius, tantam solertiam persequi potuisset in Sensibus? quæ primum Oculos membranis tenuissimis vestivit, & septit; quas primum perlucidas fecit, ut per eas cerni posset: firmas autem, ut continerentur.* Cicer. de Nat. Deor. L. 2.

(22) *Boyl of Final Causes.*

(23) It is easy to be observed, that the *Pupil* openeth in dark Places; as also when we look at far distant Objects, but contracts
by

Animals of divers Forms, according to their peculiar Occasions. In some (particularly in Man) it is round; that being the most proper Figure for the Position of our Eyes, and the Use we make of them both by Day and Night. In some other Animals it is of a longish Form: in some Transverse (24), with its Aperture large; which is an admirable Provision for such Creatures to see the better laterally, and thereby avoid Inconveniencies, as well as to help them to gather their Food on the Ground, both by Day and Night. In other Animals the Fissure of the Pupil is erect (25), and also capable of opening wide, and shutting up close. The

by an increase of Light, and when Objects are nigh. This Motion of the Pupil some say, is effected by the circular and straight Fibres of the *Uvea*, and some attribute it to the *Ligamentum Ciliare*. But I have no great doubt but that they both concur in that Action, and that the *Ligamentum Ciliare* doth, at the same time the Pupil opens or shuts, dilate or compress the *Crystalline*, and bring it nigher unto, or carry it farther off the *Retina*. For the Structure of the *Ligamentum Ciliare*, and its two Sorts of Fibres, drawn with the help of a Microscope, I shall refer to Mr. Comper's *Anat.* T. II.

(24) In Bove, Capra, Equo, Ove, & quibusdam aliis elliptica est [Pupilla] ut eo magis in hisce forsan animalibus, quæ prono incessu victum in agris quæritant, radios laterales ad mala & incommoda utrinque devitanda admittat. Briggs's *Opthal.* c. 7. §. 6.

Homini erecto, aliisque, &c. caput erigere, & quaquaversus circumspicere solitis, plurima simul objecta, tum supra, tum infra, tum e latere utroque — visu excipiuntur; quapropter Oculi Pupilla rotunda esse debet. — Attamen Bovi, &c. caput ferè semper prorum — gerentibus, tantùm quæ coràm, & paulo a latere obversantur, intuitu opus est: quapropter Pupilla — oblonga est, &c. Willis's *de Anim. Brut.* p. 1. c. 15.

(25) Thus in Cats, whose Pupils being erect, and the shutting of their Eye-lids transverse thereto, they can so close their Pupil, as to admit of, as it were, one only single Ray of Light; and by throwing all open, they can take in all the faintest Rays. Which is an incomparable Provision for these Animals, that have occasion to watch and way-lay their Prey both Day and Night.

The latter of which serveth to exclude the brighter Light of the Day ; and the former to take in the more faint Rays of the Night, thereby enabling those Nocturnal Animals (in whom generally this erect Form of the Pupil is) to catch their Prey with the greater facility in the dark (26), to see upwards and downwards, to climb, &c. Thus much for the *Tunicks*.

The next thing I shall take Notice of, will relate to the *Humours* of the Eye, and that only concerning the Mechanism of the *Crystalline Humour* ; not its incomparable Transparency ; nor its exact lenticular Form ; nor its curious Araneous Membrane,

(26) There is besides this large opening of the Pupil in some Nocturnal Animals, another admirable Provision, enabling them to catch their Prey in the dark, and that is a Radiation of the Eyes. Of which Dr. *Willis* thus : *Hujus usus est Oculi Pupillam, quasi jubari insito illuminare, ut res noctu, & in tenebris positas conspiciere valeat : quare in Felle plurimum illustris est : at Homini, Avibus, & Piscibus deest.* This Illumination he speaks of, is from the *Tapetum* in the bottom of the Eye, or the Shining of the *Retina* round the Optick-Nerve.

Besides which, he saith, the *Iris* hath a Faculty also, in some, of darting out Rays of Light, so as to enable them to see in the dark. Of which he tells this Story ; *Novi quendam cerebro calidiori præditum, qui post uberiores vini generosi potum in nocte atrata, sive tenebris profundis, literas distinctè legere potuit. Cujus ratio videtur esse, quod spiritus animales velut accensi, adeoque ab hac Iride irradiantes, jubare insito Medium illuminabant.* *Willis* *Ibid.*

Such another thing *Pliny* tells us was reported of *Tiberius Caesar*. *Ferunt Tib. Cæs. nec alii genitorum mortalium, fuisse naturam, ut expergescens noctu paulisper, haud alio modo quàm luce clara, contueretur omnia.* *Nat. Hist. l. 11. c. 37.*

So Dr. *Briggs*. *Virum sanè calidæ indolis novi in comitatu Bedfordiensi degentem, qui Oculis felineis — donatus est ; adeo ut epistolam — mirè admodum in loco obscuro (ubi eadem mihi vix apparuit) perlegit. Hujus verò Oculi (nisi quod Pupillas insigniores obtinuerent) ab aliorum formatione neutiquam discrepabant.* *Ophthal. c. 5. §. 12.*

(27) The

Membrane (27), that constringeth and dilateth it, and so varieth its Focus, (if any such Variation there

(27) The *Tunica Aranea* is taken notice of by Frier Bacon, who calls it *Tela Aranea*, and saith in *hâc continetur — glaciale vel Crystallinum*. Rog. Bacon's *Perspect. Distinct.* 2. c. 3. The wrinkling of this, and the *Cornea* (as the Skin is of old Persons) he thinks is the cause of the obscurity of the Sight in such Persons. Bacon. *Ibid.* par. 2. cap. 2. But this *Tunick* some deny, and others allow of: Dr. A. M. of Trinity College, Dublin, (in his *Relat. of Anat. Observ.* in the Eyes of Animals in a Letter to Mr. Boyle, Anno. 1682. annexed to his *Anat. Account of the Elephant burnt in Dublin*, pag. 57.) affirms the *Tunica Aranea*, and saith, *I have often seen it before 'twas exposed to the Air one Minute, notwithstanding what Dr. Briggs saith to the contrary, &c.* But Dr. Briggs his Opinion is, *Humor Crystallinus, nisi aeri diutius expositus, vel lenitèr coctus (instar lactis) cuticulam non acquirit: quæ verò improprie Tunica aranea dicitur, cum sit tantum adventitia, ut in Oculo Bovis recens execto appareat.* Briggs's *Ophthalm.* c. 3.

The *Crystalline Humour* being of a double Substance, outwardly like a Gelly, towards the Center as consistent as Suet, upon occasion whereof its Figure may be varied; which Variation may be made by the *Ligamentum Ciliare*, Dr. Grew doth, upon these Accounts, not doubt to ascribe to the *Ligamentum Ciliare* a power of making the *Crystalline* more Convex, as well as of moving it to, or from the *Retina*. See Grew's *Cosmolog. Sacr.* l. 1. c. 4. Now it is certain by the Laws of Opticks, that somewhat of this is absolutely necessary to distinct Vision, inasmuch as the Rays proceeding from nigh Objects do more diverge, and those from distant Objects less: which requires either that the *Crystalline Humour* should be made more Convex, or more Flat; or else an Elongation or Shortening of the Eye, or of the Distance between the *Crystalline Humour* and the *Retina*.

But although Dr. Briggs (so good a Judge) denies the *Tunica Crystallina*, contrary to the Opinion of most former Anatomists, yet there is great reason to conclude he was in a Mistake, in my Opinion, from the Observations of the French Anatomists of the *Crystalline* of the Eye of the Gemp or Chamois, who say, The *Membrana Arachnoides* was very thick, and hard, so that it was easily separated from the *Crystallinus*, pag. 145.

The same Anatomists also favour the Surmise of Dr. Grew. This [Contraction of the Fibres of the *Ligamentum Ciliare* on one side, and Dilatation on the other] would make us think that these

there be, as some affirm with great probability,) nor lastly, its admirable approach to, or from the *Retina*, by help of the *Ciliar Ligament* (28), according as Objects are far off or near, because these things

Fibres of the Ligamentum Ciliare are capable of a Contraction and voluntary Dilatation, like to that of the Fibres of the Muscles; and that this Action may augment or diminish the Convexity of the Crystallinus, according as the need which the Distance of the Objects may make it to have on the Eye to see more clearly and distinctly. Anat. Descript. of a Bear, pag. 49.

Since my penning the foregoing Notes, having as critically as I could, dissected many Eyes, I manifestly found the *Membrana Arachnoides*, and will undertake to shew it any one, with great ease and certainty. It is indeed so Transparent, as not to be seen distinct from the *Crystalline*. But if the *Cornea* and *Uvea* be taken off before, or the *Vitreous Humour* behind it, and the out-side of the *Crystalline* be gently flashed, the *Arachnoides* may be seen to open, and the *Crystalline* will easily leap out, and part from the *Ligamentum Ciliare*; which otherwise it would not do. For it is by the *Arachnoides* braced to the *Ligamentum Ciliare*. This Membrane or Tunick, in the Ox, is so substantial and strong, though thin, that it yields to, or sinks under the sharpest Lancet, and requires (for so thin and weak a Membrane in appearance) a strong Pressure to pierce it.

(28) As Birds and Fishes are in divers things conformable, so in some Sort they are in their Eye; to enable it to correspond to all the Convergencies and Divergencies of the Rays, which the Variations of each of the Mediums may produce. For this service the *Tunica Choroeides* in Fishes hath a musculous Substance at the bottom of it, lying round the Optick-Nerve at a small Distance from it: by which means I imagine they are able to contract and dilate the *Choroeides*, and thereby to lengthen and shorten the Eye. For the helping in which service I imagine it is that the *Choroeides* and *Sclerotica* are in a great Measure parted, that the *Choroeides* may have the greater Liberty of acting upon the Humours within.

But in Birds, although the *Choroeides* be parted from the *Sclerotica*, yet the *Choroeides* hath no Muscle, but instead thereof a curious pectinated Work seated on the Optick-Nerve, represented in Fig. 2. In which *c. a. e. b. d.* represents the *Choroeides*, and *Sclerotica*: *a. b.* the part of the Optick-Nerve that is within the Eye: *v. v. v.* the *Vitreous Humour*: *a. f. g. b.* the *Pecten*: *b. i.* the *Crystalline*. For the reception of this *Pecten*, the Optick

things are what are usually taken Notice of: but that which I shall observe is, the prodigious Art and Finery

tick-Nerve comes farther within the Eye, than in other Creatures. The Structure of this *Peſten* is very like that of the *Ligamentum Ciliare*, and in the Eye of a *Magpy*, and some others, I could perceive it to be musculous towards the bottom. This *Peſten* is so firmly fixed unto, or embodied in the *Vitreous Humour*, that the *Vitreous Humour* hangs firmly to it, and is not easily parted from it. By which means all the Motions of the *Peſten* are easily communicated to the *Vitreous Humour*, and indeed to all contained in the *Choroeides*. And forasmuch as the *Crystalline* is connected to the *Vitreous Humour*, therefore all the Alterations in the *Vitreous Humour* affect also the *Crystalline*; and the *Crystalline* is hereby brought nearer unto, or farther from the *Retina*, as occasion is.

Besides all which observables in the *Choroeides* and inner Eye, there is this farther remarkable in the *Sclerotica* and outer-part of the Eye of Birds, viz. That the fore-part of the *Sclerotica* is horny and hard, the middle-part thin and flexible, and *Braces* intervene between the fore and hind-part, running between the *Choroeides* and *Sclerotica*. By which means the *Cornea* and Back-part of the Eye are brought to the same Conformity, that the rest of the Eye hath.

The great End and Design of this singular and curious Apparatus in the Eyes, both of Birds and Fishes I take to be, 1. To enable those Creatures to see at all Distances far off, or nigh; which (especially in the Waters) requireth a different Conformation of the Eye. In Birds also, this is of greatest Use, to enable them to see their Food at their Bill's end, or to reach the utmost Distances their high Flights enable them to view; as to see over great Tracts of Sea or Land, whether they have occasion to fly; or to see their Food, or Prey, even small Fishes in the Waters, and Birds, Worms, &c. on the Earth, when they sit upon Trees, high Rocks, or are hovering high in the Air. 2. To enable those Animals to adapt their Eye to all the various Refractions of their *Medium*. Even the Air it self varies the Refractions, according as it is rarer or denser, more or less compressed; as is manifest from the learned and ingenious Mr. *Lowthorp's* Experiment in *Phil. Trans.* Nr. 257. and some other Experiments since of the before-commended Mr. *Hawksbee*, both in natural, rarified, and compressed Air; in each of which the Refractions constantly varied in exact Proportion to the rarity or density of the Air. *Vid. Hawksbee's Exp.* pag. 175, &c.

Besides

Finery of its constituent Parts, it being, according to some late nice Microscopical Observations (29), composed of divers thin Scales; and these made up of one single minuteſt Thread, or Fibre, wound round and round, ſo as not to croſs one another in any one place, and yet to meet, ſome in two, and ſome in more different Centers. A Web not to be woven, an *Optick-Lens* not to be wrought, by any Art leſs than infinite Wiſdom.

Laſtly, To conclude the Parts of this admirable Organ, I ſhall make only one Remark more, and that is about its *Nerves*. And here among others, the admirable make of the *Optick-Nerves* might deſerve to be taken Notice of in the firſt place, their
Medullary

Befides this Conformity in general between the Eyes of Birds and Fiſhes, *Du Hamel* tells us of a ſingular Conformity in the *Cormorant's* Eye, and that is, that the *Crystalline* is globous, as in Fiſhes, to enable it to ſee and purſue its Prey under Water: which *J. Faber*, in *Mr. Willughby* ſaith, they do with wonderful ſwiftneſs, and for a long time. *Will. Ornithol. pag. 329.*

(29) The *Crystalline Humour*, when dried, doth manifeſtly enough appear to be made up of many very thin ſpherical *Laminae*, or Scales lying one upon another. *Mr. Leewenhoek* reckons there may be 2000 of them in one *Crystalline*, from the outermoſt to the Center. Every one of theſe Scales, he ſaith, he hath diſcovered to be made up of one ſingle Fiber, or fineſt Thread wound, in a moſt ſtupendous manner, this way, and that way, ſo as to run ſeveral Courſes, and to meet in as many Centers, and yet not to interfere, or croſs one another in any one place. In *Oxen*, *Sheep*, *Hogs*, *Dogs*, and *Cats*, the Thread ſpreads into three ſeveral Courſes, and makes as many Centers: in *Whales* five; but in *Hares* and *Rabbits* only two. In the whole Surface of an *Ox's Crystalline*, he reckons there are more than 12000 Fibres juxta-poſited. For the right and clear underſtanding of the manner of which admirable piece of Mechanifm, I ſhall refer to his Cuts and Descriptions in *Philos. Tranſact. Nrs. 165* and 293. The Truth hereof I have heard ſome ingenious Men queſtion. But it is what I my ſelf have ſeen, and can ſhew to any Body, with the help of a good Microſcope.

Medullary Part (30) terminating in the Brain it self, the Teguments propagated from the *Meninges*, and terminating in the Coats of the Eye; and their commodious Insertions into the Ball of the Eye; in some directly opposite to the Pupil of the Eye; in others obliquely towards one side (31). But most of these things have been treated of, and the Convenience hereof set forth by others that have written of God's Works. I shall therefore take notice only of one wise Provision the Creator hath made about the Motion of the Eye, by uniting into one the *Third Pair* of Nerves, called the *Motory-Nerves* (32); each of which sending its Branches into each Muscle of each Eye, would cause a Distortion in the Eyes; but being united into one, near their Insertion into the Brain, do thereby cause both Eyes to have the same Motion; so that when one Eye is moved this way, and that way to this, and that Object, the other Eye is turned the same way also.

Thus

(30) *S. Malpighi* observed the middle of the *Optick-Nerve* of the *Sword-Fish*, to be nothing else but a large Membrane folded according to its Length in many Doubles, almost like a Fan, and invested by the *Dura mater*: whereas in Land-Animals it is a bundle of Fibres. *V. Philos. Transf. Nr. 27.*

(31) *Certissimum est, quod in omnibus Oculis Humanis (quos saltem mihi dissectare contigit) Nervus Opticus Pupillæ e diametro opponitur, &c. Briggs's Opthal. c. 3. §. 15. Ita Willis de Anim. Brut. p. 1. c. 15.*

Nervi Optici in Nobis, item in Canis, Fele (& in cæteris forsan animalibus calidis) ad fundum Oculi delati Pupillæ regioni prospiciunt, dum interim in aliis Quadrupedibus, uti etiam in Piscibus, & Volucris oblique semper Tunica Sclerodi inseruntur. Unde, &c. Will. ib. c. 7. §. 11.

(32) *This Pair is united at its Rise; whence is commonly drawn a reason why one Eye being moved towards an Object, the other is directed also to the same. Gibson's Anat. Book III. Chap. 11. So Bartholine Anat. Libellus 3. c. 2.*

(33) Among

Thus from this transient and flite View (I may call it) of the Parts of the Eye, it appears what an admirable Artift was the Contriver thereof. And now in the

7th and laſt Place, Let us conſider what Proviſion this admirable Artift hath made for the *Guard* and *Security* of this ſo well formed Organ (33). And here we ſhall find the guard Equivalent to the Uſe

(33) Among all the other Security the Eye hath, we may reckon the Reparation of the *Aqueous Humour*. By which means the Eye when wounded, and that in all appearance very dangerously too, doth often recover its Sight. Of which *Bern. Verzaſcha* gives divers Examples Ancient and Modern. One is from *Galen* of a Boy ſo wounded, that the *Cornea* fell, and became flaccid, but yet recovered his Sight. Other ſuch like Inſtances alſo he gives from *Realdus Columbus*, *Rhodius*, and *Tulpius*: and one that he cured himſelf in theſe Words, *Ego in Nobiliſſimi viri Filiolâ ſimilem caſum obſervari: hæc dum levibus de cauſis cum Fratre altercaret, iſte iracundiâ percitus cultellum Scriptorium apprehendit, & ſororis oculo vulnus infligit, unde humor aquens effluxit. Vocatus præſentem Chirurgum juſſi ſequens collyrium anodynum & exſiccans tepidè ſæpiùs admovere. R. aq. Plantag, ʒiv Roſar. Sanicul. Euphraſ. aa ʒi Trochiſc. alb. Rhaſ. cum Opio ʒii Tutia ppp ʒi Croci orient. ʒſs. M. Hoc Collyrium inflammationem compeſcuit, vulnus ſiccavit & ſanavit. Hinc poſt aliquot menſes Humor aquens ſuccevit. Nam Viſus, ſed debilior cum ſummo Parentum gaudio rediit.* B. Verzaſchæ Obſerv. Medicæ. Obſ. 14.

Another Cure of this kind was experimented by Dr. Daniel Major upon a *Goose*, Ann. 1670. the *Aqueous Humour* of both whoſe Eyes they let out, ſo that the Eyes fell, and the *Goose* became quite Blind. But without the uſe of any Medicine, in about two Days time, Nature repaired the watery Humour again, the Eyes returned to their former Turgency, and the *Goose* was in a Week after produced ſeeing before twenty-eight or thirty Spectators. *Ephem. Germ. T. 1. Add. ad Obſ. 117.*

From the ſame cauſe I doubt not it was that the Eye of a Gentleman's Daughter, and thoſe of a Cock, when wounded, ſo that the *Cornea* ſunk, were reſtored by a *Lithuanian* Chymiſt, that paſſed for a Conjuror, by the Uſe of a Liquor found in *May*, in the *Veficulæ* of *Elm*. Of which ſee Mr. *Rays's Catal. Cantab.* in *Ulmus*, from *Hern. ab Heers*.

Use and Excellency of the Part. The whole Organ fortified, and fenced with strong, compact Bones, lodged in a strong, well-made Socket, and the Eye it self guarded with a nice-made Cover (34). Its Humours, and its inward Tunicks, are indeed tender,

(34) *Palpebræ, quæ sunt tegumenta Oculorum, molliſſimæ taſtu, ne læderent aciem, aptiſſimæ factæ, & ad claudendas Pupillas, ne quid incideret, & ad aperiendas; idque providit, ut identidem fieri poſſet cum maximâ celeritate. Munitæque ſunt Palpebræ tanquam vallo pilorum: quibus & apertis oculis, ſiquid incideret, repellere-tur, & ſomno conniventibus, cum Oculis ad cernendum non egeri-mus, ut qui, tanquam involuti, quieſcerent. Latent præterea uti-litèr, & excelsis undique partibus ſapiuntur. Primum enim ſupe-riora Superciliis obduſta ſudorem a capite, & fronte deſluentem re-pellunt. Genæ deinde ab inferiore parte tutantur ſubjectæ, levitèr-que eminentes. Cicer. de Nat. Deor. L. 2.*

Tully, in the Person of a Stoick, having ſo well accounted for the Use of the Eye-lids, I ſhall for a farther Maniſtation of the Creator's Contrivance and Structure of them, take notice of two or three things. 1. They conſiſt of a thin and flexible, but ſtrong Skin; by which means they the better wipe, clean, and guard the *Cornea*. 2. Their edges are fortified with a ſoft *Car-tilage*; by which means they are not only enabled the better to do their Office, but alſo to cloſe and ſhut the better. 3. Out of theſe Cartilages grow a Palliſade of ſtiff Hairs, of great Uſe to warn the Eye of the Invaſion of Dangers, to keep off Motes, and to ſhut out too exceſſive Light, &c. and at the ſame time to ad-mit of (through their Internals) a ſufficient paſſage for Objects to approach the Eye. And it is remarkable, that theſe Hairs grow but to a certain, commodious Length, and need no cut-ting, as many other Hairs of the Body do: Alſo, that their Points ſtand out of the way, and in the upper-lid bend upwards, as they do downwards in the lower-lid, whereby they are well adapted to their Uſe. From which laſt obſervables we may learn, how critical and nice the great Author of Nature hath been in even the leaſt and moſt trivial Conveniences belonging to Animal Bodies; for which reaſon I have added it to Tully's Remarks. And more might have been added too, as particu-larly concerning the curious Structure and Lodgment of the *Right-Muſcle*, which opens the Eye lids; and the *Orbicularis* or *Circular* one, that ſhuts them: the nice Apparatus of Glands, that keep the Eye moiſt, and ſerve for *Tears*; together with the
reaſon

der, proportionate to their tender, curious Uses: but the Coats, without, are context and callous, firm and strong. And in some Animals, particularly

reason why Man alone, who is a sociable Animal, doth exhibit his social Affections by such outward Tokens, as *Tears*; the *Nerves* also, and other Organs acting in this Ministry. I might also speak of the Passages for discharging the superfluous Moisture of the Eyes through the Nostrils, and much more of the like kind. But it would take up too much room in these Notes; and therefore it shall suffice to give only such Hints, as may create a Suspicion of a noble Oeconomy and Contrivance in this (I had almost said) least considerable part of the Eye. But for Particulars I shall refer to the Anatomists; and for some of these things, particularly to Dr. Willis's *Cerebr. Anat.* and *De Anim. Brut.* and Mr. Comper's *Elegant Cuts* in the 11 *Tab.* of his *Anatomy*.

To the Eye-lids we may add another guard afforded the Eyes of most Quadrupeds, Birds, and Fishes, by the *nictitating Membrane*, which Dr. Willis gives this Account of, *Plurimis [Animalibus] quibus Musculus Suspensorius adest* (which Limitation he needed not to have added) *etiam alter Membranosus conceditur, qui juxta interiorem Oculi canthum situs, quando elevatur, Oculi globum ferè totum obtegit. Hujus usus esse videtur, ut cum Bestiæ inter gramina, &c. capita sua propter victum capeffendum demergunt, hic Musculus Oculi Pupillam, ne a stipularum incursu feriatur, occultit munitque.* De Anim. Brut. p. 1. c. 15.

This Membrane Man hath not, he having little Occasion to thrust his Head into such places of Annoyance, as Beasts, and other Animals have; or if he hath, he can defend his Eyes with his Hands. But Birds, (who frequent Trees and Bushes,) and Quadrupeds, (Hedges, and long Grass,) and who have no part ready, like the Hand, to fence off Annoyances; these, I say, have this incomparable Provision made for the safety of their Eyes. And for Fishes, as they are destitute of Eye-lids, because in the Waters there is no Occasion for a Defensative against Dust and Motes, offensive to the Eyes of Land-Animals, nor to moisten and wipe the Eyes, as the Eye-lids do; so the Nictitating-Membrane is an abundant Provision for all their Occasions, without the Addition of the Eye-lids.

And now, if we reflect, are these the Works of any thing but a wise and indulgent Agent?

larly Birds (35), some part of those Tunicles have the nature, and hardness of Bone, or Horn.

But for Creatures, whose Eyes, like the rest of their Body, are tender, and without the guard of Bones; there Nature hath provided for this necessary, and tender Sense, a wonderful kind of Guard, by endowing the Creature with a faculty of withdrawing its Eyes into its Head (36), and lodging them in the same safety with the Body.

Thus have I surveyed this first Sense of Animals, I may say in a cursory, not accurate, strict manner, considering the prodigious Workmanship thereof; but so as abundantly to demonstrate it to be the Contrivance, the work of no less a Being than the infinitely Wise, Potent, and indulgent Creator (37). For none less could compose so admirable an Organ, so adapt all its Parts, so adjust it to all Occasions, so nicely provide for every Use, and for every Emergency: In a word, none less than GOD could I say thus contrive, order, and provide an
Organ,

(35) Although the hardness and firmness of the *Adnata* or *Sclerotica* in Birds is a good guard to their Eyes, yet I do not think it is made thus so much for a Defence, as to minister to the lengthening and shortening the Eye, mentioned before in *Note 27*.

(36) *Cochleis oculorum vicem Cornicula bina prætentu implent.* Plin. Nat. Hist. l. II. c. 37. See more of the Eyes of *Snailles* before in *Note 10*: and in *Note 11* I said that I suspected *Moles* also might thrust out, or withdraw their Eyes more or less within the Hair and Skin.

(37) The diligent *Sturmius* was fully perswaded there could not be any speculative Atheism in any one that should well survey the Eye. *Nobis, faith he, fuit persuasissimum, Atheismum, quem vocant, Speculativum, h. e. obfirmatam de Deitate in Universo nulla persuasionem, habere locum aut invenire non posse in eo homine qui vel unius corporis organici, & speciatim Oculi, fabricam attento animo inspexerit.* Sturm. Exerc. Acad. 9. De Vis. Organ. & Rat. in Epilogo.

(38) The

Organ, as magnificent and curious, as the Sense is useful. A Sense without which, as all the Animal World would be in perpetual Darkneſs, ſo it would labour under perpetual Inconveniencies, be expoſed to perpetual Harms, and ſuffer perpetual Wants and Diſtreſſes. But now by this admirable Sense, the great *GOD* who hath placed us in this World, hath as well provided for our comfortable Residence in it; enabled us to ſee, and chuſe whoſome, yea delicate Food, to provide our ſelves uſeful, yea gaudy Cloathing, and commodious Places of Habitation and Retreat. We can now diſpatch our Affairs with Alacrity and Pleaſure; go here and there as our Occaſions call us. We can, if need be, ranſack the whole Globe, penetrate into the Bowels of the Earth, deſcend to the Bottom of the Deep, travel to the fartheſt Regions of this World, to acquire Wealth, to encrease our Knowledge, or even only to pleaſe our Eye and Fancy. We can now look about us, diſcern and ſhun the Precipices, and Dangers, which every where encloſe us, and would deſtroy us. And thoſe glorious Objects which fill the Heavens and the Earth, thoſe admirable Works of God which every where ſurround us, and which would be as nothing to us without being ſeen, do by means of this noble Sense preſent their Glories to us (38), and fill us with Admiration and Pleaſure. But I need not expatiate in the Uſefulneſs and Praises

(38) The glorious Landſkips, and other Objects that preſent themſelves to the Eye, are manifeſtly painted on the *Retina*; and that not erect, but inverted as the Laws of Opticks require, and is manifeſt to the Eye, from *Monſieur Cartes* Experiment, of laying bare the Vitreous Humour on the back-part of the Eye, and clapping over it a bit of white Paper, or the ſkin of an Egg; and then placing the fore-part of the Eye to the hole of the Window of a darkened Room. By which means we have a pretty Landſkip of the Objects abroad invertedly painted on the

Praises of this Sense, which we receive the Benefit of every Moment, and the want, or any defect of which, we lament among our greatest Misfortunes.

Leaving then this Sense, I shall proceed to the other Four, but more briefly treat of them, by reason we have so ample a Sample of the divine Art in the last, and may presume that the same is exerted in all as well as one. For a Demonstration of which, let us in the next place carry our Scrutiny to the Sense of *Hearing*.

I

C H A P.

the Paper, on the back of the Eye. But now the question is, how in this case the Eye comes to see the Objects erect? *Monsieur Cartes's* answer is, *Notitia illius ex nullâ imagine pendet, nec ex ulla actione ab objectis veniente, sed ex solo situ exiguarum partium cerebri, e quibus Nervi expullulant.* — *E. g. cogitandum in Oculo* — *situm capillamenti nervi optici,* — *respondere ad alium quendam partis cerebri* — *qui facit ut anima singula loca cognoscat, quæ jacent in rectâ, aut quasi rectâ lineâ; ut ita mirari non debeamus corpora in naturali situ videri, quamvis imago in oculo delineata contrarium habeat.* *Dioptr. c. 6.* But our most ingenious *Mr. Molyneaux* answereth thus, *The Eye is only the Organ or Instrument, 'tis the Soul that sees by means of the Eye. To enquire then how the Soul perceives the Object erect, by an inverted Image, is to enquire into the Soul's Faculties.* — *But erect and inverted are only Terms of Relation to up and down, or farther from, or higher to the Center of the Earth, in parts of the same thing.* — *But the Eye, or visive Faculty takes no notice of the internal Posture of its own Parts, but useth them as an Instrument only, contrived by Nature for the exercise of such a Faculty.* — *Let us imagine, that the Eye [on its lower Part] receives an impulse [by a Ray from the upper Part of an Object] must not the visive Faculty be necessarily directed hereby to consider this Stroke, as coming from the top rather than the bottom [of the Object] and consequently be directed to conclude it the Representation of the Top? Hereof we may be satisfied, by supposing a Man standing on his Head. For here, though the upper Parts of Objects are painted on the upper Parts of the Eye, yet the Objects are judged to be Erect. What is said of Erect and Reverse, may be understood of Sinister and Dexter.* *Molyneaux's Dioptr. Nov. Part 1. Prop. 28.*

C H A P. III.

Of the Sense of Hearing.

CONCERNING the Sense of *Hearing*, I shall take Notice of two things; the Organ, the *Ear*; and its Object, *Sound*.

I. For the Organ, the *Ear*. I shall pass by its convenient Number of being double, which (as in the last Sense) serves for the commodious Hearing every way round us; as also is a wise Provision for the utter Loss, or Injury (1) of one of the Ears. But I shall a little insist upon its Situation, and its admirable Fabrick and Parts.

I. It

(1) I presume it will not be ungrateful to take Notice here of the admirable, as well as useful Sagacity of some deaf Persons, that have learnt to supply their want of *Hearing* by understanding what is said, by the Motion of the Lips. My very ingenious Friend Mr. Waller, R. S. Secr. gives this Account, *There live now, and have from their Birth, in our Town, a Man, and his Sister, each about fifty Years Old, neither of which have the least Sense of Hearing, — yet both these know by the Motion of the Lips only whatever is said to them, and will answer pertinently to the Question proposed to them. — The Mother told me they could hear very well, and speak when they were Children, but both lost that Sense afterwards, which makes them retain their Speech: though that, to Persons not used to them, is a little uncouth and odd, but intelligible enough.* Phil. Trans. Nr. 312.

Such another Instance is that of Mr. Gody, Minister of St. Gervais in Geneva, his Daughter. She is now about sixteen Years old. Her Nurse had an extraordinary thickness of Hearing: at a Year Old, the Child spake all those little Words that Children begin to speak at that Age. — At two Years Old they perceived she had lost her Hearing, and was so Deaf, that ever since, though she hears great Noises, yet she hears nothing that one can speak to her. — But by observing the Motions of the Mouth and Lips of others, she hath acquired so many Words, that out of these she hath formed a sort of Jargon, in which she can hold Conversation whole

1. It is situated in the most convenient part of the Body, (like as I said the Eye is,) in a part near the common Sensory in the Brain, to give the more speedy Information; in a part where it can be best guarded, and where it is most free from Annoyances and Harms it self, and where it gives the least Annoyance, and Hindrance to the Exercises of any other part; in a part appropriated to the peculiar use of the principal Senses; in the most lofty, eminent part of the Body; where it can perceive the most Objects, and receive the greatest Information: And lastly, in a part in the neighbourhood of its Sister Sense the Eye; with whom it hath peculiar and admirable Communication by its Nerves, as I intend to shew in its proper place. In respect then of its Situation and Place in the Body, this Sense is well designed and contrived, and may so far be accounted the Work of some admirable Artist. But,

2 If we survey its Fabrick and Parts, it will appear to be an admirable Piece of the divine Wisdom, Art and Power. For the Manifestation of which, let us distinctly survey the outward, and the inward Part of this curious Organ.

1. For the *outward Ear*. If we observe its Structure in all kinds of Animals, it must needs be acknowledged

whole Days with those, that can speak her own Language. I could understand some of her Words, but could not comprehend a Period, for it seemed to be but a confused Noise. She knows nothing that is said to her, unless she seeth the Motion of their Mouths that speak to her; so that in the Night, when it is necessary to speak to her, they must light a Candle. Only one thing appeared the strangest Part of the whole Narration: She hath a Sister, with whom she hath practised her Language more than with any other: And in the Night by laying her Hand on her Sister's Mouth, she can perceive by what she saith, and so can discourse with her in the Night.
 Bishop Burnet's Let. 4. pag. 248.

known to be admirably Artificial; it being so nicely prepared, and adjusted to the peculiar Occasions of each respective Animal. In Man (2), it is of a form proper for the erect Posture of his Body. In Birds, of a form proper for Flight; not protuberant, because that would obstruct their Progress, but close and covered, to afford the easier passage through the Air. In Quadrupeds, its Form is agreeable to the Posture, and slower Motion of their Bodies: and in these too, various, according to their various Occasions. In some large, erect, and open, to hear the least approaches of Dangers (3). In others covered,

(2) I cannot but admire that our most eminent modern Anatomists should not agree, whether there be any Muscles in the outward Ear of Man or not. Dr. Keil saith, there are two; Dr. Drake the same Number; and Dr. Gibson makes them to be four: So also doth Monsieur Dionis, and so did the ancient Anatomists. But Dr. Schelhammer expressly denies there are any, and saith, *Seduxit autem reliquos Brutorum Anatome, in quorum plerisque tales Musculi plures inveniuntur; putarunt autem fortassis ignominiosum Homini, si non & his instructus esset, & minus inde perfectum animal fore.* Schel. de Audit. p. 1. c. 1. §. 7. But Valsalva, who wrote very lately, and is very accurate in his Survey of the Ear, saith, *Musculi Ariculæ posteriores quandoque quatuor, quandoque duo; sed ut plurimum tres adnotantur; & quando solum duo se manifestant, tunc unus ex illis duplicato tendine versus Concham deferri solet.* Horum musculorum in numero varietatem non solum in diversis; verum etiam in eodem subiecto quandoque vidi.—Ex quibus differentiis suborta sunt Auctorum discrepantia in horum Musculorum numero, & positu:—quod non evenisset, si pluries in diversis Corporibus iidem Musculi quæsiti essent. Ant. Mar. Valsalva de Aur. Human. c. 1. §. 6. But Dr. Drake thinks some of Valsalva's Muscles the product of Fancy. Mr. Comper makes them to be three, one Attollent, and two Retrabent Muscles. See Anat. Tab. 12.

(3) *Inter cetera [animalia aurita] maximè admirabilis est auris Leporinæ fabrica, quod cum timidissimum animal sit, & prorsus inerme, natura id tum auditu acutissimo, tanquam hostium exploratore ad persentienda pericula, tum pedibus ceu armis ad currendum aptis munisse videtur.* A. Kircher's Phonurg. l. 1. §. 7. Technol. 2.

(4) Moles

covered, to keep out noxious Bodies. In the subterraneous Quadrupeds, who are forced to mine, and dig for their Food, and Habitation, as a protuberant Ear, like that of other Quadrupeds, would obstruct their Labours, and be apt to be torn and injured; so they have the contrary (4), their Ears short, lodged deep, and backward in their Head, and passing

(4) *Moles* have no protuberant Ear, but only a round Hole between the Neck and Shoulder; which Situation of it, together with the thick short Furr that covers it, is a sufficient Defensive against external Annoyances. The *Meatus Auditorius* is long, round, and cartilaginous, reaching to the under part of the Skull. Round the inside runs a little Ridge resembling two Threads of a Skrew, at the bottom whereof is a pretty Inlet, leading to the Drum, made on one side with the aforefaid cochleous Ridge, and on the other with a small Cartilage. I observed there was *Cerumen* in the *Meatus*.

As to the *inner Ear* it is somewhat singular, and different from that of other Quadrupeds, and much more from Birds, although I have met with some Authors that make it agreeing with that of Birds. There are three small Bones only (all Hollow) by which the Drum (to use the old Appellation) or the *Membrana Tympani* (as others call it) acteth upon the *Auditory Nerve*. The first is the *Malleus*, which hath two Processes, nearly of equal Length; the longer of which is braced to the *Membrana Tympani*, the shorter to the side of the Drum or *Os Petrosum*; the back part of it resembles the Head and Stalk of a small *Mushroom*, such as are pickled. On the back of the *Malleus* lies the next small Bone, which may be called the *Incus*, long, and without any Process, having somewhat the form of the short Scoop wherewith Waterman throw the Water out of their Wherries. To the end of this, the third and last small Bone is tacked by a very tender Brace. This little Bone bears the Office of the *Stapes*, but is only forked without any Base. One of these Forks is at one *Fenestra*, or *Foramen*, the other at another; in which *Fenestræ* I apprehend the Forks are tacked to the *Auditory Nerve*. These *Fenestræ* (equivalent to the *Fenestra Ovalis*, and *Rotunda* in others) are the Inlets into the *Cochlea* and *Canales Semicirculares*, in which the *Auditory Nerve* lieth. The *Semicircular Canals* lie at a Distance from the Drum, and are not lodged (as in other Animals) in a strong thick Body of Bone, but are thrust out with

passing to the under part thereof, and all sufficiently fenced and guarded. And as for Insects, Reptiles, and the Inhabitants of the Waters; if they enjoy this Sense, (as there is great reason to think they do,) it may probably be lodged commodiously under the same Security and Guard, as the Smelling, or some other Sense is.

And moreover, as the Form of this Organ is various in various Animals, so in each of them its Structure is very curious and observable, being in all admirably contrived to collect the wandering, circumambient Impressions, and Undulations of Sound, and to convey them to the Sensory within. If I should run over the several Genera of Animals, we might find a notable Prospect of the Handy-Work of God (5), even in this so inconsiderable part of Animals. But I shall only carry my Survey to
that

in the Skull, making an *Antrum*, with an handsome *Arch* leading into it, into which a part of the Brain enters.

One Leg of the *Malleus* being fastened to the *Membrana Tympani*, and the *Incus* to the back of the *Malleus*, and the top of that to the top of the *Stapes*, and the Forks or Branches of the *Stapes* to the *Auditory Nerve*, I observed that whenever I moved the Membrane, all the little Bones were at the same time moved, and consequently the *Auditory Nerve* thereby affected also.

I hope the Reader will excuse me for being so particular in this Organ only of the *Mole*, a despised Creature, but as notable an example of God's Work, as its Life is different from that of other Quadrupeds; for which reason it partly is that I have enlarged on this part differing from that of others, and which no Body that I know of, hath taken much notice of, and which is not discoverable without great Patience and Application; and partly because by comparing these Observations with *Book VII. Chap. 2. Note 4.* we may judge how the Sense of Hearing is performed.

(5) Among many Varieties, both in the inner, and outer Ear, those which appear in the Passage into the Rock-bone, are remarkable. For in an Owl, that perches on a Tree or Beam, and hearkens after the Prey beneath her; it is produced farther out above, than it is below,

that of Man. And here the first thing that offereth it self to our View is the *Helix*, with its tortuous cavities, made to stop, and collect the sonorous Undulations, to give them a gentle Circulation and Refraction, and so convey them to the *Concha*, or larger and more capacious round Cell at the entrance of the Ear. And to bridle the Evagation of the Sound, when arrived so far, but withal not to make a Confusion thereof, by any disagreeable Repercussions, we may take notice of a very curious Provision in those little Protuberances, called the *Tragus*, and *Antitragus* of the outward Ear, of a commodious Form and Texture (6), and conveniently lodged for this Use. The great Convenience and Benefit of this Form and Contrivance of the outward Ear, is sufficiently manifest by the want thereof, which causeth a *confusion in the Hearing*, with a certain *Murmur*, or *Swooning* like the fall of *Waters* (7).

Another

below, for the better Reception of the least Sound. But in a Fox, that scouteth underneath the Prey at Roost; it is for the same reason, produced farther out below. In a Pole-Cat, which hearkeneth straight forward, it is produced behind, for the taking of a forward Sound. Whereas in an Hare, which is very quick of hearing, and thinks of nothing but being pursued, it is supplied with a bony Tube; which as a natural Otocoustick, is so directed backward, as to receive the smallest, and most distant Sound that comes behind her. Grew's Cosmolog. Sacr. lib. 1. c. 5. §. 6.

(6) The Texture of the *Tragus* and *Antitragus*, is softer than that of the *Helix*; which serveth gently to blunt, not forceably to repel the Sound in the *Concha*.

(7) Dr. Gibson's Anatomy, Chap. 22. Book III.

Those whose Ears are cut off, have but a confused way of Hearing, and are obliged either to form a Cavity round the Ear with their own Hands, or else to make use of a Horn, and apply the end of it to the inner Cavity of the Ear, in order to receive the agitated Air. 'Tis likewise observed, that those whose Ears jut out, hear better than flat-eared Persons. Monsieur Dionis's Anat. Demonstr. 8.

Another wise Provision of the Creator is in the Substance of the outward Ear, which is Cartilaginous, the fittest for this place. For (as an ingenious Anatomist (8) observes) "if it had been Bone, it would have been troublesome, and might by many Accidents have been broken off: If Flesh, it would have been subject to Contusion". But indeed a worse Consequence than this would have ensued such a softness as that of Flesh, and that is, it would neither have remained expanded, neither would it so kindly receive and circulate the Sounds, but absorb, retard, or blunt their Progress into the inward Organ. But being hard, and curiously smooth and tortuous, Sounds find an easy passage, with a regular Volution and Refraction; as in a well-built Arch, Grotto, or musical Instrument, which magnify and meliorate Sounds; and some of which convey even a whisper to a large Distance (9). But from the outward, let us carry our Survey,

2. To

(8) *Gibb. ibid.*

(9) It would nauseate the Reader to reckon up the places famed for the Conveyance of Whispers, such as the Prison of *Dionysius* at *Syracuse*, which is said to encrease a Whisper to a Noise; the clapping ones Hands to the Sound of a Cannon, &c. nor the *Aqueducts* of *Claudian*, which carry a Voice sixteen Miles, and many others both Antient and Modern. If the Reader hath a mind to be entertained in this way, he may find enough in *Kircher's Phonurgia*. But it may not be irksome to mention one or two of our own in *England*. Among which, one of the most famed is the *Whispering-place* in *Glocester Cathedral*; which is no other than a Gallery above the East-end of the Choir, leading from one side thereof to the other. It consisteth, (if I mistake not) of five Angles, and six Sides, the middle-most of which is a naked, uncovered Window, looking into a Chapel behind it. I guess the two Whisperers stand at about twenty-five Yards Distance from one another. But the *Dome* of *St. Paul's, London*, is a more considerable *Whispering-place*, where the

2. To the inward part of this admirable Organ. And here we find the most curious and artful Provision for every Emergency and Occasion. The *auditory Passage*, in the first place, curiously tunnelled, and artfully turned, to give Sounds an easy Passage, as well as a gentle Circulation and Refraction; but withal, so as to prevent their too furious rushing in, and assaulting the more tender parts within.

And forasmuch as it is necessary that this Passage should be always open, to be upon the Watch (10), therefore to prevent the Invasion of noxious Insects, or other Animals, (who are apt to make their retreat in every little Hole,) Nature hath secured this Passage (11) with a bitter nauseous Excrement (12), afforded

the Ticking of a Watch (when no Noise is in the Streets) may be heard from Side to Side; yea, a Whisper may be sent all round the Dome. And not only in the Gallery below, but above, upon the Scaffolds, I tried, and found that a Whisper would be carried over one's Head round the top of the Arch, notwithstanding there is a large Opening in the middle of it into the upper part of the Dome.

(10) *Auditus autem semper patet: ejus enim sensu etiam dormientes egemus. A quo cum sonus est acceptus, etiam e somno excitamur. Flexuosum iter habet, ne quid intrare possit, si simplex, & directum pateret; provisum etiam, ut, siqua minima bestiola conaretur irrumperere, in sordibus aurium, tanquam in visco, inhaeresceret.* Cicero. de Nat. Deor. L. 2.

It deserves a particular Remark here, that in Infants in the Womb, and newly Born, the *Meatus Auditorius* is shut up very closely, partly by the Constriction of the Passage, and partly by a glutinous Substance, whereby the *Tympanum* is guarded against the Water in the *Secundine*, and against the injuries of the Air as soon as the Infant is Born.

(11) It is remarkable, that in most, if not all Animals, whose Ears are tunnelled, or where the *Meatus Auditorius* is long enough to afford harbour to *Ear-wigs*, or other Insects; that, I say, in the Ears of such, *Ear-wax* is constantly to be found. But in Birds, whose Ears are covered with Feathers, and where the *Tympanum* lies but a little way within the Skull, no *Ear-wax*

(12), afforded from the Glands (13) appointed for that purpose.

From hence let us approach the most inward Parts, in which we shall see Strokes of the most exquisite Art. To pass over the *innate Air* that most Authors talk of (14), (because there is no such) the passage to

is found, because none is necessary to Ears so well guarded, and so little tunnelled.

(12) The *Ear-wax* was thought by the old Anatomists to be an Excrement of the Brain: *Humor biliosus a cerebro expurgatus*, the Bartholines say of it. L. 3. c. 9 But as Schelhammer well observes, *Nil absurdius, quam cerebri excrementum hoc statuere. Nam & ratio nulla suadet, ut in cerebro fieri excrementum tale credamus: — neque via patent per quas ab eo seclusum in meatum auditorium possit inde penetrare.* As to its Taste, Casserius gives Instances of its being Sweet in some Creatures. But Schelhammer says, *Ego vero semper cum amaritie aliquid dulcedinis in illo deprehendi.* Vid. Schel. de Audit. p. 1, c. 2. §. 10 But I could never distinguish any Sweetness in it; but think it insipid mixed with a Bitterness.

(13) *Cerumina amara Arteriolis exudantia.* Willis's de Anim. Brut. par. 1. c. 14. In the Skin — are little Glands, which furnish a yellow and bitter Humour. Monsieur Dionis's Dem. 18. An handsome Cut of those *Glandulæ ceruminosæ* is in Dr. Drake, from *Valsalva*.

Pliny attributes great Vertue to the *Ear-wax*; *Mursus hominis inter asperissimos numeratur: medentur sordes ex auribus: ac ne quis miretur, etiam Scorpionum ictibus Serpentiumque, statim impositæ.* Plin. Nat. Hist. l. 28. c. 4. And that it hath an healing Quality, and may be accounted a good Balsam, I my self have experienced.

(14) That there is such a thing as the *innate Air*, (talked of much by most Authors on this Subject,) Schelhammer very justly, I think, denies; by reason there is a passage into the inner Ear from the Throat, through which the innate Air may pass out, and the outward Air enter in. V. Par. Alt. p. 2. c. 1. §. 10. When by stopping our Breath, and Straining, we force the external Air into the Ear, it may be heard rushing in; and if much be forced in, it may be felt also to bear against the *Tympanum*. When the passage to the Throat is by any means stop'd, as by a Cold in the Head, &c. the Hearing thereby becomes dull and blunt; by reason the Communication between the outward and

to the Palate (15), and their Uses, with divers other curious things that might be named, let us stop a little at the part containing the rest, namely, the Bone (16). The particular texture and hardness of which above other Bones of the Body is very remarkable, whereby it serves not only as a substantial Guard to the Sensory, but also to oppose the Impulses of the æthereal Matter, that there may be no loss, nor confusion of the Sound; but that it may

and inward Air, are obstructed: but when by strong Swallowing, or such like Motion of the Throat, the passage is opened, we perceive it by a sudden Smack or Crack, and we immediately hear very clearly; the load of feculent Air, being at that time discharged from the inner Ear.

It is a wise Provision, that the passage for the Air into the Ear, is from the Throat; *Ut non statim quivis aer externus irrumpere queat* (as Schelhammer saith, *Part Ult. c. 4. §. 8.*) *sed nonnihil immutatus, ac temperatus, calore ex medio ventre expirante; imo fortassis non facile alius, nisi ex pulmonibus.*

(15) *Valsalva* hath given us a more accurate Description of the *Tuba Eustachiana*, or Passage to the Palate, than any other Author, to whom I therefore refer. *De Aur. Human. c. 2. §. 16, &c.*

The chief Use hereof he thinks is to give way to the inner Air, upon every Motion of the *Membrana Tympani*, the *Malleus*, *Incus*, and *Stapes*. This passage, if it be shut up, Deafness ensues. Of which he gives two Instances: one a Gentleman, who lost his Hearing by a Polypus in the Nose reaching to the *Uvula*; the other a Yeoman, labouring with an Ulcer above the left side of the *Uvula*; which when he stopt with a Tent dipped in Medicine, he lost his Hearing in the left Ear, and recovered it, as soon as the Tent was out. *Ibid. c. 5. §. 10.*

(16) *Os [petrosum] ex quo interiores singularum [Labyrinthi] cavitatum parietes conflati sunt, album, durissimum, necnon maxime compactum. Id autem a Naturâ ita comparatum esse videtur, ut materia ætherea Sonorum objectorum impressionibus onusta, dum prædictis impingitur Parietibus, nihil aut saltem ferè nihil motus sui amittat, atque adeo illum qualem ab Objectis sonoris accepit, talem communicet Spiritui animali contento intra expansiones rami mollioris Nervorum Auris.* Dr. Raym. Vieussens of Montpellier, in *Phil. Trans. Nr. 258.*

may be conveyed regularly, and intirely to the Auditory Nerves.

The next part I shall take notice of, may be that fine Membrane, called the *Tympanum*, or *Membrana Tympani* (17), with its inner Membrane (18); together with the four little appendant Bones (19), and the three inner Muscles to move them, and adjust the

(17) The *Tympanum* of the Ear, or as *Valsalva* and the Moderns, the *Membrana Tympani* was taken notice of as early as *Hippocrate's* time. In Birds, it is strained towards the outward Parts; in other Animals towards the Brain, or inner Parts. *Monsieur Dionis* saith, It is not equally fastened to the whole Circumference of the bony Circle, in which it is incased; for on the upper side it hath a free disengag'd Part, by which some can give vent to the Smoak in their Mouth. *Demonstr. 8.* That there is some passage I doubt not, but I question whether *Monsieur Dionis* ever saw the disengaged part he mentions. I have my self carefully searched divers Subjects, and do not remember to have seen any such passage; and I perceive it escaped the diligent *Schelhammer's* Eye. *Valsalva* also by injecting in through the *Tuba Eustachiana*, could not force any Liquor into the *Meatus Auditorius*. But yet he imagines he found the passage out in another place of the Drum, in some morbid, and one sound Head. *Valsalv. de Aur. Hum. c. 2. §. 2.* Mr. *Cowper* also affirms there is a passage by the upper part of the Membrane. *Anat. Ap. Fig. 8.*

(18) Dr. *Vieussens* before-named, discovered a Membrane, *tenuissima raraque admodum texture intra cavitatem Tympani*; as he describes it. Whose use he saith is, 1. *Occludens Labyrinthi januam impedit ne naturalis purissimus ac subtilissimus Aer intra cavitates — communicationem — habeat cum aere crasso.* 2. *Labyrinthi basin calefacit, &c. ubi supra.* Probably this double Membrane may be such, or after the same manner as it is in the *Tympanum* of Birds: Of which see my Observations in *Book VII. Chap. 2. Note 4.*

(19) The four little Bones being treated of by all that have concerned themselves about this Sense of Hearing since their discovery, I shall take notice of only two things concerning them. 1. The discovery of them is owing wholly to the Diligence and Sagacity of the latter Ages; of which *Schelhammer* gives this Account from *Fallopious*. *Hæc Ossicula antiquis Anatomicis — ignota fuere; primusque qui in lucem produxit [Malleum & Incum] fuit Jac. Carpentis; primus quoque procul omni dubio anatomica*

the whole Compages to the several purposes of Hearing, to hear all manner of Sounds, loud or languid, harsh or grateful (20).

From

anatomica artis, quam Vesalius postea perfecit, restaurator. Tertium [Stapedem] invenit ac promulgavit primus Joh. Phil. ab Ingrassia, Siculus, Philosophus ac Medicus doctissimus. — Quartum, Thomas Bartholino teste, viro longè celeberrimo, Fran. Sylvio debetur. Schel. ubi supr. c. 3. §. 9. 2. Their Difference in different Animals: In Man, and Quadrupeds, they are four, curiously inarticulated with one another; with an external and internal Muscle to draw, or work them, in extending, or relaxing the Drum. But in Fowls the case is very different. His unum Ossiculum solum largita est Natura, quod columellam forte adpellaveris: teres enim est & subtilissimum, basi innitens latiori, rotundæ. Huic adnexa est Cartilago valde mobilis, quæ in Tympanum videtur terminari. Id. ib. §. 8. In the Ears of all the Fowl that I could examine, I never found any more than one Bone and a Cartilage, making a Joynt with it, that was easily moveable. The Cartilage had generally an Epiphyse, or two, one on each side. — The Bone was very hard and small, having at the end of it a broad Plate, of the same Substance, very thin, upon which it rested, as on its Basis. Dr. Al. Moulen in Phil. Transf. Nr. 199.

These are the most material things I find observed by others concerning the Ears of Fowls, and some of them hardly, I believe, observed before. To which I shall subjoin some other things I have my self discovered, that I presume escaped the Eyes of those most curious and inquisitive Anatomists. Of which see the last-cited Book VII. Chap. 2. Note 4.

(20) *Videtur quod Tympanum Auditionis instrumentum praliminare, & quasi preparatorium fuerit, quod Soni impressionem, sive species sensibiles primo suscipiens, eas in debitâ proportionem, & aptâ conformitate, versus Sensorium, quod adhuc interius situm est, dirigat: simili officio fungitur respectu Auditûs, ac tunica Oculi Pupillam constituentes respectu Visûs; utraque Membrana Species sensibiles refringunt, & quasi emolliunt, easque Sensorio non nisi proportionatas tradunt, cui nudo si adveniant, teneriorem ejus eras in faciliè lædant, aut obruant. Revera Tympanum non audit, sed meliori tutiorique Auditioni confert. Si hæc pars destruat, Sensio adhuc aliquandiu, rudi licet modo, peragi possit; quippe experimento olim in Cane factò, &c. — Janitoris officio ut Tympanum rectè defungi possit, expansum ejus pro datâ occasione stringi, aut relaxari debet, veluti nimirum Oculi Pupilla. — Quapropter huic Auris Tympano, non secus ac bellico, machinæ, sive taniæ quadam apponuntur,*

From this Region of the *Tympanum*, I might pass to

nuntur, quæ superficiem ejus modo tensiorem, modo laxiorem reddant: hoc enim efficiunt tria Officula, cum Musculo, &c. Willis's de Anim. Brut. c. 14.

For this Opinion of Dr. *Willis*, Dr. *Schelhammer* is very severe upon him, deriding the Refractions he speaks of; and therefore seriously proves that they are the Humours, not Tunicks of the Eye, that refract the Rays of Light; and then jeeringly demandeth, whether the sonorous Rays are refracted by passing through a different Medium? Whether the Convexity or Concavity of the Drum collects those Rays into a focal Point, or scatter them, &c? And then saith, *Ob has rationes a clariss. Viri, ac de re Medicâ præclare meriti, sententiâ non possumus non esse alienores; in quo uti ingenium admiror, quoties medicamentorum vires, aut morborum causas explicat, sic ubi forum suum egressus, Philosophum agit, ac vel Partium usum, vel Chymicarum rerum naturam scrutetur, ejus haud semel non modo judicium desidero, verum aliquando etiam fidem.* This is so severe and unjust a Censure of our justly famous Countryman, (a Man of known Probity,) that might deserve a better answer; but I have only time to say, that although Dr. *Schelhammer* hath out-done all that wrote before him, in his Book *de Auditu*, and shewed himself a Man of Learning and Industry; yet as our Countryman wrote more than he, (though perhaps not free from Errours too,) so he hath manifested himself to have been as curious and sagacious an Anatomist, as great a Philosopher, and as learned and skilful a Physician as any of his Censurers, and his Reputation for Veracity and Integrity, was no less than any of theirs too. But after all this terrible Clamour, Dr. *Schelhammer* prejudicately mistaketh Dr. *Willis's* meaning, to say no worse. For by *utraq; Membrana refringunt*, Dr. *Willis* plainly enough, I think, means no more than a Restriction of the ingress of too many Rays; as his following explicatory Words manifest, *viz. refringunt, & quasi emolliunt, easque Sensorio non nisi proportionatas tradunt.* But indeed Dr. *Schelhammer* hath shewn himself a too rigid Censor, by making Dr. *Willis* say, the *Ear-drum* had such like Braces as the *War-drum*, *viz. Quod porro de machinis seu taniis Tympani bellici adducit, dicitque idem in Tympano auditorio conspici, id prorsus falsissimum est.* I wonder Dr. *Schelhammer*, did not also charge Dr. *Willis* with making it a Porter, since he saith in the same Paragraph, *Fanitoris officio, &c.* But Dr. *Willis's* meaning is plain enough, that the little Bones and Muscles of the *Ear-drum* doth the same Office in straining and relaxing it, as the

the Braces of the *War-drum* do in that. And considering how curious and solemn an Apparatus there is of Bones, Muscles, and Joynts, all adapted to a ready Motion; I am clearly of Dr. *Willis's* Opinion, that the Use of the *Ear-drum* is chiefly for the proportionating Sounds, and that by its Extension and Retraction it corresponds to all Sounds, loud or languid, as the Pupil of the Eye doth to several Degrees of Light: and that they are no other than secondary Uses assigned by Dr. *Schelhammer*, as the principal or sole Uses; of keeping out the external colder Air, Dust, and other Annoyances, but especially that *ob solius aeris interni potissimum irrumpentis vim, hunc motum Tympani, ac Mallei esse conditum, ut cedere primum, deinde sibi restitui queat*; as his Words are. *P. ult. c. 6. §. 13.*

It was no improbable thought of *Rohault*, *nos attentos præbere, nil aliud est, nisi Tympanum, ubi ita opus est factum, contendere aut laxare, & operam dare ut illud in eâ positione intentum stet, in quâ tremulum aeris externi motum commodissime excipere possit.* *Roh. Phys. p. 1. c. 26. §. 48.*

The hearing of deaf Persons more easily by means of loud Noises, is another Argument of the Use of the Straining or Relaxation of the *Tympanum* in Hearing. Thus, Dr. *Willis* (*ubi supra*) *Accepi olim a viro fide digno, se mulierem novisse, quæ licet surda fuerit, quousque tamen intra conclavè Tympanum pulsaretur, verba quævis clarè audiebat: quare Maritus ejus Tympanistam pro servo domestico conducebat, ut illius ope, colloquia interdum cum Uxore suâ haberet. Etiam de alio Surdaestro mihi narratum est, qui prope Campanile degens, quoties unâ plures Campanæ resonarent, vocem quamvis facilè audire, & non aliàs potuit.*

Abscisso Musculo [Processus majoris Mallei] in recenti aure, relaxatur [Tympani Membrana.] Valsalv. de Aur. Hum. c. 2. §. 5.

Upon considering the great Difference in Author's Opinions about the Use of the Parts, and Manner how Hearing is performed, as also what a curious Provision there is made in the Ear, by the four little Bones, the Muscles, Membrane, &c. I was minded (since I penned this Note) to make enquiry my self into this Part, and not rely upon Authority. And after a diligent search of various Subjects, I find we may give as rational and easy an Account of Hearing, as of Seeing, or any other Sense; as I have shewn in my last cited *Note 4. Book VII. Chap. 2.* with relation to Birds. And as to Man and Beasts, the case is the same, but the Apparatus more Complex and Magnificent. For whereas in Birds, the *Auditory Nerve* is affected by the Impressions made on the *Membrane*, by only the intermediacy of the *Columella*; in Man, it is done by the Intervention of the four little Bones, with the Muscles acting upon them, his Hearing being to be adjusted to all kinds of Sounds, or Impressions made upon

to that of the *Labyrinth* (21), and therein survey the curious and admirable Structure of the *Vestibulum*, the *Semicircular Canals* (22), and *Cochlea*; particularly the artificial Gyration, and other singular Curiosities observable in the two latter.

But

upon the *Membrana Tympani*. Which Impressions are imparted to the *Auditory Nerve* in this manner, viz. first they act upon the *Membrane* and *Malleus*, the *Malleus* upon the *Incus*, and the *Incus* upon the *Os Orbiculare* and *Stapes*, and the *Stapes* upon the *Auditory Nerve*: for the Base of the *Stapes* (the same as the *Operculum* in Birds) not only covers the *Fenestra Ovalis*, within which the *Auditory Nerve* lieth, but hath a part of the *Auditory Nerve* spread upon it too. It is manifest that this is the true Process of Hearing, because, if the *Membrane* be moved, you may see all the Bones move at the same time, and work the Base of the *Stapes* up and down in the *Fenestra Ovalis*, as I shewed in this Chapter, Note 4. concerning the *Mole*; and as it may be seen in other Ears carefully opened, if the Parts remain *in situ*.

(21) I do not confine the *Labyrinth* to the *Canales Semicirculares*, or any other Part, as the elder Anatomists seem to have done, who by their erroneous and blind Descriptions seem not well to have understood these Parts: but with those much more curious and accurate Anatomists *Monsieur du Vernay*, and *Dr. Valsalva*, under the *Labyrinth*, I comprehend the *Canales Semicirculares*, and the *Cochlea*, together with the intermediate Cavity, called by them the *Vestibulum*.

(22) In the *Semicircular Canals*, two things deserve to be noted. 1. That the three Canals are of three different Sizes, *Major*, *Minor*, and *Minimus*. 2. Although in different Subjects they are frequently different; yet in the same Subject they are constantly the same. The reason of all which, together with their Uses, *Valsalva* ingeniously thinks is, that as a part of the tender *Auditory Nerve* is lodged in these Canals, so they are of three Sizes, the better to suit all the Variety of Tones; some of the Canals suiting some, and other other Tones. And although there be some difference as to the Length and Size of these Canals in different Persons; yet, lest there should be any discord in the *Auditory Organs* of one and the same Man, those Canals are always in exact Conformity to one another in one and the same Man. *V. Valsal. ubi supr. c. 3. §. 7. and c. 6. §. 4, 9.*

(3) *Hic*

But I shall not expatiate on these reclude Parts, only there is one especial Contrivance of the Nerves ministring to this Sense of Hearing, which must not be passed by; and that is the Branches of one of the *Auditory Nerves* (23), spread partly to the Muscles of the Ear, partly to the Eye, partly to the Tongue and Instruments of Speech, and inosculated with the Nerves to go to the Heart and Breast. By which means there is an admirable and useful consent between these parts of the Body; it being natural for most Animals upon the hearing any uncouth Sound, to erect their Ears, and prepare them to catch every Sound; to open their Eyes (those constant faithful Sentinels) to stand upon their Watch; and to be ready with the Mouth to call out, or utter what the present Occasion shall dictate. And accordingly it is very usual for most Animals when surprized and terrified with any frightful Noise, presently to shriek and cry out.

But there is besides this, in Man, another great Use of this nervous Commerce between the Ear and Mouth: and that is, (as one of the best Authors on this Subject expresseth it,) (24) “That the Voice
“ may correspond with the Hearing, and be a kind
“ of

(23) *Hic posterior Nervus, extra cranium delatus, in tres ramos dividitur, qui omnes motibus patheticis — inserviunt. Primus — musculis Auris impenditur. Proculdubio hujus actione efficitur, ut animalia quævis, a subito soni impulsu, aures, quasi sonum nimis cito transeuntem captaturas, erigant. Ramus alter — versus utrumque oculi angulum furculos emittit: qui musculis palpebrarum attollentibus inferuntur; quorum certè munus est, ad subitum soni appulsum oculos confestim aperire, eosque velut ad Excubias vocare. — Tertius — ramus versus Linguae radicem descendens, musculis ejus & ossis Hyoeideos distribuitur, adeoque organa quadam vocis edendæ aëtuat, &c. Willis's Cereb. Anat. c. 17.*

(24) *Hujusmodi Nervorum conformatio in Homine usum alium insigniorem præstat, nempe ut Vox, &c. Willis Ibid.*

“ of Echo thereof, that what is *heard* with one of
 “ the two Nerves, may be readily expressed with
 “ the Voice, by the help of the *other*.

Thus much shall suffice to have spoken concerning the *Organ*. Let us,

2. Take notice of the *Object* of this admirable Sense, namely *Sound*, and so conclude this Chapter. I shall not here enquire into the Nature and Properties of Sound, which is in a great Measure intricate, and hath puzzled the best Naturalists: Neither shall I shew how this admirable Effect of the divine Contrivance may be improved to divers Uses (25), and Purposes in humane Life. But my business will be to shew that this thing, of so admirable

(25) Among the Uses to which the Wit of Man hath employed Sounds, we may reckon the Instruments useful in convoking Assemblies, managing Armies, and many other Occasions, wherein Bells, Trumpets, Drums, Horns, and other sounding Instruments are used; the Particularities of which it would be tedious to recount, as that the biggest *Bell* in *Europe* is reckoned to be at *Erfurt* in *Germany*, which they say may be heard twenty-four Miles; with much more to the same purpose. I shall therefore only for a Sample take notice of the *Speaking-Trumpet*; the Invention of which is commonly ascribed to our eminent Sir *Samuel Morland*; but was more probably *Ath. Kircher's*, at least he had contrived such an Instrument, before Sir *Samuel* hit upon his. *Kircher* in his *Phonurg.* saith, the *Tromba* published last Year in *England*, he had invented twenty-four Years before, and Published in his *Musurgia*; that *Jac. Albanus Ghibbesius*, and *Fr. Eschinardus* ascribe it to him; and that *G. Schottus* testifieth he had such an Instrument in his Chamber in the *Roman-College*, with which he could call to, and receive answers from the Porter. And considering how famed *Alexander the Great's* Tube was, which is said might be heard 100 *Stadia*, it is somewhat strange that no Body sooner hit upon the Invention. Of this *Stentorophonick Horn* of *Alexander*, there is a Figure preserved in the *Vatican*; which for Curiosity sake, I have from *Kircher* represented in *Fig. 3.* He saith its Diameter was five Cubits, and that it was suspended on a Supporter.

mirable Use in the Animal World, is the Work of God. And this will appear, let the subject Matter of Sounds be what it will, either the Atmosphere (26) in gross, or the æthereal Part thereof, or soniferous Particles of Bodies, as some fancy, or whatever

For the Make of the *Speaking-Trumpet*, and the Reason why it magnifies Sounds, I shall refer to *Kircher*; especially to *Sir Samuel Morland's Tuba Stentorophonica*, Publish'd in 1672.

Kircher saith, he took one of these Trumpets, of fifteen Palm's Length, along with him to the *Mons Eustachianus*, where he convoked 2200 Persons to Prayers, by means of the unusual Sound, at two, three, four, and five *Italian Miles* Distance.

With these *Bellowing-Trumpets*, I shall join some *Bellowing-Caves* for the Reader's Diversion. *Ol. Magnus* describes a Cave in *Finland*, near *Viburg*, called *Smellen*, into which, if a Dog, or other living Creature be cast, it sends forth so dreadful a Sound, that knocks down every one near it. For which reason they have guarded the Cave with high Walls, to prevent the Mischiefs of its Noise. *Vid. Ol-Magn. Histor. l. 11. c. 4.* Such another *Peter Martyr* saith is in *Hispaniola*, which, with a small Weight cast into it, endangers Deafness at five Miles Distance. And in *Switzerland*, *Kircher* saith, in the *Cucumber-Mountain* is a Pit that sends out both a dreadful Noise and a great Wind therewith: And that there is a Well in his Country 300 Palm's deep, whose Sound is equal to that of a great Gun. *Vid. Kirch. Phonurg.*

Ol-Magnus speaking of the vast high Mountains of a Northern Province, called *Angermannia*, saith, *Ubi bases eorum in profundissimo gurgite stantes, casu aliquo, vel proposito Nautæ accesserint, tantum horrorem ex alta fluctuum collisione percipiunt, ut nisi præcipiti remigio, aut valido vento evaserint, solo pavore ferè exanimés fiant, multoque dierum curriculo, ob capitis turbationem, pristinae mentis, & sanitatis compotes vix evadant. Habent bases illorum montium in fluctuum ingressu & regressu tortuosas rimas, sive scissuras, satis stupendo naturæ opificio fabricatas, in quibus longa voragine formidabilis ille Sonitus quasi subterraneum tonitru generatur.* *Ol-Mag. ib. l. 2. c. 4.* See also *Chap. 12.*

(26) That the Air is the Subject, or Medium of Sound, is manifest from the Experiments in rarefied and condensed Air. In an unexhausted Receiver, a small Bell may be heard at the Distance of some Paces; but when exhausted, it can scarce be heard at the nearest Distance: And if the Air be compressed,

whatever else the Philosopher may think it. For who but an intelligent Being, what less than an omnipotent, and infinitely wise God could contrive, and

the Sound will be louder, proportionably to the Compression, or Quantity of Air crouded in, as I have often tried my self, and may be farther seen in Mr. *Hawksbee's* curious Experiments, p. 97. Also his Experiments in *Phil. Transact.* Nr. 321.

Neither doth this succeed only in forced Rarefactions and Condensations of the Air, but in such also as are natural; as is evident from *David Frædlichius* in *Varenius*, upon the highest Eminencies of *Carpathus*, near *Kesmarckt* in *Hungary*. The Story of *Frædlichius* is this, *Ego mense Junii 1615. tum adolescens, sublimitatem horum montium, cum duobus comitibus Scholaribus, experiri volens, ubi, cum in primæ rupis vertice, magno labore, me summum terminum affectum esse putarem, demum sese obtulit alia multo altior cautes, ubi per vasta, eaque vacillantia saxa (quorum unum, si loco a viatore dimovetur — aliquot centena — rapit, & quidem tanto cum fragore, ut illi metuendum sit, ne totus Mons corruat, eumque obruat) enixus essem, iterum alia sublimior prodiit, &c. donec summo vitæ periculo ad supremum cacumen penetraverim. Ex declivioribus montibus, cum in subiectas valles, — nil nisi obscuram noctem, aut cœruleum quid, instar profundi aeris, quod vulgo sudum cœlum appellatur, observare potui, mihiq; videbar, si de mente caderem, non in terram, sed rectâ in cœlum me prolapsurum. Nimiâ enim declivitate, species visibiles, extenuatæ & hebetatæ fuerunt. Dum vero altiorem montem peterem, quasi intra nebulas densissimas hærebam. — Et cum non procul a summo vertice essem, de sublimi quiescens prospexi & animadverti iis in locis, ubi mihi antea videbar intra nebulas hæsisse, compactas atque albas sese movere Nubes, supra quas, per aliquot milliaria, & ultra terminos Sepusi commodus mihi prospectus patuit. Alias tamen etiam nubes altiores, alias item humiliores, necnon quasdam equalitèr a terrâ distantes vidi. Atque hinc tria intellexi. 1. Me tum transivisse principium mediæ Aeris regionis. 2. Distantiam Nubium a terrâ, non esse æqualem. — 3. Distantiam Nubium — non 72 Mill. Ger. ut quidam — sed tantum dimidiatum Mill. Ger. In summum montis verticem cum pervenissem, adeo tranquillum & subtilem aerem ibi offendi, ut ne pili quidem motum sentirem, cum tamen in depressioribus ventum vehementem expertus sim: unde collegi summum cacumen istius montis *Carpathici* ad Mill. Ger. a radicibus suis imis exurgere, & ad supremam usque aeris regionem, ad quam Venti non ascendant, pertingere. Explosi in eâ summitate Sclopetum;*

and make such a fine Body, such a Medium, so susceptible of every Impression, that the Sense of Hearing

tum; quod non majorem sonitum primo præ se tulit, quam si ligillum vel bacillum confregissem; post intervallum autem temporis murmur prolixum invaluit, inferioresque montis partes, convalles & sylvas opplevit. Descendendo per nives annosas intra convalles, cum iterum Sclopetum exonerarem, major & horribilior fragor, quam ex tormento capacissimo inde exoriebatur: hinc verebar ne totus mons concussus mecum corrueret: duravitque hic sonus per semiquadrantem horæ usque dum abstrusissimas cavernas penetrasset, ad quas aer undique multiplicatus resiliit. — In his celsis Montibus, plerumque ningit grandinatae mediâ æstate, quoties nempe in subjectâ & vicinâ planitie pluit, uti hoc ipsum etiam expertus sum. Nives diversorum annorum ex colore & cortice duriore dignosci possunt. Varen. Geogr. Gen. l. 1. c. 19. Prop. ult.

The Story being diverting, and containing divers things remarkable, I have chosen to note the whole of it (although somewhat long) rather than single out the Passages only which relate to the diminishing the Sound of his Pistol by the rarity of the Air, at that great ascent up into the Atmosphere; and the magnifying the Sound by the Polyphonisms, or Repercussions of the Rocks, Caverns, and other phonocaptick Objects below in the Mount.

But 'tis not the Air alone that is capable of the Impressions of Sound, but the Water also, as is manifest by striking a Bell under Water, the Sound of which may plainly enough be heard, but it is much duller, and not so loud: and it is also a Fourth deeper, by the Ear of some great Judges in musical Notes, who gave me their Judgment in the matter. But *Mersenne* saith, a Sound made under Water is of the same Tone or Note, if heard under Water; as are also Sounds made in the Air, when heard under Water. *Vid. Mersen. Hydraul.*

Having mentioned the hearing of Sounds under Water, there is another Curiosity worth mentioning, that also farther proves Water to be susceptible of the Impressions of Sound, viz. Divers at the bottom of the Sea can hear the Noises made above, only confusedly. But, on the contrary, those above cannot hear the Divers below. Of which an Experiment was made, that had like to have been fatal: one of the Divers blew an Horn in his Diving-Bell, at the bottom of the Sea; the Sound whereof (in that compressed Air) was so very loud and irksome, that it stunned the Diver, and made him so giddy, that he had like to have dropt out of his Bell, and to have been drowned. *Vid. Sturmii Colleg. Cur. Vol. 2. Tentam. 1.*

Hearing hath occasion for, to empower all Animals to exprefs their Sense and Meaning to others; to make known their Fears, their Wants, their Pains and Sorrows in melancholick Tones; their Joys and Pleasures in more harmonious Notes; to send their Mind at great Distances (27), in a short time (28), in loud Boations; or to exprefs their Thoughts near at Hand with a gentle Voice, or in secret

(27) As to the Distance to which Sound may be sent, having some doubt whether there was any difference between the Northern and Southern Parts; by the favour of my learned and illustrious Friend Dr. *Newton*, Her Majesties late Envoy at *Florence*, I procured some Experiments to be made for me in *Italy*. His most Serene Highness the *Great Duke*, was pleased to order great Guns to be Fired, for this purpose, at *Florence*, and Persons were appointed on purpose to observe them at *Leghorne*; which they compute is no less than 55 Miles in a straight Line. But notwithstanding the Country between be somewhat hilly and woody, and the Wind also was not favouring, only very calm and still, yet the Sound was plainly enough heard. And they tell me that the *Leghorne* Guns are often heard 60 Miles off, at *Porto Ferrato*; that when the *French* bombarded *Genoa*, they heard it near *Leghorne* 90 Miles distant: and in the *Messina-Insurrection*, the Guns were heard from thence as far as *Augusta* and *Syracuse*, about 100 *Italian* Miles. These Distances being so considerable, give me reason to suspect that Sounds fly as far, or nearly as far in the Southern, as in the Northerly Parts of the World, notwithstanding we have a few Instances of Sounds reaching farther Distances. As Dr. *Hearn* tells us of Guns fired at *Stockholm* in 1685. that were heard 180 *English* Miles. And in the *Dutch-War*, 1672. the Guns were heard above 200 Miles. *Vid. Phil. Trans. Nr. 113.* Also there is this farther reason of suspicion, that the *Mercury* in the *Barometer* riseth higher without than within the Tropicks, and the more Northerly, still the higher; which may encrease the strength of Sounds by *Note 26.*

(28) As to the Velocity of Sounds, by reason the most celebrated Authors differ about it, I made divers nice Experiments my self with good Instruments: by which I found, 1. That there is some, although a small difference in the Velocity of Sounds with or against the Wind; which also is, 2. Augmented or diminished by the Strength or Weakness of the Wind. But that

secret Whispers ! And to say no more, who less than the same most wise and indulgent Creator, could form such an Oeconomy, as that of Melody and Musick is ! That the *Medium* should (as I said) so readily receive every Impression of Sound, and convey the melodious Vibration of every musical String, the harmonious Pulses of every Animal Voice, and of every musical Pipe ; and the Ear as well adapted and ready to receive all these Impressions, as the *Medium* to convey them : And lastly, that by means of the curious Lodgment and Inosculation of the *Auditory Nerves* before-mentioned, the Orgasmes of the Spirits should be allayed, and Perturbations of the Mind, in a great Measure quieted, and stilled (29) : Or to express it in the Words

that nothing else doth accelerate or retard it, nor the differences of Day or Night, Heat or Cold, Summer or Winter, Cloudy or Clear, Barometer high or low, &c. 3. That all kinds of Sounds have the same Motion, whether they be loud or languid, of Bells, Guns great or small, or any other sonorous Body. 4. That they fly equal Spaces in equal Times. 5th and lastly, That the Mean of their Flight is at the rate of a Mile in $9\frac{1}{4}$ Half-seconds, or 1142 Feet in one Second of time. *Vid. Phil. Trans. Ibid.*

(29) *Timothy* a Musician could excite *Alexander the Great* to Arms with the *Phrygian Sound*, and allay his Fury with another Tone, and excite him to Merriment. So *Ericus King of Denmark*, by a certain Musician could be driven to such Fury, as to kill some of his best and most trusty Servants. More of this power of Musick over the Affections may be seen in *Ath. Kirch. Phonurg. L. 2. Sect. 1.* Also in *Is. Vossius de Poimatum cantu, & Rhythmi viribus.*

And not only upon the Affections, but also on the parts of the Body, Musick is able to exert its force, as appears from the *Gascoigne-Knight*, *Cui Phormingis sono audito Vesica statim ad Urinam reddendam vellicabatur.* Such another we have in *A°. 1. Ephem. Nat. Curios. Obs. 134.* Also *Morhoff de Scyph. vitr. per cert. human. vocis sonum fracto* : where there is not only the Account of the Dutchman at *Amsterdam*, one *Nic. Petter*, that brake *Romer-Glasses* with the Sound of his Voice ; but also di-

vers other Instances of the Power and Effects of Sound. But to the Story of the *Gascoigne-Knight*, Mr. *Boyl* from *Scaliger* adds a pleasant Passage, That one he had disoblighd, to be even with him, caused at a Feast, a Bag-pipe to be play'd, when he was hemmed in with the Company; which made the Knight bepiss himself, to the great Diversion of the Company, as well as Confusion of himself. *Boyl's Essay of the Effects of Lang. motion.* In the same Book are other Matters that may be noted here. One whose Arm was cut off, was exceedingly tormented with the discharge of the great Guns at Sea, although he was at a great Distance on Land. And a great Ship-Commander observed his wounded Men with broken Limbs suffered in like manner at the Enemies Discharges. An ingenious Domestick of his own would have his Gums bleed at the tearing of Brown-paper. And an ingenious Gentleman of Mr. *Boyl's* Acquaintance confessed to him, that he was inclined to the *Knight of Gascoigne's* Distemper upon hearing the Noise of a Tap running. The Dancing to certain Tunes, of Persons bit with the *Tarantula*, he was assured of by an ingenious Acquaintance at *Tarentum*, who saw several, among the rest a Physician, affected with that Distemper. And many other Accounts of this kind, seemingly credible, are related in *Morhoff*, *Kircher*, and many others; although Dr. *Cornelio* questions the Matters of Fact, in *Phil. Transf. Nr. 83.* Mr. *Boyl* also saith, a sober Musician told him, he could make a certain Woman weep, by playing one Tune, which others would be little affected at. And he saith, that he himself had a kind of shivering at the repeating two Verses in *Lucan.* And I add, that I very well know one to have a sort of chill about his *Præcordia* and Head, upon reading, or hearing the 53d Chapter of *Isaiah*; as also *David's* Lamentation for *Saul* and *Jonathan*, 2 Sam. 1.

Neither are our Minds and Bodies only affected with Sounds, but also inanimate Bodies: Of which many Stories may be met with in *Kircher*, particularly a large Stone that would tremble at the Sound of one particular Organ-pipe; in *Morhoff* also, who among many other Relations, hath this, *Mimini cum ipsi [clariss. Willisio] de experimento Vitri per vocem fracti narrarem, ex eo audivisse, quod in ædibus Musicis sibi vicinis aliquoties collapsum pavimentum fuerit: quod ipse sonis continuis adscribere non dubitavit.* *Morhoff.* cap. 12. *Mersenne* also among many Relations in his *Harmon*, and other Books, tells a far more probable Story, of a particular part of a Pavement, that would shake as if the Earth would open, when the Organs played, than what he relates about *Antipathy* in his *Quæst. & Comment. in Genes*, viz. That the Sound of a Drum made of Wolf's-Skin, will break another made of Sheep's-Skin: That Hens will fly at the Sound of an Harp strung with Fox-Gut-Strings; and more to the same purpose. Mr. *Boyl* also in his last-cited Book tells us, Seats will tremble at the Sound of Organs; and that he hath felt his Hat to do so

Words of the last-cited famous Author (30),
 “ That Musick should not only affect the Fancy
 “ with Delight, but also give Relief to the Grief
 “ and Sadness of the Heart, yea appease all those
 “ turbulent Passions, which are excited in the
 “ Breast by an immoderate Ferment, and Fluctua-
 “ tion of the Blood.

And now, who can reflect upon all this curious Apparatus of the *Sense of Hearing*, and not give the great Creator his due Praise! Who can survey all this admirable Work, and not as readily own it to be the Work of an omnipotent, and infinitely wise and good God (31), as the most artful Melodies we hear, are the Voice or Performances of a living Creature?

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too under his Hand, at certain Notes both of Organs, and in Discourse: that he tried an Arch that would answer to C fa-ur, and had done so 100 Years; and that an experienced Builder told him any well-built Vault will answer some determinate Note. And at *Eastbury House* near *Barking*, I my self discovered the Porch, (having firm Brick-Walls,) not only to Sound when struck on the Bottom, but also to give almost as loud a Sound, when I sounded the same Note with my Voice.

(30) *Willis*, ubi supr.

(31) *Ille Deus est* — qui non calamo tantum cantare, & agreste, atque inconditum carmen ad aliquam tantum oblectationem modulari docuit, sed tot artes, tot vocum varietates, tot sonos, alios spiritu nostro, alios externo cantus adituros commentus est. *Senec. de Benef. l. 4. c. 6.*

(1) A piece

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Of the Sense of Smelling.

THIS Sense I shall dispatch in less compass than the two last, because its Apparatus (although sufficiently grand and admirable, yet) is not so multiplicitious as of the Eye and Ear: It being sufficient in this Sense, that the odoriferous Effluvia of Bodies (1) can have an easy, free Passage to the Olfactory Nerves, without the formalities of Refractions, and other Preparations necessary to the Perfection of the two former Senses. Accordingly the All-wise Creator hath made sufficient Provision for the reception of Smells, by the Apertures of the Nostrils (2); made not of Flesh or Bone, but Cartilaginous, the better to be kept open, and withal to be dilated or contracted, as there is occasion: For which Service it hath several proper and curious Muscles (||).

And

(1) A piece of *Ambergreece* suspended in a pair of Scales, that would turn with a very small part of a Grain, lost nothing of its Weight in $3\frac{1}{2}$ Days; neither did *Assa-fetida* in $5\frac{1}{2}$ Days; but an Ounce of *Nutmegs* lost $5\frac{1}{2}$ Grains in 6 Days; and *Cloves* $7\frac{1}{2}$ Grains. *Boyl's Subtil. of Effluv.* c. 5.

(2) *Nares eo quod omnis Odor ad superiora fertur, rectè sursum sunt: Et quod Cibi & Potionis judicium magnum earum est, non sine causa vicinitatem Oris secutæ sunt.* *Cicer. de Nat. Deor.* L. 2.

(||) Had not the Contriver of Animal Bodies been minded his Work should have all the Signatures of Accuracy, this Sense might have been performed with a bare Aperture of the Nose; but that nothing might go imperfect out of his Hand, he hath made a part of the Nose easily moveable, and given a Set of Muscles to lift up, and to open and shut the Nostrils; and so adjust it to every Occasion of this Sense.

(3) *Odorem*

And forasmuch as it is by Breathing (3), that the odorant Particles are drawn in, and conveyed to the Sensory, therefore there is a very wise Provision made in the *Laminae*, with which the upper part of the Nose is barricaded, which serve to two excellent Uses: partly, to fence out any noxious Substances from entering the breathing Passages in our Sleep, or when we cannot be aware (4); and partly, to receive the Divarications of the *Olfactory Nerves*, which are here thick spread, and which do by these means meet the Smells entering with the Breath, and striking upon them.

And accordingly the more accurate this Sense is in any Animal, the longer we may observe those *Laminae* are, and more of them in number folded up, and crouded together, to contain the more nervous Filaments, and to detain, and fetter the odoriferous Particles in their Windings and Turnings.

And an admirable Provision this is, which the great Creator hath made for the good of Brute-Creatures (5); the chief Acts of many of whose Lives are performed by the ministry of this Sense.

In

(3) *Odorem non aliud, quam infectum Aera, intelligi posse. Plin. Nat. Hist. l. 9. c. 7.*

(4) For a farther guard against the Ingress of noxious things the *Vibrissi*, or Hairs placed at the entrance of the Nostrils serve, which in some measure stop the entrance of things improper, or however give warning of them, but at the same time allow an easy Passage to the Breath and Odours.

(5) *Multo præclarius emicat [Olfactus] in brutis animalibus, quam in homine: ista namque hoc solo indice, herbarum, aliorumque corporum prius ignotorum virtutes certissime dignoscunt, quin & victum suum absentem, vel in abstruso positum, Odoratu venantur, ac facillime investigant. Quod autem minus sagaces sunt hominum Nares, illud non facultatis hujus abusui (prout nonnulli volunt) ascribi debet, verum in causâ est ipsius Organi defectus; hoc enim circa victus humani criteria (ubi ratio, & intellectus adsunt)*

In Insects, and many other Creatures, it is of great Use in the Propagation of their Kind; as particularly in helping them to safe and convenient Places for the Incubation of their Eggs, and Breeding up their Young. Others are by the accuracy of this Sense, of Use to Mankind, which would be otherwise of little or no Use (6). And most of the irrational Animals, Birds, Beasts, and Creeping things, do, by their Smell, find out their Food; some at great distances, and some at hand. With what Sagacity do some discover their Food in the midst of Mud and Dirt (7)? With what Curiosity do the herbaceous Kind pick and chuse such Plants as afford them wholesome Food, or sometimes such as are Medicinal (8), and refuse such as would hurt and destroy them? And all by the help principally, if not only, of the Smell, assisted by its near Ally the Taste. Of which I shall in the next place speak very briefly.

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non ita accuratum requiritur: Propterea enim inferiores potentia in homine, a natura minus perfecta existunt, ut superiorum cultui, & exercitio, relinqueretur locus. Willis de Anim. Brut. cap. 13.

(6) Thus the chief Use of Hounds is to Hunt; and other Dogs to be a Watch and Guard to our Houses by Night. For which Services (particularly in Hounds) their *Olfactory Nerves* are not only remarkably large, (like as they are in other Brutes,) but their Branches, and Filaments are in the *Lamina* of the Nostrils both more, and larger than I have seen in any other Creature whatsoever. Also there are more Convolutions of the *Lamina*, than I ever remember to have found in any other Animal.

The Sagacity of Hounds is prodigious, of which see an Instance in *Book IV. Chap. 11. Note 56.*

(7) See *Book VII. Chap. 2. Note 5.*

(8) *Vid. Plin. Hist. Nat. l. 8. c. 27. Quæ animalia quas herbas ostenderunt.*

C H A P. V.

Of the Taste (1).

IN this, as in the last Sense, we have an Apparatus abundantly sufficient to the Sense; Nerves curiously divaricated about the Tongue (2), and Mouth, to receive the Impressions of every Gusto; and these Nerves guarded with a firm and proper Tegument to defend them from Harms; but withal so perforated in the papillary Eminences, as to give a free admission to Tastes.

But

(1) Τὰ δὲ εἶδη τῶν χυλῶν, &c. Saporum genera—*dulcis, pinguis, austerus, acerbus, acris, salsus, amarus, acidus.* Theophr. de Caus. Plant. l. 6. c. 1. What may be the cause of the difference of Tastes, he saith is hard to assign, πότερον γὰρ τῆς πίψεως, &c. *Utrum affectionibus Sensuum, — an figuris, quibus singuli constant, ut Democritus censet.* id. ib. *Διευκρινετὸ δὲ, &c. Democritus — dulcem esse saporē qui rotundus: acerbum qui figurā magnā; asperum qui multis angulis, &c.* id. ib. c. 2. But of the Diversities and Causes of Tastes, see Dr. Grew, Lect. 6. and Dr. Willis de Anim. Brut. c. 12.

(2) *Intellectus Saporum est ceteris in primā linguā: Homini, & in palato.* Plin. l. 11. 37.

The Opinions of Anatomists concerning the Organ of Taste are various. *Baubin, T. Bartholin, Bartholette, Veslinge, Deafinge, &c.* place it in the laxer fleshy Parts of the Tongue: Our famous *Wharton*, in the Gland at the Root of the Tongue: *Laurentius* in the thin Tunick covering the Tongue: but the learned *Malpighi* with great probability concludes, because the outward covering of the Tongue is perforated, under which lie papillary Parts, (of which Mr. *Cowper* hath very good Cuts in his *Anat. Tab. 13*) that in these the Taste lieth. *Malpighi's* Words are, *Quare cum dictis meatibus insignibus occurrant papillaria corpora, probabilius est in his ultimis, ex subintranti sēpido humore titillationem, & mordicationem quandam fieri, quæ Gustum efficiat.* *Malpig. Op. Tom. 2. De Linguā, pag. 18.*

But I shall say no more of this Sense, only a word or two of its consent with the Smell, and the Situation of them both: Their Situation is in the most convenient place imaginable, for the discharge of their Offices; at the first entrance (3), into the way to the grand Receptacle of our Food and Nourishment; to Survey what is to be admitted therein; to judge between what is wholesome, and fit for Nourishment, and what is unsavoury and pernicious. And for this end, the All-wise Creator seems to have established a great consent between the Eye, the Nose, and Tongue, by ordering the Branches of the same Nerves (4) to each of those three Parts, as also indeed to divers other Parts of the Body, which I may have Occasion to mention in a more proper place (5). By which means

Præcipuum ac ferè solum Gustatûs organon est Lingua; cui aliquatenus subobscurè tamen Palatum, & superior Gula pars consentiunt: in omnibus vero fibræ nervosæ immediata sensionis instrumenta sunt. Quare observare est, Linguam præ aliâ quâvis parte insignitèr fibrosam esse, etiam texturâ valdè porosâ constare, in eum nempe finem, ut particulae rei sapidae copiosius, ac penitus intra Sensorii meatus admittantur. — Nervi autem qui fibris Linguae densissime intertextis famulantur, ac saporum impressiones τῷ πρῶτῳ αἰσθητικῷ communicant, sunt — Nervi e paribus tum quinto, tum nono, & ubique cum densâ propaginum serie per totam ejus compagem distributi. Willis ibid.

(3) Gustatus, qui sentire eorum quibus vescimur genera debet, habitat in eâ parte Oris, quâ esculentis, & poculentis ita natura patefecit. Cicer. de Nat. Deor. L. 2. Vid. quoque supr. Note 2. Chap. 4.

(4) Multa hujus [quinti Paris] Nervi propagines Masticationis operi destinantur; ideoque quoniam alimenta ingerenda non modo Gustûs, ast etiam Olfactûs & Visûs examen subire debent, ab eodem Nervo, cujus rami ad Palatum & Fauces missi, Manducationis negotium peragunt, propagines aliæ, velut exploratrices, ad Nares & Oculos feruntur, nempe ut isthæc aliorum sensuum organa, etiam ad objecta Gustûs melius dignoscenda, probationum auxiliis quibusdam instruuntur. Willis Nerv. Deor. & Usus. Cap. 22.

(5) See Book V. Chap 8.

(1) Malpighi

means there is all the Guard that can be, against pernicious Food ; forasmuch as before it is taken into the Stomach, it is to undergo the trial of three of the Senses ; the Scrutiny of the Eye, that strict Surveyor of its outward Appearance ; and the Probation of the Smell and Taste, the two severest Judges of its natural Constitution and Composition.

C H A P. VI.

Of the Sense of Feeling (1).

HAVING spent so much Time upon the other Senses, and therein given such ample Proofs of the infinite Creator's Wisdom, I shall but briefly take Notice of two things relating to this last Sense.

One

(1) *Malpighi* is of Opinion, that as *Taste* is performed by the *Papillæ* in the Tongue ; so is *Feeling* by such like *Papillæ* under the Skin. From several Dissections, and other Observations he thus concludes, *Ex his, & similibus videbatur animus abundè certior redditus, earundem Papillarum pyramidalium copiam, quas aliàs in Linguâ descripsi, in locis præcipuè exquisitiori Tactui dicatis reperiri, eodem progigni nervoso, & cuticulari corpore, simulque circumvolvi reticulari involucre, & extimam cuticulam, veluti ultimum terminum attingere.*—*Microscopio quilibet in manûs dorso pro sudore orificia quædam miro ordine dispersa intueri potest, circa quæ frequentia quædam capitula assurgunt ; hæc verò sunt Papillarum fines, dum a cute assurgentes interpositum superant rete, simulque extimam cuticulam. Hæc repetitis sectionibus deprehendi : ex quibus non improbabilitè deducam, sicuti ex elatioribus—papillis—in Linguâ, Gustûs Organon eliciter,—ita ex copiosâ harum Papillarum congerie—in organis, ubi maximè animalia Tactûs motione afficiuntur,—adæquatum Tactûs organum sufficientè haberi. Malpig. de extern. Tact. Org. p. 26. Consul. quæque ejusd. Vit. p. 28.*

These

One is its Organ, the Nerves. For as all Sensation is performed by the Nerves (2), and indeed the other Senses (performed by Nerves) are a kind of Feeling; so is this Sense of *Feeling* performed by Nerves likewise, spread in the most incomparable, curious manner throughout the whole Body. But to describe their Origine in the Brain, and Spinal-Marrow, their Ramifications to all the Parts, their Inosculation with one another, and other Matters, whereby not only the Sense of *Feeling* is performed, but also Animal-Motion, and an admirable Consent and Harmony of all the Parts of the Body is effected, (to describe, I say, these things) would take up too much time, and I have already, and shall as I go along, give some Hints thereof.

The other thing I shall take notice of, is the dispersion of this Sense throughout the Body, both without, and within. The other Senses, I have observed, are seated in the very best place for the Relief and Comfort, the Guard and Benefit of the Animal. And forasmuch as it is necessary to the Being, and Well-being of the Body, that every Part should be sensible of things safe, or things prejudicial to it self, therefore it is an admirable Contrivance of the great Creator, to disperse this Sense
of

These Observations of *Malpighi*, our late curious and diligent Mr. *Comper* hath confirmed, and given us very elegant Cuts both of the Skin, and the *Papillæ*, and the Nerves, Glands, &c. under it, from Microscopical Observations. *Vid. Comper's Anat. Introd. and Tab. 4.*

(2) Although the Eye be the usual Judge of Colours, yet some have been able to distinguish them by their Feeling. *Quidam fuit qui venit ad M. Duc. Hettrurix aulam qui colores per Tactum cognoscebat. Pro experimento velum sericum, uniformiter textum, pluribus coloribus tinctum & offerebatur, & veraciter de colore in singulis partibus judicabat. Grimald. de Lum. & Col. pr. 43. §. 59.*

(3) *Tactus*

of *Feeling* throughout every part (3), to distinguish between Pleasure and Pain, things Salutary, and things Hurtful to the Body.

Thus in the five Senses of Animals we have an Oeconomy worthy of the Creator, and manifestly demonstrating his Power, Wisdom, and Indulgence. For whether we consider the Mechanism of the Organs, or the great Use and Convenience of each Sense, we find it noble and grand, curious and artificial; and every way worthy of its infinite Maker, and beyond the Wit and Power of any thing but a *GOD*. And therefore we must even deny our Senses, by denying them to be God's Handy-work.

And now from those chief Machines of Animal Performances and Enjoyments, the five Senses; let us pass to another thing in common to all the sensitive Creatures, which is Respiration.

L

C H A P.

(3) *Tactus autem toto corpore æquabiliter fusus est, ut omnes illius, omnesque nimios & frigoris, & caloris appulsus sentire possimus.* Cicer. ubi supr.

Tactus sensus omnibus est, etiam quibus nullus alius: nam & Ostreis, & terrestribus vermibus quoque. Existimaverim omnibus scusum & Gustatus esse. Cur enim alios alia sapes appetunt? in quo vel Naturæ præcipua architectio. Plin. Nat. Hist. l. 10. c. 71.

(1) The

C H A P. VII.

Of Respiration.

OF all the Acts of Animal-Life, this is one of the chief, and most necessary. For whatsoever hath Animal Life, hath also the Faculty of Respiration, or somewhat equivalent thereto (1). Indeed

(1) The Uses assigned to Respiration by all the Anatomists before Malpighi's Discoveries of the Structure of the Lungs, are so various, and many of them so improbable, that it would be frivolous to recount them. But the more eminent modern Anatomists assign these Uses. Willis thus Sums up his Opinion, *Præcipua Pulmonum functio & usus sunt sanguinem & aerem per totas partium compages intimosque recessus, atque ductus quosque minutissimos traducere, & ubique invicem committere; in eum nempe finem, ut sanguis venosus a circuitu redux, & chymo recenti dilutus, — tum perfectius misceatur & velut subigatur, tum potissimum ut secundum omnes suas partes ab aere nitroso de novo accendatur.* Pharmaceut. p. 2. S. 1. c. 2. §. 2. Mayow saith rightly, that one grand Use of Expiration is, *Ut cum aere expulso, etiam vapores e sanguine exhalantes, simul exsufflentur.* And as for Inspiration, that it conveyeth a nitro-aereal ferment to the Blood, to which the Animal Spirits are owing, and all Muscular-motion. Mayow de Respir. pag. 22, &c. mea Edit.

Somewhat of the Opinion of these two last-cited, if I mistake not, (it being long since I read their Tracts, and have them not now at Hand,) were Ent, Sylvius, Swammerdam, Diemerbroeck, and my Friend Mr. Ray in an unpublished Tract of his, and in his Letters now in my Hands.

But our Dr. Thurston for good reasons rejects these from being principal Uses of Respiration, and thinks, with great reason, the principal Use to be to move, or pass the Blood from the right to the left Ventricle of the Heart. Upon which account Persons hanged, drowned, or strangled by Catarrhs, so suddenly die, namely, because the Circulation of their Blood is stopped. For the same reason also it is, that Animals die so soon in the Air-pump. Among other Proofs he instanceth in an Experiment of Dr. Croon, (Profess. Gresh.) which he made before our R. S. by strangling a Pullet, so that not the least

deed so congenial is this with Life, that *Breath* and *Life* are in Scripture Phrase and common Speech taken

sign of Life appeared ; but by blowing Wind into the Lungs through the *Trachea*, and so setting the Lungs a playing, he brought the Bird to Life again. Another Experiment was one tryed by Dr. *Walter Needham* before Mr. *Boyl*, and others at *Oxford*, by hanging a Dog, so that the Heart ceased moving. But hastily opening the Dog, and blowing Wind into the *Ductus Pecquetianus*, he put the Blood in Motion, and by that means the Heart, and so recovered the Dog to Life again. *V. Thurston de Respir. Us* pag. 60, and 63. *meâ Edit.*

Such an Experiment as Dr. *Croon*'s, my Friend, the late justly renowned Dr. *Hook* shewed also our *R. S.* He cut away the *Ribs*, *Diaphragm*, and *Pericardium* of a Dog ; also the top of the Wind-pipe, that he might tie it on to the Nose of a pair of Bellows ; and by blowing into the Lungs, he restored the Dog to Life ; and then ceasing blowing, the Dog would soon fall into dying Fits ; but by blowing again, he recovered : and so alternately would die, and recover for a considerable time, as long and often as they pleased. *Philos. Transf. Nr. 28.*

For the farther Confirmation of Dr. *Thurston*'s Opinion, the ingenious Dr. *Musgrave* cut off, and close stopped up the Wind-pipe of a Dog with a Cork, and then threw open the *Thorax* ; where he found the Blood stagnating in the Lungs, the *Arteria Pulmonaris*, the right *Ventricle* and *Auricle* of the Heart, and the two great Trunks of the *Cava* distended with Blood to an immense Degree ; but at the same time the *Vena Pulmonaris*, the left *Ventricle* and *Auricle* of the Heart in a manner empty, hardly a spoonful of Blood therein. *Philos. Transact. Nr. 240.* Or both the Experiments may be together met with in *Lowth. Abridg. Vol. 3. pag. 66. 67.*

This Opinion of our learned *Thurston*, the late learned *Emmuller* espoused, who being particular in reckoning up the Uses of Respiration, I shall therefore the more largely cite him. Respiration, saith he, serves, 1. *Ad Olfactum.* 2. *Ad Screatum & Sputaionem.* 3. *Ad Oscitationem, Tussim, Sternutationem, Emunditionemque.* 4. *Ad liquidorum sorbitionem, Suctionemve.* 5. *Ad Loquelam, Cantum, Clamorem, Risum, Fletum, Flatum, &c.* 6. *Ad fecum Alvi, Urinæ, Fætus, Molæve, necnon Secundinarum expulsionem.* 7. *Ad promovenda Ventriculi, Intestinorum, Laeteorumque vasorum, &c. contenta.* 8. *Ad halitus aqueos Sanguinis e pulmonibus aeris ope exportandos.* 9. *Ad Diapnoen.* 10. *Ad exactiorem Chyli, Lymphaque, necnon Sanguinis — miscelam.* 11. *Ad*

taken as synonymous Things, or at least necessary
Concom-

conciliandam sanguini — coccineam rubedinem, &c. 12. Nec morose negabimus, aerem — pulmones & sanguinem illos transcurrentem, minus calida reddere, &c. 13. Quod denique aer sanguini singulis Respirationibus aliquantillâ sui parte, admixtus, paucissimas quasdam in Spirituum animalium elaboratione particulas simul contribuat. All these Uses although of great Consequence, yet he thinks rather conduce to the *Well-Being*, than the *Being* of the Animal; because without any one of them, the Animal would not so speedily die, as it doth by Strangling, or in the Air-pump. He therefore assigns a 14th, and the principal use of Respiration to be, *For the passing of the Blood through the Lungs, that is thrown into them by the Heart.* Etmull. Dissert. 2. c. 10. §. 1, & 16.

But the late Dr. Drake with great Ingenuity and Address, (like a Person so considerable for his Years as he was in his time,) not only establisheth this Notion of Respiration, but also carries it farther, making it the true cause of the *Diastrale* of the Heart; which neither Borelli, Lower, or Cowper, much less any before those great Men, have well accounted for. That the Heart is a Muscle, is made evident beyond all doubt by Dr. Lower. And that the Motion of all Muscles consists in Constriction, is not to be doubted also. By which means the *Systole* is easily accounted for. But forasmuch as the Heart hath no *Antagonist-Muscle*, the *Diastrale* hath puzzled the greatest Wits. But Dr. Drake with great Judgment, and much probability of Reason, maketh the Weight of the incumbent Atmosphere to be the true *Antagonist* to all the Muscles which serve both for ordinary Inspiration, and the Constriction of the Heart. The particulars of his Opinion may be seen in his *Anatomy*. L. 2. c. 7. and in *Philos. Transact.* Nr. 281.

And I remember when I was at the University, my most ingenious and learned Tutor Dr. Wills, when he read Anatomy to us, was of Opinion, that the Lungs were blown up by the Weight of the incumbent Air, and represented the manner of Respiration in this manner, *viz.* He put a Bladder into a pair of Bellows, turning back the neck of the Bladder, and tying it fast, so that no Air might enter in between the Bladder and Bellows. This being done, when the Bellows were opened, the Bladder would be blown up, by the Weight of the incumbent Air; and when shut, the Air would be thereby pressed forceably out of the Bladder, so as to blow the Fire. This Experiment I take notice of here, because, (besides the Illustration it gives to Respiration,) that great Genius seems to have had a truer No-

Concomitants of one another. *Moses* (2) expresseth Animal-Life, by [*The Breath of Life.*] Saith he, *Gen.* 7. 21, 22. *All Flesh that moved on the Earth, Fowl, Cattel, Beast, creeping Things, and Man; all in whose Nostrils was the Breath of Life in the dry Land died.* So the Psalmist, *Psal.* 104. 29. *Thou takest away their Breath, they die.* So grand an Act therefore in common to all Animals, may justly deserve a place in this Survey of the Works of God, in the Animal-Kingdom.

And here I might launch out into an ample Description of all the Parts ministering to this necessary Act, and shew the curious Contrivance, and artificial Structure of them. But a transient View shall suffice. I might begin with the outward Guards, the Nose and Mouth; but these have been already touched upon. But the exquisite Mechanism of the *Larynx*, its variety of Muscles, its Cartilages, all so exquisitely made for the purpose of Respiration, and forming the Voice (3), are very admirable:

tion of this *Phenomenon* than was very common then, viz. about the Year 1677 or 78; as also, because I have in some Authors met with the same Experiment, without mention of *Dr. Wills*, whose I take it to have been.

Another use of great Consideration the already commended *Dr. Cheyne* assigns, namely, to form the elastick Globules of which the Blood principally consists, without which there would be a general Obstruction in all the capillary Arteries. *Cheyne's Phil. Prin. of Nat. Rel. or Harris's Lex. Tech. in Lungs.*

(2) *Gen.* 2. 7. 6. 17. & 7. 15.

(3) Because it would be endless to specify the curious Mechanism of all the Parts concurring to the formation of the Voice, I shall therefore for a Sample note only two things. 1. There are thirteen Muscles provided for the Motion of the five Cartilages of the *Larynx*. *Gibb. Anat. l. 2. c. 14.* A sign of the careful and elaborate Provision that is made for the Voice. 2. It is a prodigious Faculty of the *Glottis* in contracting and dilating it self with such Exquisiteness, as to form all Notes. For (as the ingenious *Dr. Keil* saith) *supposing the greatest Distance*

admirable: And no less so is the Tongue (4), which ministers to that and many other Uses too.

Next the Fabrick of the (5) *Trachea* deserves especial Remark. Its Valve the *Epiglottis* on the top,

of the two Sides of the Glottis to be one tenth Part of an Inch in sounding 12 Notes, (to which the Voice easily reaches,) this Line must be divided into 12 Parts, each of which gives the Aperture requisite for such a Note, with a certain Strength. But if we consider the Sub-division of Notes into which the Voice can run, the Motion of the Sides of the Glottis is still vastly nicer. For if two Chords sounding exactly Unisons, one be shortened $\frac{1}{100}$ th Part of its Length, a just Ear will perceive the Disagreement, and a good Voice will sound the Difference, which is $\frac{1}{100}$ th Part of a Note. But suppose the Voice can divide a Note into 100 Parts, it follows that the different Apertures of the Glottis actually divide the tenth Part of an Inch into 1200 Parts, the effect of each of which produces a sensible Alteration upon a good Ear. But because each Side of the Glottis moves just equally, therefore the Divisions are just double, or the Sides of the Glottis, by their Motion, do actually divide one tenth Part of an Inch into 2400 Parts. Keil's Anat. c. 3. Sect. 7.

(4) Among the Instruments of Speech, the Tongue is a necessary one; and so necessary, that it is generally thought no Speech can be without it. But in the third Tome of the *Ephem. Germ.* is published, *Jac. Rolandi Aglossostomographia, sive Descriptio Oris sine Lingua, quod perfectè loquitur, & reliquas suas functiones naturaliter exercet.* The Person described is one Pet. Durand, a French Boy of eight or nine Years Old, who at five or six lost his Tongue by a Gangrene, occasioned by the Small-Pox. Notwithstanding which, he could (as the Title saith) speak perfectly, as also Taste, Spit, Swallow, and Chaw his Food; but this latter he could do only on that side he put it into, not being able to turn it to the other side his Mouth.

In the same Tract, Chap. 6. is this Observation of Ventriloquous Persons, *Memini me a quodam sat celebri Anatomico audivisse, dum de duplicaturâ Mediastini ageret, si Membrana ista duplex naturaliter unita in duas partes dividatur, loquelam quasi ex pectore procedere, ut circumstantes credant Dæmoniacum hunc, aut Stereomythum.*

(5) The Variation of the Wind-pipe is observable in every Creature, according as it is necessary for that of the Voice. In an Urchan, which hath a very small Voice, 'tis hardly more than Mem-

branous,

top, to fence against all Annoyances; its cartilaginous Rings (6) nearly environing it, with its membranous Part next the Gullet, to give the freer passage to the descent of the Food; and lastly, its inner Tegument of exquisite Sense to be readily affected with, and to make efforts against every thing that is hurtful or offensive, these, I say, do all justly deserve our Admiration.

And no less prodigious are the Parts farther within; the *Bronchi*, the *Vesiculæ* (7), with their muscular

branous. And in a Pigeon, which hath a low and soft Note, 'tis partly Cartilaginous, and partly Membranous. In an Owl, which hath a good audible Note, 'tis more Cartilaginous. But that of a Jayes, hath hard Bones, instead of Cartilages: and so of a Linnæ, whereby they have both of them, a louder and stronger Note, &c.

The Rings of the Wind-pipe, are fitted for the Modulation of the Voice. For in Dogs and Cats, which in the Expression of divers Passions use a great many Notes, (as Men do,) they are open and flexible, as in Man. Whereby all, or any of them are dilated, or contracted, more or less, as is convenient for a higher or deeper Note, &c. whereas in some other Animals, as in the Japan-Peacock, which useth hardly more than one single Note, they are entire, &c. Grew's Cosmolog. Sacr. Book I. Chap. 5. §. 9, 10.

(6) It is a farther manifest Indication of singular Design in the cartilaginous Rings of the *Aspera Arteria*, that all the way where they are Contiguous to the *Oesophagus*, they are Membranous, to afford an easy Passage to the Food; but after that, in the *Bronchi*, they are some compleatly Annular, some Triangular, &c. And another observable is, the lower Parts of the superiour Cartilages, receive the upper Parts of the inferiour, in the *Bronchi*; whereas in the *Aspera Arteria*, the Cartilages run and remain parallel to one another; which is a noble difference of Mechanism in this (in a manner) one and the same Part, enabling the Lungs and *Bronchi* to contract themselves in Expiration, and to extend and dilate themselves in Inspiration.

(7) I shall not here intrench so much upon the Anatomist's Province, to give a Description of the Lungs, although it be a curious Piece of God's Workmanship, but refer to *Seignior Malpighi*, the first Discoverer of their *Vesiculæ* in 1660, in his two Letters to *Borelli de Pulmon*: also to Dr. *Willis's Pharm. rat.*

lar Fibres (+), as some assert they have, together with the Arteries and Veins, which every where accompany the airy Passages, for the Blood to receive there its Impregnations from the Air.

From

p. 2. S. 1. c. 1. *de Respir. Orig. & Us.* who as he wrote after *Malpighi*, so hath more accurately described those Parts; and to *Mr. Cowper's Anat. Tab. 24, 25.* And if the Reader hath a mind to see what opposition *Seignior Malpighi's* Discoveries met with at Home and Abroad, and what Controversies he had on that Account, as also his Censures of *Dr. Willis's* Descriptions and Figures, he may consult *Malpighi's Life* written by himself, pag. 4, to 21.

That the Lungs consist of *Vesiculæ*, or *Lobuli* of *Vesiculæ* admitting of Air from the *Bronchi* is visible, because they may be blown up, cleansed of Blood, and so dried. But *Mr. Cowper* saith, he could never part the *Lobuli*, (so as to make the Doctor's *Fig. 1. Tab. 3. & 4.*) so that probably the *Vesiculæ* are contiguous to one another throughout each Lobe of the Lungs. And not only Air, but *Diemerbroeck* proves, that the *Vesiculæ* admit of Dust also from two Asthmatick Persons he opened; one a Stone-Cutter's Man, the *Vesiculæ* of whose Lungs were so stuffed with Dust, that in cutting, his Knife went as it through an heap of Sand. The other was a Feather-Driver, who had these Bladders filled with the fine Dust or Down of Feathers.

(+) There is a considerable difference between *Dr. Willis*, and *Etmuller*, viz. whether the *Vesiculæ* of the Lungs have any muscular Fibres or not? *Etmuller* expressly saith, *Nullas Fibras musculosas, multo minus rubicandam Musculorum compagem (sunt enim Vesiculæ albæ & fere diaphanæ) in ipsis reperiri. ubi supr. c. 6. S. 2.* And afterwards §. 3. *Pulmones esse molles flexilesque, musculosis fibris ceu propriæ explicationis organis destitutos.* But *Dr. Willis* as expressly asserts they have muscular Fibres, and assigns an excellent Use of them; *Cellulæ istæ vesiculares, ut nixus pro expiratione contractivos edant, etiam fibras, uti per Microscopium planè conspicere est, musculares obtinent. ubi supr. §. 16.* And in the next §, *Ut pro datâ occasione majorem aeris copiam exsufflent, aut materiam extussendam ejiciant, fibræ muscularibus donatæ, sese arctius contrahunt, contentaque sua penitus exterminant. Etenim ordinariæ pectoris Systolæ, quas musculorum relaxationes ex parte efficiunt, aerem forsan totum a Trachea & Bronchiis, haud tamen a Vesiculis, quaque vice ejiciunt: propter has (quoties opus erit) inaniendas, & totius Pectoris cavitas plurimum angustatur,*

From hence I might proceed to the commodious Form of the Ribs (8), the curious Mechanism of the Intercostal-muscles (9), the Diaphragm, and all the other Muscles (10) ministering both to the ordinary, and extraordinary Offices of Respiration. But

Et cellulae ipsae vesiculares a propriis fibris contractis coarctantur.

(8) Circa hos motus [Scil. Pectoris dilatationem, &c.] divini Conditoris mechanice, ad regulas Mathematicas plane adaptatam, satis admirari non possumus; siquidem nullâ aliâ in re manifestius ô Θεός κωυεργεῖν videatur. Quippe cum pectoris tum ampliatio, tum coarctatio a quibusdam Musculis (quorum munus unicum est contrahere) perfici debeat; res ita instituitur, ut Costæ, quæ thoracis, velut parallelogrammi oblongi versus cylindrum incurvati, latera efformant, in figuram modo quadratam, cum angulis rectis pro pectoris ampliatioe; modo in rhomboeidem, cum angulis acutis, pro ejusdem contractione, ducantur, &c. Willis, ubi supr. §. 28.

Galen having spoken of the Parts ministering to Respiration, concludeth, Nihil usquam a Naturâ ullo pacto per incuriam fuisse præteritum, quæ cum omnia præsentiret, & provideret, quæ sunt necessario illa, quæ causa alicujus extiterunt, consecutura, omnibus instaurationes parare occupavit, cujus apparatus copiosa facultas admirabilem Sapientiam testantur. De ul. part. l. 5. c. 15. See also l. 6. c. 1.

(9) For the Structure of the Intercostals, Midriff, &c. I shall refer to Dr. Willis, and other Anatomists. But Dr. Drake taxeth Dr. Willis with an Errour in fancying there is an opposition in the Office of the Intercostals, by reason the Fibres of the external and internal Intercostals decussate; that therefore the External serve to raise the Ribs, the Internal to draw them down. But Dr. Drake is of Steno's, and Dr. Mayow's Opinion, that notwithstanding the Decussation of their Fibres, the Power they exert upon, and the Motion they effect in the Ribs is one and the same. Drake's Anat. l. 2. c. 7. and l. 4. c. 5. Mayow's de Respir. c. 7.

(10) Although Dr. Drake and some others deny the Intercostals being Antagonist-Muscles, as in the preceding Note, yet they, and most other Anatomists that I have met with, attribute a considerable power to them in the act of Respiration, as they do also to the Subclavian, and Triangular Muscles: but the learned Etmüller denies it for these three Reasons, 1. Quia respirando nullam in illis contractionem sentio. 2. Quia—sibi invicem

But passing them by, I shall stop at one prodigious Work of Nature, and manifest Contrivance of the Almighty Creator, which although taken notice of by others (11), yet cannot be easily passed by in the Subject I am upon; and that is the Circulation of the Blood in the *Fœtus in the Womb*, so different from the Method thereof after it is Born. In the Womb, whilst it is as one Body with the Mother, and there is no Occasion, nor place for Respiration, there are two Passages (12) on purpose for the transmission of the Blood without passing it through the Lungs.

vicem non adducuntur, &c. 3. Quia Costæ omnes ab aliis modo enarratis Musculis moventur, idque simul, &c. Intercostales itaque, necnon Subclavios Musculos Costis, parietum instar, ad complenda interstitia intercostalia, pectusque integrandum, ac Costas connectendas, intertextos esse, probabiliter concludo: quo munere Triangulares etiam — fungi, rationi consentaneum est. Etmul. Dissert. 2. cap. 4. §. 6.

But as to the use of the *Triangular-Muscle* in Respiration, we may judge of it, from its remarkable Size, and Use in a Dog; of which Dr. Willis gives this Account from Fallopius: *In Homine parvus adeo & subtilis iste [Musculus] est, ut vix pro Musculo accipi queat: in cane per totum os pectoris protenditur, & cartilagine omnes, etiam verarum Costarum sterna inosculatas, occupat. Cujus discriminis ratio divinam circa Animalium fabricas Providentiam planè indigitat. Quippe cum hoc animal, ad cursus velocissimos & diu continuandos natum, quo sanguis, dum intensius agitur, ritè accendatur eventileturque, aerem celerrimè & fortiter uti inspirare, ita etiam expirare debet — idcirco propter hunc actum firmitus obeundum (cujus in Homine haud magnus est usus) musculus caninus molem ingentem & tanto operi parem sortitur. Willis ubi supr. §. 32.*

(11) Ray's Wisdom of God in the Creation, pag 343.

(12) Mr. Cheselden an ingenious, and most accurate Anatomist, having somewhat particular in his Observations about the Circulation of the Blood through the Heart of the Fœtus, I shall present the Reader with some of his Observations, which he favoured me with the sight of. *The Blood, (saith he,) which is brought to the Heart by the ascending Cava, passeth out of the right Auricle into the left, through a Passage called Foramen Ovale, in the* [Septum

Lungs. But as soon as the *Fœtus* is Born, and become thereby a perfectly distinct Being, and breathes for it self, then these two Passages are shut up: one nearly obliterated, the other becomes only a Ligament, except in some Creatures that are Amphibious, or are forced to lie long under Water, in whom these Passages probably remain open (12).

And now what Action of any rational Creature, what is there in a Man's Life, that doth more plainly

[Septum common to them both] without passing through the right Ventricle (as after the Birth) while the Blood from the descending Cava passeth through the right Auricle and Ventricle into the pulmonary Artery, and thence into the Aorta through a Duct, betwixt that and the pulmonary Artery, called *Ductus Arteriosus*, whilst a small Portion of the Blood, thrown into the pulmonary Artery passeth through the Lungs, no more than is sufficient to keep open the pulmonary Vessels. Thus both Ventricles are employed in driving the Blood through the Aorta to all Parts of the *Fœtus*, and to the Mother too. But after the Birth, the Blood being to be driven from the Aorta through the *Fœtus* alone, and not the Mother too, one Ventricle becomes sufficient, whilst the other is employed in driving the Blood through the Lungs, the *Ductus Arteriosus* being shut up by means of the Alteration of its Position, which happens to it from the raising the Aorta by the Lungs when they become inflated. After that the Blood is thus driven into the Lungs, in its return it shuts the Valve of the Foramen Ovale against the Foramen it self, to whose sides it soon adheres, and so stops up this Passage. The *Ductus Arteriosus*, or *Ductus Arteriosus* in Ligamentum versus, is seldom to be discerned in adult Bodies, but the Figure of the Foramen Ovale is never obliterated.

(13) It hath been generally thought to be not improbable, but that on some Occasions the *Foramen Ovale* may remain open in Man. In a Girl of four or five Years of Age, Dr. Conner found it but half closed, and in the Form of a Crescent. And he thinks somewhat of this kind might be in the Person whose Sceleton was found to have no Joynts in the Back-bone, Ribs, &c. Of which a Description, with Cuts. may be found in *Phil. Trans.* Nr. 215. and more largely in his *Dissert. Med. Phys. de Stupendo Ossium coalitu*, where he adds to the Girl, in whom the *For-Ov.* was not shut; a like Observation of another Girl he opened at Oxford of three Years Old, in qua *Foramen Ovale fere erat*

plainly shew Design, Reason, and Contrivance, than this very Act of Nature doth the Contrivance and

erat occlusum, in medio tamē, exili foramine, per quod Turundam facile transmissi, erat pervium, pag. 30. So Mr. Cowper (than whom none more accurate nor a better Judge) saith, *I have often found the Foramen Ovale open in the Adult.* Anat. Append. Fig. 3. But Mr. Cheselden is of a different Opinion. Of which in the following Note.

From somewhat of this cause I am apt to think it was that the Tronningholm Gardiner escaped drowning, and some others mentioned by Pechlin. His Stories are, *Hortulanus Tronningholmensis etiamnum vivens, annos natus 65, pro illā etate satis adhuc valens & vegetus, cum ante 18 annos, alii in aquas delapso opem ferre vellet, forte-fortunā & ipse per glaciem incautiū procedens, aquas incidit 18 ulnas profundas: ubi ille, corpore erecto quasi ad perpendiculum, pedibus fundo adhæsit. Constitit sic per 16 horas, antequam produceretur in auras. Dixit autem, simul ac infra aquarum superficiem fuit demersus, statim obriguisse totum, & si quem tum habuit motum & sensum, amisisse, nisi quod sonantes Stockolmii campanas etiam sub aquis obscurius percipere sibi sit visus. Sensit etiam, statim sese velut vesiculam ori applicasse, adeo ut aqua nulla os penetraverit, in aures vero transitum, etiam sentiente illo, habuerit; atque inde auditum suum debilitatum aliquandiu esse. Hoc statu dum 16 horas permansit frustra quæsitus, tandem repertum, conto in caput infixio, cujus etiam sensum se habuisse dixit, fundo extraxerunt, sperantes ex more aut persuasione gentis reviviturum esse. Itaque pannis linteisque productum obvolvunt, ne aer admitti possit perniciosus futurus subito illapsu: custoditum sic satis ab aere sensim sensimque tepidiori loco admovent, mox calidis adoriuntur fasciis, fricant, radunt, & sufflaminatum tot horis sanguinis corporisque motum negotiosā illā operā reducunt: denique antapoplecticis & genialibus liquoribus vita reddunt & pristinae mobilitati. Retulit is atque ostendit se etiamnum in capite circumferre vestigia violentiæ a conto illatæ, & cephalalgias vexari gravissimas. Et propter hunc ipsum casum, religiosè a popularibus, & hujusce rei testibus probatum, Serenissimæ Reginæ matris munificentia & annuo stipendio est donatus — & Serenis. Principi — oblati, vivus sui testis. — Consignatam manu habes Historiam D. Tilasii, Biblioth. Reg. Præfæti, qui testatus est se prænovisse mulierem, quæ tres ipsos dies sub aquis hæsit, & similem in modum, quo Hortulanus ille, resuscitata, adhuc dum lucis plenā fruitur usurâ. Accedit Nob. Burmanni — fides, qui confessus est, — se in pago Boness parochiæ Pithoviz concionem frequentasse funebrem,*

and Design of the great God of Nature? What is Thought and Contrivance, if this be not? That there should be a temporary Part in the Body, made just for the present Exigence; to continue whilst there is occasion for it, and to cease when there is none; in some Creatures to remain always, by reason of their amphibious way of living, and in Land-Animals (purely such) to cease?

Another excellent Contrivance, a-kin to the last, is for the Preservation of such Creatures whose occasions

brem, in quâ, dum acta recenseret Præco Senis cujusdam 70genarii, Laur. Jonæ — audiverit ex ore Concionatoris, virum eum, adolescentem 17 annorum, aquis submersum, 7 demum hebdomadâ (rem prodigiosam!) extractum ad se rediisse vivum & incolumem. Pechlin. de Aer. & Alim. def. c. 10.

Shall we to this Cause, or to the Ossification, or more than ordinary Strength of the Wind-pipe, attribute the recovery to Life of Persons hanged. Of which *Pechlin* gives an Instance that fell under his own Knowledge, of a Woman hanged, and in all appearance Dead, but recovered by a Physician accidentally coming in, with a plentiful Administration of *Spir. Sal. Armon.* *Pechl. ib. c. 7.* And the Story of *Ann Green* executed at *Oxford*, Dec. 14. 1650. is still well remembered among us. She was hanged by the Neck near half an Hour, some of her Friends in the mean time thumping her on the Breast, others hanging with all their weight upon her Legs, sometimes lifting her up, and then pulling her down again with a sudden Firk, thereby the sooner to dispatch her out of her Pain; as her printed Account wordeth it. After she was in her Coffin, being observed to breath, a lusty Fellow stamped with all his force on her Breast and Stomach, to put her out of her Pain. But by the assistance of *Dr. Peity*, *Dr. Willis*, *Dr. Bathurst*, and *Dr. Clerk*, she was again brought to Life. I my self saw her many Years after, after that she had (I heard) born divers Children. The particulars of her Crime, Execution, and Restauration, see in a little Pamphlet called *News from the Dead*, written, as I have been informed, by *Dr. Bathurst*, (afterwards the most vigilant and learned President of *Trinity-College, Oxon.*) and published in 1651. with Verses upon the Occasion.

sions frequently necessitate them to live without, or with but little Respiration. Fishes might be named here, whose Habitation is always in the Waters. But these belong to an Element which I cannot at present engage in. But there are many Animals of our own Element, or partly so, whose Organs of Respiration, whose Blood, whose Heart, and other Instruments of Life are admirably accommodated to their method of living. Thus many amphibious Creatures (14), who live in Water as well as Air, many Quadrupeds, Birds, Insects, and other Animals, who can live some Hours, Days, yea whole Winters with little or no Respiration, in a Torpitude, or sort of Sleep, or middle State between Life and Death. The Provision made for these peculiar Occasions of Life, in the Fabrick of the

(14) The *Sea-Calf* hath the *Foramen Ovale*, by which means it is enabled to stay long under Water, as the *Paris. Anatomists*. Of which see in *Book VI. Chap. 5. Note 3.*

But the fore-commended Mr. *Cheselden* thinks the *Foramen Ovale* is neither open in amphibious Creatures, nor any adult Land-Animals. When I first (saith he) applied my self to the Dissection of Humane Bodies, I had no distrust of the frequent Accounts of the *Foramen Ovale* being open in Adults: but I find since, that I mistook the *Ostium Venarum Coronariarum* for the *Foramen*. The like I suppose Authors have done, who assert that it is always open in amphibious Animals: for we have made diligent enquiry into those Animals, and never found it open. Neither would that (as they imagine) serve those Creatures to live under Water, as the *Fœtus* doth in Utero, unless the *Ductus Arteriosus* was open also.

This opinion of Mr. *Cheselden* hath this to render it probable, that the *Ostium Venarum Coronariarum* is so near the *Foramen Ovale*, that without due regard it may be easily mistaken for it. Such therefore as have opportunity of examining this part in amphibious Animals, or any other Subject, ought to seek for the *Ostium*, whenever they suspect they have met with the *Foramen*.

the Lungs, the Heart, and other Parts of such Creatures (15), is manifestly the Work of him, who as St. Paul saith (16), *giveth to all Breath, and Life, and all things.*

C H A P. VIII.

Of the Motion of Animals.

NEXT to the two grand Acts of Animal Life, their Sense and Respiration, I shall consider their *Motion*, or *Locomotive Faculty*, whereby they convey themselves from place to place, according to their Occasions, and way of Life. And the admirable Apparatus to this purpose is a plain demonstration of God's particular Fore-sight, Care, and especial Providence towards all the Animal World.

And here I might view in the first place the Muscles, their curious Structure (1), the nice tacking them to every Joynt, to pull it this way, and that way, and the other way, according to the special Purpose, Design, and Office of every such Joynt: Also their various Size and Strength; some large

(15) Of the singular Conformation of the Heart and Lungs of the *Tortoise*, which is an amphibious Animal, see *Book VI. Chap. 5. Note 2.*

(16) Act 17. 25.

(1) That the Muscles are compounded of Fibres is visible enough. Which Fibres the curious and ingenious *Borelli* saith, are cylindraceous: not hollow, but filled with a spongy, pithy Substance, after the manner of Elder, as he discovered by his Microscopes. *Borel. de Mot. Animal. Part 1.*

large and corpulent, others less, and some scarce visible to the naked Eye; all exactly fitted to every Place, and every Use of the Body. And lastly, I might take notice of the muscular Motions, both Involuntary, and Spontaneous (2).

Next I might survey the special Fabrick of the Bones (3) ministring to Animal Motion. Next I might

These Fibres he saith are naturally white, but derive their redness only from the Blood in them.

These Fibres do in every Muscle, (in the Belly at least of the Muscle,) run parallel to one another, in a neat orderly Form. But they do not all tend the same way, but some run assant, some longways, &c. according to the Action or Position of each respective Muscle. The particulars of which, and of divers other observables in the Muscles would, besides Figures, take up too much room in these Notes; and therefore I must refer to the Anatomists, particularly *Steno*, *Borelli*, *Cowper*, &c.

(2) The infinite Creator hath greatly exerted his Art and Care in the Provision made by proper Muscles and Nerves for all the different Motions in Animal Bodies, both involuntary, and voluntary. It is a noble Providence that most of the vital Motions, such as of the Heart, Stomach, Guts, &c. are involuntary, the Muscles acting whether we sleep or wake, whether we will or no. And it is no less providential that some even of the vital Motions are partly voluntary, partly involuntary, as that, for instance, of Breathing; which is performed both sleeping and waking; but can be intermitted for a short time on occasion, as for accurate hearing any thing, &c. or can be encreased by a stronger Blast, to make the greater discharges of the Blood from the Lungs, when that any thing overcharges them. And as for the other Motions of the Body, as of the Limbs, and such as are voluntary, it is a no less Providence that they are absolutely under the power of the Will; so as that the Animal hath it in its power to command the Muscles and Spirits of any part of its Body, to perform such Motions and Actions as it hath occasion for.

(3) *Quid dicam de Ossibus? quæ subiecta corpori mirabiles commissuras habent, & ad stabilitatem aptas, & ad artus finiendos accommodatas & ad motum, & ad omnem corporis actionem.* *Cicer. de Nat. Deor. l. 2.*

By reason it would be endless to mention all the Curiosities observable in the Bones, I shall for a Sample, single out only an instance or two, to manifest that Design was used in the Structure of these Parts in Man.

The first shall be in the *Back-bone*, which (among many others) hath these two things remarkable. 1. Its different Articulations from the other Joynts of the Body. For here most of the Joynts are flat, and withal guarded with Asperities and Hollows, made for catching and holding; so as firmly to lock, and keep the Joynts from Luxations, but withal to afford them such a Motion, as is necessary for the Incurvations of the Body. 2. The difference of its own Joynts in the Neck, Back, and Loins. In the Neck, the *Atlas*, or upper *Vertebra*, as also the *Dentata* are curiously made, and joynted (differently from the rest) for the commodious, and easy bending and turning the Head every way. In the Thorax, or Back, the Joynts are more close and firm: and in the Loins more lax and pliant; as also the Spines are different, and the Knobs and Sockets turned the quite contrary way, to answer the occasions the Body hath to bend more there, than higher in the Back. I shall close this Remark with the ingenious Dr. Keil's Observation.

The Structure of the Spine is the very best that can be contrived; for had it been all Bone, we could have had no Motion in our Backs: had it been of two or three Bones articulated for Motion, the Medulla Spinalis must have been necessarily bruised at every Angle or Joynt; besides, the whole would not have been so pliable for the several Postures we have occasion to put our selves in. If it had been made of several Bones without intervening Cartilages, we should have had no more Use of it, than if it had been but one Bone. If each Vertebra had had its own distinct Cartilages, it might have been easily dislocated. And lastly, the oblique Processes of each superiour and inferiour Vertebra, keep the middle one that it can neither be thrust backwards nor forwards to compress the Medulla Spinalis. Keil's Anat. c. 5. §. 8.

Compare here what Galen saith of the Articulations, Ligaments, Perforation, &c. of the Spine to prove the Wisdom and Providence of the Maker of Animal Bodies, against such as found fault with Nature's Works; among which he names *Diagoras*, *Anaxagoras*, *Asclepiades*, and *Epicurus*. V. Galen de Us. Part. L. 12. init. and Chap. 11, &c. also L. 13. init.

2. The next Instance shall be in one or two things, wherein the Sclerons of Sexes differ. Thus the *Pelvis* made in the Belly by the *Ilium*, *Ossa Coxendicis* and *Pubis*, is larger in a Female than Male Skeleton, that there may be the more Room for the lying of the Viscera, and Fœtus. So the Cartilage bracing together the two *Ossa Pubis*, or *Sharebones*, is laxer in Women than Men: as also is the Cartilage that tieth the *Os Sacrum* to its *Vertebra*; and all to give way to the passage of the Fœtus.

might take notice of the Joynts (4), their compleat Form adjusted to the Place, and Office they are employed in; their Bandage, keeping them from Luxations; the oily Matter (||) to lubricate them, and

Another considerable Difference is in the cartilaginous Productions of the seven long Ribs, whereby they are braced to the Breast-bone. These are harder and firmer in Women than in Men; the better to support the Weight of the Breasts, the sucking Infant, &c.

(4) It is remarkable in the Joynts, and a manifest Act of Caution and Design, 1. That although the Motion of the Limbs be circular, yet the Center of that Motion is not in a Point, but an ample Superficies. In a Point, the Bones would wear, and penetrate one another; the Joynts would be exceedingly weak, &c. but the Joynts consisting of two large Superficies, Concave and Convex, some furrowed and ridged, some like a Ball and Socket, and all lubricated with an oily Substance, they are incomparably prepared both for Motion and Strength. 2. That the Bones next the Joynt are not spungy, as their Extremities commonly are, nor hard and brittle; but capped with a strong, tough, smooth cartilaginous Substance, serving both to Strength and Motion.

But let us here take notice of what Galen mentions on this Subject. *Articulorum unusquisque Eminentiam Cavitati immissam habet. Veruntamen hoc fortasse non adeo mirabile est, sed si consideratâ omnium totius corporis ostium mutuâ connexionem, Eminentias cavitatibus suscipientibus æquales semper inveneris, Hoc mirabile. Si enim justo amplior esset Cavitas, latus sanè & infirmus fieret Articulus: si strictior, motus difficulter fieret, ut qui nullam versionem haberet, ac periculum esset non parvum, eminentias ostium arctatas frangi: sed horum neutrum factum est. — Sed quoniam ex tam secura constructione periculum erat, ne motiones difficilius fierent, & eminentie ostium extererentur, duplex rursus auxilium in id Natura molita est. 1. Cartilagine os utrumque subungens, atque oblinens: alterum, ipsis Cartilaginibus humorem unctuosum, velut oleum superfundens; per quem facile mobilis, & attritu contumax omnis articulatio Ostium facta est. — Ut undique diligenter Articulus omnis custodiretur, Ligamenta quædam ex utroque osse produxit Natura.* Galen de Us. Part. l. 1. c. 15.

(||) For the affording this oily or mucilagnious Matter, there are Glandules very commodiously placed near the Joynts, so as not to suffer too great Compression by the Motion of the neighbouring

and their own Smoothness to facilitate their Motion.

And lastly, I might trace the various Nerves throughout the Body, sent about to minister to its various Motions (5). I might consider their Origine (6), their Ramifications to the several Parts, and their Inosculation with one another, according to the Harmony and Accord of one part with another, necessary for the benefit of the Animal. But some of those things I have given some touches upon already, and more I shall mention hereafter (7), and it would be tedious here to insist upon them all.

I

bouring Bones, and yet to receive a due Pressure, so as to cause a sufficient emission of the Mucilage into the Joynts. Also another thing considerable is, that the excretory Ducts of the *mucilaginous Glands* have some length in their Passage from the Glands to their Mouths; which is a good Contrivance to prevent their Mouths being oppressed by the Mucilage, as also to hinder the too plentiful Effusion thereof, but yet to afford a due expresseure of it at all times, and on all occasions, as particularly in violent and long-continued Motions of the Joynts, when there is a greater than ordinary expence of it. See *Cowper's Anat. Tab. 79.*

(5) There is no doubt to be made, but that the Muscles receive their Motion from the Nerves. For if a Nerve be cut, or straightly bound, that goes to any Muscle, that Muscle shall immediately loose its Motion. Which is doubtless the case of Paralyticks; whose Nerves are some of them by Obstructions, or such like Means reduced to the same State as if cut, or bound.

Neither is this a modern Notion only: for *Galen* saith, *Principium Nervorum omnium Cerebrum est, & Spinalis Medulla. — Et Nervi a Cerebro animalem virtutem accipiunt. — Nervorum utilitas est facultatem Sensus & Motus a principio in partes deducere.* And this he intimates to have been the Opinion of *Hippocrates* and *Plato*. *De Us. Part. l. 1. c. 16. & passim.*

(6) *Dr. Willis* thinks, that in the *Brain* the Spirits are elaborated that minister to voluntary Motion: but in the *Cerebellum*, such as effect involuntary, or natural Motions; such as that of the Heart, the Lungs, &c. *Cerebri Anat. c. 15.*

(7) See *Book V. Chap. 8.*

I shall therefore only speak distinctly to the Locomotive Act it self, or what directly relates to it. And here it is admirable to consider the various Methods of Nature (8), suited to the Occasions of the various Animals. In some their Motion is swift, in others slow. In some performed with two, four, or more Legs: in some with two or four Wings: in some with neither (9).

And first for swift or slow Motion. This we find is proportional to the Occasions of each respective Animal. *Reptiles*, whose Food, Habitation, and Nests, lie in the next Clod, Plant, Tree, or Hole, or can bear long Hunger and Hardship, they need neither Legs, nor Wings for their Transportation; but their vermicular, or sinuous Motion, (performed with no less Art, and as curiously provided for, as the Legs or Wings of other Creatures; this, I say,) is sufficient for their Conveyance.

Man

(8) To the foregoing, I shall briefly add some Examples of the special Provision made for the Motion of some Animals by *Temporary Parts*. *Frogs* and *Toads* in their *Tadpole-state* have Tails, which fall off when their Legs are grown out. The *Lacerta aquatica*, or *Water-Newt*, when Young, hath four near ramified Fins, two on a side, growing out a little above its Fore-Legs, to poise, and keep its Body upright, (which gives it the resemblance of a young Fish,) which fall off when the Legs are grown. And the *Nymphae* and *Aureliae* of all or most of the Insects bred in the Waters, as they have particular Forms, different from the Insects they produce; so have also peculiar Parts afforded them for their Motion in the Waters, Oars, Tails, and every Part adapted to the Waters, which are utterly varied in the Insects themselves in their *mature State* in the Air.

(9) *Jam vero alia animalia gradiendo, alia serpendo ad pastum accedunt, alia volando, alia nando.* Cicer. de Nat. Deor. l. 2. c. 47.

Compare also what *Galen* observes concerning the Number of Feet in Man, and in other Animals; and the wise Provision thereby made for the Use and Benefit of the respective Animals *De Usu Par.* in the beginning of the third Book.

(10) As

Man and Beasts, whose Occasions require a large Room, have accordingly a swifter Motion, with proper Engines for that Service; answerable to their range for Food, their Occupation or Business, or their want of Armature, and to secure them against Harms (10).

But for the winged Creatures, (*Birds and Insects*,) as they are to traverse large Tracts of Land, and Water, for their Food, for their commodious Habitation, or Breeding their Young, to find places of Retreat and Security from Mischiefs; so they have accordingly the Faculty of flying in the Air; and that swiftly or slowly, a long or a short time, according to their Occasions and way of Life. And accordingly their Wings, and whole Body are curiously prepared for such a Motion; as I intend to shew in proper place (11).

Another remarkable thing in the motive Faculty of all Creatures, is the neat, geometrical Performance of it. The most accurate Mathematician, the most skilful in mechanick Motions, can't prescribe a nicer Motion (than what they perform) to the Legs and Wings of those that walk or fly (12), or to the Bodies of those that creep (13). Neither can the Body be more compleatly poised for the Motion

(10) As I shall hereafter shew, that the indulgent Creator hath abundantly provided for the safety of Animals by their Cloathing, Habitations, Sagacity and Instruments of Defence; so there appears to be a Contemperament of their Motion with these Provisions. They that are well armed and guarded, have commonly a slower Motion; whereas they that are destitute thereof, are swifter. So also timid helpless Animals are commonly swift; thus Deers and Hares: but Animals endowed with Courage, Craft, Arms, &c. commonly have a slower Motion.

(11) See *Book VII. Chap. 1.*

(12) See *Book VII. Chap. 1. the end.*

(13) See *Book IX. Note 3.*

Motion it is to have in every Creature, than it already actually is. From the largest Elephant to the smallest Mite, we find the Body artfully ballanced (14). The Head not too heavy, nor too light for the rest of the Body, nor the rest of the Body for it (15). The Viscera not left loose, or so placed, as to swag, over-balance, or over-set the Body; but well-braced, and distributed to maintain the æquipoise of the Body. The motive Parts also are admirably well-fixed in respect to the Center of Gravity; placed in the very Point, fittest to support and convey the Body. Every Leg beareth his true share of the Body's Weight. And the Wings so nicely are set to the Center of Gravity, as even in that fluid Medium, the Air, the Body is as truly ballanced, as we could have ballanced it with the nicest Scales.

But among all Creatures, none more elegant than the sizing the Body of *Man*, the gauging his Body so nicely, as to be able to Stand erect, to
Stoop,

(14) *Siquis unquam alius Opifex, æqualitatis & proportionis magnam habuit providentiam, certè Natura habuit in animalium corporibus conformandis; unde Hippocrates eam rectissime justam nominat. Galen de Us. Part. 1. 2. c. 16.*

(15) The Make of the Bodies of some Water-Fowls, seems to contradict what I here say, the Heads and long Necks of some, as of Swans, Ducks, and Geese; and the hinder Parts of others, as of the Doucker and More-Hen, and some other kinds, seeming to be too heavy for the rest of their Body. But instead of being an Argument against, it is a notable Instance of the divine Art and Providence, these things being nice Accommodations to their way of Life. Of such as have long Necks, see *Book VII. Chap. 3. Note 9.*

And as for such whose hinder Parts seem to over-balance their foremost Parts, whereby they fly with their Bodies in a manner erect, this also is an excellent Accommodation to their way of Life, which is Diving, rather than Flying. *Vid. Book VII. Chap. 4. Note 9.*

(16) See

Stoop, to Sit, and indeed to Move any way, only with the help of so small a Stay as the Feet (16): whose Mechanism of Bones, Tendons and Muscles to this purpose, is very curious, and admirable.

CHAP. IX.

Of the Place allotted to the several Tribes of Animals.

HAVING dispatched the Motion of Animals, let us in the next place consider the *Place* which the infinitely wise Creator hath appointed them to Move and Act, and Perform the Offices of the Creation in: And here we find every Particular well ordered. All Parts of our Terraqueous Globe fit for an Animal to live and act in, are sufficiently stocked with proper Inhabitants: The watery Element (unfit one would think for Respiration and Life) abounding with Creatures fitted for it: its Bowels abundantly stored, and its Surface well bespread. The Earth also is plentifully stocked in all its Parts, where Animals can be of any Use: not probably the deepest Bowels thereof indeed, being Parts in all likelihood unfit for Habitation and Action, and where a living Creature would be useless in the World; but the Surface every where abundantly stored.

But that which is most considerable in this Matter, and plainly sheweth the divine Management in the Case, is, that those Creatures are manifestly designed for the Place in which they are, and the Use

(16) See *Book V. Chap. 2. Note 8.*

Use and Services they perform therein. If all the Animals of our Globe had been made by Chance, or placed by Chance, or without the divine Providence, their Organs would have been otherwise than they are, and their Place and Residence confused and jumbled. Their Organs (for Instance) of Respiration, of Vision, and of Motion would have fitted any Medium, or have needed none; their Stomachs would have served any Food, and their Blood, and Covering of their Bodies been made for any Clime, or only one Clime. Consequently all the Animal World would have been in a confused, inconvenient, and disorderly Commixture. One Animal would have wanted Food, another Habitation, and most of them Safety. They would have all flocked to one, or a few Places, taken up their Rest in the Temperate Zones only, and coveted one Food, the easiest to be come at, and most specious in shew; and so would have poisoned, starved, or greatly incommoded one another. But as the matter is now ordered, the Globe is equally bespread, so that no place wanteth proper Inhabitants, nor any Creature is destitute of a proper place, and all things necessary to its Life, Health, and Pleasure. As the Surface of the Terraqueous Globe is bespread with different Soils, with Hills, and Vales, with Seas, Rivers, Lakes, and Ponds, with divers Trees and Plants, in the several Places; so all these have their Animal Inhabitants, whose Organs of Life and Action are manifestly adapted to such and such Places and Things; whose Food and Physick, and every other Convenience of Life, is to be met with in that very Place appointed it. The Watery, the Amphibious (†), the airy Inhabitants, and those on the

(†) *Est etiam admiratio nonnulla in Bestiis aquatilibus iis, quæ gignuntur in terrâ: veluti Crocodili, fluviatilesque Testudines, quæ-*
damque

the Dry-land Surface, and the Subterraneous under it, they all Live and Act with Pleasure, they are gay, and flourish in their proper Element, and allotted Place, they want neither for Food, Cloathing, or Retreat; which would dwindle and die, destroy, or poison one another, if all coveted the same Element, Place, or Food.

Nay, and as the Matter is admirably well ordered, yet considering the World's encrease, there would not be sufficient Room, Food, and other Necessaries for all the living Creatures, without another grand Act of the divine Wisdom and Providence, which is the *Ballancing the Number of Individuals* of each Species of Creatures in that place appointed thereto: Of which in the next Chapter.

C H A P. X.

Of the Balance of Animals, or their due Proportion wherewith the World is stocked.

THE whole Surface of our Globe can afford Room. and Support only to such a number of all sorts of Creatures. And if by their doubling, trebling, or any other Multiplication of their Kind, they should encrease to double or treble that number, they must starve, or devour one another. The
keeping

damque Serpentes orta extra aquam, simul ac primum niti possunt, aquam persequuntur. Quin etiam Anatum ova Gallinis saepe supponimus — [Pulli] deinde eas [matres] relinquunt — & effugiunt, cum primum aquam, quasi naturalem domum, videre potuerunt. Cicer. de Nat. Deor. l. 2. c. 48.

keeping therefore the Balance even is manifestly a Work of the Divine Wisdom and Providence. To which end, the great Author of Life hath determined the Life of all Creatures to such a Length, and their Increase to such a Number, proportional to their Use in the World. The Life of some Creatures is long, and their Increase but small, and by that means they do not overstock the World. And the same Benefit is effected, where the Increase is great, by the Brevity of such Creature's Lives, by their great Use, and the frequent Occasions there are of them for Food to Man, or other Animals. It is a very remarkable Act of the Divine Providence, that useful Creatures are produced in great plenty (1), and others in less. The prodigious and frequent Increase of Insects, both in and out of the Waters, may exemplify the one: and 'tis observable in the other, that Creatures less useful, or by their voracity pernicious, have commonly fewer Young, or do seldomer bring forth. Of which many instances might be given in the voracious Beasts and Birds. But there is one so peculiar an Animal, as if made for a particular instance in our present case, and that is the *Cuntur* of *Peru* (2); a Fowl of that Magnitude, Strength, and Appetite, as to seize not only on the Sheep, and lesser Cattel, but even the

(1) *Benigna circa hoc Natura, innocua & esculenta animalia fecunda generavit.* Plin. Nat. Hist. l. 8. c. 55.

(2) Captain J. Strong, gave me this Account, together with a Quill-Feather of the [*Cuntur* or Condore of Peru] on the Coast of Chili, they met with this Bird in about 33° S. Lat. not far from Mocha, an Island in the South-Seas, — they shot it sitting on a Cliff, by the Sea-side; that it was 16 Feet from Wing to Wing extended: that the Spanish Inhabitants told them they were afraid of these Birds, lest they should prey upon their Children. And the Feather he gave me (saith the Doctor) is 2 Foot, 4 Inches long; the Quill part $5\frac{3}{4}$ Inches long, and $1\frac{1}{2}$ Inch about in the largest

the larger Beasts; yea, the very Children too. Now these as they are the most pernicious of Birds, so are the most rare, being seldom seen, or only one, or a few in large Countries; enough to keep up the Species, but not to over-charge the World.

Thus the Balance of the Animal World is throughout all Ages kept even, and by a curious Harmony, and just Proportion between the increase of all Animals, and the length of their Lives, the World is through all ages well, but not over-stored. One Generation passeth away, and another Generation cometh (3), so equally in it's Room, to balance the Stock of the Terraqueous Globe in all Ages, and Places, and among all Creatures, that it is an actual Demonstration of our Saviour's Assertion, *Matt. 10. 29.* that the most inconsiderable, common Creature,

largest Part. It weighed 3 dr. 17½ gr. and is of a dark brown Colour. Dr. Sloane in Phil. Transf. Nr. 208.

To this Account the Doctor (in a Letter to Mr. Ray, *Mar. 31. 1694.* with other Papers of Mr. Rays in my Hands) adds the Testimony of *Jos. Acosta, l. 4. c. 37.* and *Garcilasso de la Vega, who l. 8. c. 19.* saith, *There are other Fowls, called Cuntur, and by the Spaniards corruptly Condor. Many of these Fowls having been killed by the Spaniards, had their Proportion taken, and from end to end of their Wings measured 15 or 16 Feet.—— Nature to temper and allay their Fierceness, denied them the Talons, which are given to the Eagle; their Feet being tipt with Claws like an Hen. However their Beak is strong enough to tear off the Hide, and rip up the Bowels of an Ox. Two of them will attempt a Cow or Bull, and devour him. And it hath often happened, that one of them alone hath assaulted Boys of ten or twelve Years of Age, and eaten them. Their Colour is black and white like a Magpie, It is well there are but few of them, for if they were many, they would very much destroy the Cattle. They have on the forepart of their Heads a Comb, not pointed like that of a Cock, but rather even in the form of a Razour. When they come to alight from the Air, they make such an humming Noise with the fluttering of their Wings, as is enough to astonish, or make a Man deaf.*

(3) *Eccles. 1. 4.*

(4) The

Creature, even a Sparrow (two of which are Sold for a Farthing) doth not fall on the Ground without our Heavenly Father.

This Providence of God is remarkable in every Species of living Creatures: but that especial Management of the Recruits and Decays of Mankind, so equally all the World over, deserves our especial Observation. In the beginning of the World, and so after *Noah's Flood*, the Longævity of Men, as it was of absolute necessity to the more speedy peopling of the new World, so is a special Instance of the Divine Providence in this Matter (4). And the same Providence appears in the following Ages, when

(4) The Divine Providence doth not only appear in the Longævity of Man immediately after the Creation and Flood; but also in their different Longævity at those two times. Immediately after the Creation, when the World was to be peopled by one Man, and one Woman, the Age of the greatest part of those on Record was 900 Years and upwards. But after the Flood, when there were three Persons by whom the World was to be peopled, none of those Patriarchs, except *Shem*, arrived to the Age of 500; and only the three first of *Shem's* Line, viz. *Arphaxad*, *Salah*, and *Eber*, came near that Age; which was in the first Century after the Flood. But in the second Century, we do not find any reached the Age of 240. And in the third Century, (about the later end of which *Abraham* was born,) none, except *Terah*, arrived to 200 Years. By which time the World was so well peopled, (that part of it at least where *Abraham* dwelt,) that they had built Cities, and began to be cantoned into distinct Nations, and Societies, under their respective Kings; so that they were able to wage War, four Kings against five, *Gen. 14*. Nay, if the Accounts of *Anian*, *Berosus*, *Manetho*, and others, yea *Africanus* be to be credited, the World was so well peopled even before the times we speak of, as to afford sufficient Numbers for the great Kingdoms of *Assyria*, *Ægypt*, *Perfia*, &c. But learned Men generally, with great reason, reject these as legendary Accounts.

If the Reader hath a mind to see a Computation of the increase of Mankind in the three first Centuries after the Flood, he may find two different ones of the most learned Archbishop

Usher,

when the World was pretty well peopled, in reducing the common Age of Man then to 120 Years, (*Gen. 6. 3.*) in proportion to the Occasions of the World at that time. And lastly, when the World was fully peopled after the Flood, (as it was in the Age of *Moses*, and so down to our present time,) the lessening the common Age of Man to 70 or 80 years (5), (the Age mentioned by *Moses*, *Psal. 90. 10*; this, I say,) is manifestly an appointment of the

Usher, and *Petavius*, together with a Refutation of the so early beginning of the *Assyrian Monarchy*, as also Reasons for placing *Abraham* near 1000 Years after the Flood in our most learned Bishop *Stillingfleet's Orig. Sacr.* Book III. Chap. 4. §. 9.

(5) That the common Age of Man hath been the same in all Ages since the World was peopled, is manifest from prophane, as well as sacred History. To pass by others, *Plato* lived to the Age of 81, and was accounted an old Man. And those which *Pliny* reckons up, *l. 7. c. 48.* as rare Examples of long Life, may for the most part be matched by our modern Histories, especially such as *Pliny* himself gave credit unto. Dr. *Plot* hath given us divers Instances in his History of *Oxon. C. 2. §. 3.* and Chap. 8. §. 54. and History of *Staffordshire, c. 2. §. 91, &c.* Among others, one is of twelve Tenants of Mr. *Biddulphs*, that together made 1000 Years of Age. But the most considerable Examples of aged Persons among us, is of old *Parre* of *Shropshire*, who lived 152 Years 9 Months; and *Henry Jenkins* of *Yorkshire*, who lived 169 Years; of both which, with others, see *Lowth. Abridg. Phil. Transf. V. 3. p. 306.* The great Age of *Parre* of *Shropshire*, minds me of an Observation of the Reverend Mr. *Plaxton*, that in his two Parishes of *Kinardsey* and *Donington* in *Shropshire* likewise, every sixth Soul was 60 Years of Age or upwards. *Phil. Transf. Nr. 310.*

And if we step farther North into *Scotland*, we shall find divers recorded for their great Age. Of which I shall present the Reader with only one modern Example of one *Laurence*, who married a Wife after he was 100 Years of Age, and would go out to Sea a Fishing in his little Boat, when he was 140 Years old; and is lately dead of no other Distemper, but meer old Age, saith Sir *Rob. Sibbald Prodr. Hist. Nat. Scot. p. 44.* and *l. 3. p. 4.*

the same infinite Lord that ruleth the World. For, by this means the peopled World is kept at a convenient Stay, neither too full, nor too empty. For if Men (the generality of them I mean) were to live now to *Methusalah's* Age of 969 Years, or only to *Abraham's*, long after the Flood, of 175 Years, the World would be too much over-run. Or if the Age of Man was limited to that of divers other Animals, to ten, twenty, or thirty years only, the decays then of Mankind would be too fast. But at the middle rate mentioned, the Balance is nearly even, and Life and Death keep an equal pace. Which equality is so great and harmonious, and so

As for Forreigners, the Examples would be endless, and therefore that of *Joh. Ottele* shall suffice, who was as famous for his Beard, as for being 115 Years of Age. He was but two Brabant Ells $\frac{3}{4}$ high; and his long grey Beard was $1\frac{1}{2}$ Ell long. His Picture and Account may be seen in *Ephem. Germ. T. 3. Obs. 163.*

As for the Story *Roger Bacon* tells of one that lived 900 Years by the help of a certain Medicine; and many other such Stories, I look upon them as fabulous. And no better is that of the *Wandering-Jew*, named *Joh. Buttadeus*, said to have been present at our Saviour's Crucifixion; although very serious Stories are told of his being seen at *Antwerp*, and in *France*, about the middle of the last Century but one; and before in A° 1542. conversed with by *Paul of Eitsen*, Bishop of *Sleswick*; and before that, viz. in 1228, seen and conversed with by an *Armenian Archbishop's Gentleman*; and by others at other times.

If the Reader hath a mind to see more Examples, he may meet with some of all Ages in the learned *Hakewill's Apol.* p. 181. where he will also find that learned Author's Opinion of the Causes of the Brevity and Length of Humane Life. The Brevity thereof he attributeth to a too tender Education, sucking strange Nurses, too hasty Marriages, but above all to Luxury, high Sauces, strong Liquors, &c. The Longevity of the Ancients he ascribes to Temperance in Meat and Drink, anointing the Body, the use of Saffron and Honey, warm Cloths, lesser Doors and Windows, less Phyfick, and more Exercise.

so manifest an Instance of the Divine Management, that I shall spend some Remarks upon it.

It appears from our best Accounts of these matters, that in our *European* Parts (6), (and I believe the same is throughout the World; that, I say,) there is a certain Rate or Proportion in the Propagation of Mankind. Such a number Marry (7), so many are Born, such a number Die; in proportion

(6) The Proportions which *Marriages* bear to *Births*, and *Births* to *Burials* in divers parts of *Europe*, may be seen at an easy View in this Table: which

Names of the Places.	Marriages to Births: As	Births to Burials: As
<i>England</i> in general.	1 to 4 ⁶³	1 ¹² to 1
<i>London</i> .	1 to 4.	1 to 1 ⁴
<i>Hants</i> hire, from 1569 to 1658.	1 to 4.	1 ² to 1
<i>Triverton</i> in <i>Devon</i> shire, 1560 to 1664.	1 to 3 ⁷	1 ²⁶ to 1
<i>Cranbrook</i> in <i>Kent</i> , 1560 to 1649.	1 to 3 ⁹	1 ⁶ to 1
<i>Aynho</i> in <i>Northampton</i> shire, for 118 Years.	1 to 6	1 ⁶ to 1
<i>Upminster</i> in <i>Essex</i> , for 100 Years.	1 to 4 ⁶	1 ⁰⁸ to 1
<i>Franckfort</i> on the <i>Main</i> in 1695.	1 to 2 ⁷	1 ² to 1
Old, Middle, and Lower <i>Marck</i> in 1698.	1 to 3 ⁷	1 ⁹ to 1
Dominions of <i>E.</i> of <i>Brandenburgh</i> in 1698.	1 to 3 ⁷	1 ⁵ to 1
<i>Breslaw</i> in <i>Silesia</i> , from 1687 to 91.		1 ⁶ to 1
<i>Paris</i> in 1670, 1671, and 1672.	1 to 4 ⁷	1 ⁶ to 1

Table I made from Major *Graunt's* Observations on the Bills of Mortality, Mr. *King's* Observations in the first of Dr. *Davenant's* *Essays*, and what I find put together by my ingenious Friend Mr. *Lowthorp*, in his *Abridgment*, Vol. 3. p. 668. and my own Register of *Upminster*. That from *Aynho* Register in *Northampton*shire, I had from the present Rector, the learned and ingenious Mr. *Wasse*: and I was promised some Accounts from the North, and divers other Parts of this Kingdom, but have not yet received them.

(7) The preceding Table shews, that Marriages, one with another, do each of them produce about four Births, not only in *England*, but in other Parts of *Europe* also.

And

tion to the number of Persons in every Nation, County, or Parish. And as to Births, two things are very considerable: One is the proportion of Males and Females (8), not in a wide Proportion, not

And by Mr. King's Estimate, (the best Computations I imagine of any, being derived from the best Accounts, such as the Marriage, Birth, and Burial Act, the Poll-Books, &c. by his estimate, I say,) about 1 in 104 marry. For he judgeth the number of the People in *England*, to be about five Millions and an half; of which about 41000 annually marry.

As to what might be farther remarked concerning Marriages, in regard of the Rights and Customs of several Nations, the Age to which divers Nations limited Marriage, &c. it would be endless, and too much out of the way to mention them. I shall only therefore, for the Reader's Diversion, take notice of the Jeer of *Lactantius*, *Quare apud Poetas salacissimus Jupiter desit liberos tollere? Utrum sexagenarius factus & ei Lex Papia fibulam imposuit?* *Lactant. Instit. l. 1. c. 16.* By which *Lex Papia* Men were prohibited to marry after 60, and Women after 50 Years of Age.

(8) Major *Graunt*, (whose Conclusions seem to be well-grounded,) and Mr. *King*, disagree in the Proportions they assign to Males and Females. This latter makes in *London*, 10 Males to be to 13 Females; in other Cities and Market Towns, 8 to 9; and in the Villages and Hamlets 100 Males to 99 Females. But Major *Graunt*, both from the *London* and Country Bills saith, there are 14 Males to 13 Females. From whence he justly infers, *That Christian Religion, prohibiting Polygamy, is more agreeable to the Law of Nature, than Mahumetism, and others, that allow it.* Chap. 8.

This Proportion of 14 to 13, I imagine is nearly just, it being agreeable to the Bills I have met with, as well as those in Mr. *Graunt*. In the 100 Years, for example, of my own Parish-Register, although the Burials of Males and Females were nearly equal, being 633 Males, and 623 Females in all that time; yet there were baptized 709 Males, and but 675 Females, which is 13 Females to 13 $\frac{7}{13}$ Males. Which inequality shews, not only, that one Man ought to have but one Wife, but also that every Woman may, without Polygamy, have an Husband, if she doth not bar her self by the want of Vertue, by Denial, &c. Also this Surplusage of Males is very useful for the Supplies of War, the Seas, and other such expences of the Men above the Women.

That

not an uncertain, accidental Number at all Adventures, but nearly equal. Another thing is, that a few more are Born than appear to Die, in any certain place (9). Which is an admirable Provision for the extraordinary Emergencies and Occasions of the World; to supply unhealthful Places, where Death out-runs Life; to make up the Ravages of great Plagues, and Disease, and the Depredations of War, and the Seas; and to afford a sufficient Number for Colonies in the unpeopled Parts of the

N Earth.

That this is a Work of the Divine Providence, and not a Matter of Chance, is well made out by the very Laws of Chance, by a Person able to do it, the ingenious and learned Dr. *Arbutnot*. He supposeth *Thomas* to lay against *John* that, for eighty-two Years running, more Males shall be born than Females: and giving all Allowances in the Computation to *Thomas's* side, he makes the odds against *Thomas*, that it doth not happen so, to be near five Millions of Millions, of Millions, of Millions to one: but for Ages of Ages, (according to the World's Age,) to be near an infinitely small Quantity, at least less than any assignable Fraction to one against *Thomas*. *Vid. Philos. Trans. Nr. 328.*

(9) The foregoing Table shews that, in *England* in general, fewer Die than are Born, there being but 1 Death to $1\frac{1}{10}$ Births. But in *London* more Die than are Born. So by Dr. *Davenant's* Tables, the Cities likewise and Market-Towns bury $1\frac{7}{10}$ to one Birth. But in *Paris* they out-do *London*, their Deaths being $1\frac{1}{2}$ to one Birth: the reason of which I conceive is, because their Houses are more crouded than in *London*. But in the Villages of *England*, there are fewer Die than are Born, there being but one Death to $1\frac{1}{10}$ Births. And yet Major *Graunt*, and Dr. *Davenant* both observe, that there are more Breeders in *London*, and the Cities and Market-Towns, than are in the Country, notwithstanding the *London* Births are fewer than the Country; the reason of which see in *Graunt*, Chap. 7. and *Davenant ubi supr.* p. 21.

The last Remark I shall make from the foregoing Table shall be, that we may from thence judge of the healthfulness of the places there mentioned. If the Year 1698 was the mean Account of the three *Marcks*, those places bid the fairest for being most healthful; and next to them *Aynho* and *Cranbrook* for *English* Towns.

well, or better stocked than now it is, in 1656 Years, (the time between the Creation and the Flood, this) we will suppose may be done by the natural Methods of each Species Doubling or Increase: But in double that number of Years, or at this Distance from the Flood, of 4000 Years, that the World should not be over-stocked, can never be made out, without allowing an infinite Providence.

I conclude then this Observation with the Psalmists Words, *Psal. 104. 29, 30. Thou hidest thy Face, all Creatures are troubled, thou takest away their Breath, they Die, and return to their Dust. Thou sendest forth thy Spirit, they are Created, and thou renewest the Face of the Earth.*

third Two Hundred and Twenty-eight; and Nine in the fourth Generation. So that she could say the same that the Distick doth, made of one of the Dalburg's Family of Basil.

1 2 3 4
Mater ait Natæ, dic Natæ, filia Natam

5 6
Ut moneat, Natæ plangere Filiolam.

1 2 3 4
Rise up Daughter, and go to thy Daughter, for thy Daughters

5 6
Daughter hath a Daughter. Mrs. Honywood was a very pious Woman, afflicted in her declining Age with Despair, in some measure; concerning which some Divines once discoursing with her, she in a Passion said, *She was as certainly damned as this Glass is broken*, throwing a Venice-Glass against the Ground, which she had then in her Hand. But the Glass escaped breaking, as credible Witneses attested.

C H A P. XI.

Of the Food of Animals.

THE preceding Reflection of the Psalmist mindeth me of another thing in common to Animals, that pertinently falleth next under Consideration, which is the *Appointment of Food*, mentioned in 27, 28, v. of the last-cited 104 Psal. *These [Creatures] wait all upon thee: that thou mayst give them their Meat in due Season. That thou givest them, they gather: thou openest thy hand, they are filled with good.* The same is again asserted in Psal. 145. 15, 16. *The Eyes of all wait upon thee, and thou givest them their Meat in due Season. Thou openest thy hand; and satisfiest the desire of every living thing.*

What the Psalmist here asserts, affords us a glorious Scene of the Divine Providence and Management. Which, (as I have shewed it to concern it self in lesser things,) so we may presume doth exert it self particularly in so grand an Affair as that of Food, whereby the Animal World subsists. And this will be manifested, and the *Psalmist's* Observations exemplified from these six following Particulars.

1. From the subsisting and maintaining such a large Number of Animals throughout all Parts of the World.
2. From the proportionate Quantity of Food to the Eaters
3. From the variety of Food suited to the variety of Animals: or the delight which various Animals have in different Food.
4. From the peculiar Food which peculiar Places afford to the Creatures suited to those Places.

5. From the admirable and curious Apparatus made for the gathering, preparing, and digestion of the Food. And,

6. and lastly, From the great Sagacity of all Animals in finding out, and providing their Food.

1. It is a great Act of the Divine Power and Wisdom, as well as Goodness, to provide Food for such a World of Animals (1), as every where possess the Terraqueous Globe; on the Dry-land, and in the Seas and Waters; in the Torrid and Frozen Zones, as well as the Temperate. That the Temperate Climates, or at least the fertile Valleys, and rich and plentiful Regions of the Earth should afford Subsistence to many Animals may appear less wonderful perhaps. But that in all other the most unlikely places for Supplies, sufficient Food should be afforded to such a prodigious Number, and so great variety of Beasts, Birds, Fishes, and Insects, is owing to that Being, who hath as wisely adapted their Bodies to their Place and Food, as well as provided Food for their Subsistence there.

But I shall leave this Consideration, because it will be illustrated under the following Points; and proceed,

2. To consider the adjustment of the quantity of Food in proportion to the Eaters. In all places generally enough, or such a sufficiency, as may be stiled a Plenty; but not such a Superfluity, as to waste, and corrupt, and thereby annoy the World. But that which is particularly remarkable here is, that among the great variety of Foods, the most
useful

(1) *Pastum animantibus largè & copiosè natura eum, qui cuique aptus erat, comparavit. Cicer. de Nat. Deor. L. 2.*

Ille Deus est, — qui per totum orbem armenta dimisit, qui gregibus ubique passim vagantibus pabulum præstat. Senec. de Benef. l. 4. c. 6.

(2) *Tritico*

useful is the most plentiful, most universal, easiest propagated, and most patient of Weather, and other Injuries. As the herbaceous Eaters (for Instance) are many, and devour much; so the Dry-land Surface we find naturally every where almost carpeted over with Grass, and other agreeable wholesome Plants; propagating themselves in a manner every where, and scarcely destroyable by the Weather, the Plough, or any Art. So likewise for Grain, especially such as is most useful, how easily is it cultivated, and what encrease doth it produce? *Pliny's* example of *Wheat* (2) is a sufficient Instance in this matter; which, (as that curious Heathen observes,) being principally useful to the support of Man, is easily propagated, and in great plenty. And an happy Faculty that is of it, that it can bear either extreams of Heat or Cold, so as scarce to refuse any Clime.

3. Another wise Provision the Creator hath made relating to the Food of Animals is, that various Animals delight in various Food (3); some in Grass and Herbs; some in Grain and Seeds; some in Flesh; some in Insects; some in this (4), some in that; some more delicate and nice, some voracious

(2) *Tritico nihil est fertilius: hoc ei Natura tribuit, quoniam eo maximè alit hominem: ut pote cum e modio, si sit aptum solum — 150 modii reddantur. Misit D. Augusto procurator — ex uno grano (vix credibile dictu) 400 paucis minus germina. Misit & Neroni similiter 340 stipulas ex uno grano. Plin. Nat. Hist. l. 18. c. 10.*

(3) *Sed illa quanta benignitas Naturæ, quod tam multa ad vescendum, tam varia, tamque jucunda gignit; neque ea uno tempore anni, ut semper & novitate delectemur & copiâ. Cic. de Nat. Deor. l. 2.*

(4) *Swammerdam* observes of the *Ephemeron-Worms*, that their Food is Clay, and that they make their Cells of the same. Upon which occasion he saith of *Moths*, that eat Wool and Furr,

cious and catching at any thing. If all delighted in, or subsisted only with one sort of Food, there would not be sufficient for all; but every variety chusing various Food, and perhaps abhorring that of others, is a great and wise means that every Kind hath enough, and oftentimes somewhat to spare.

It deserves to be reckoned as an Act of the Divine Appointment, that what is wholesome Food to one, is nauseous, and as a Poyson to another; what is a sweet and delicate Smell and Taste to one, is foetid and loathsome to another. By which means all the Provisions the Globe affords are well disposed of. Not only every Creature is well provided for, but a due Consumption is made of those things that otherwise would encumber the World, lie in the way, corrupt, rot, stink, and annoy, instead of cherish and refresh. For our most useful Plants, Grain, and Fruits, would mould and rot; those Beasts, Fowls, and Fishes, which are reckoned among the greatest Dainties, would turn to Carrion, and Poyson us: Nay, those Animals, which are become Carrion, and many other things that are noysome, both on the Dry-land, and in the Waters, would be more grievous Annoyances, and breed Diseases, was it not for the Provision which the infinite Orderer of the World hath made, by causing these things to be sweet, pleasant, and wholesome Food to some Creature or other, in the place

There are two things very considerable, 1. That the Cells they make to themselves, wherein they live, and with which as their House, Tortoise-like, they move from place to place, they make of the Matter next at hand. 2. That they feed also on the same, therefore when you find their Cells, or rather Coats or Cases to be made of Yellow, Green, Blew, or Black-Cloth, you will also find their Dung of the same Colour. Swammerd. Ephem. vita. Published by Dr. Tyson, Chap. 3.

place where those things fall : to Dogs, Ravens, and other voracious Animals, for Instance, on the Earth ; and to rapacious Fishes, and other Creatures inhabiting the Waters.

Thus is the World in some measure kept sweet and clean, and at the same time divers Species of Animals supplied with convenient Food. Which Providence of God, particularly in the Supplies afforded the *Ravens*, is divers times taken notice of in the Scriptures (5); but whether for the Reasons now hinted, or any other special Reasons I shall not enquire. Thus our Saviour, *Luke 12. 24. Consider the Ravens ; for they neither sow, nor reap, which neither have Store-house, nor Barn, and God feedeth them.* It is a manifest Argument of the Divine Care and Providence in supplying the World with Food and Necessaries, that the *Ravens* accounted as unclean, and little regarded by Man, destitute of Stores, and that live by Accidents, by what falleth here and there; that such a Bird, I say, should be provided with sufficient Food ; especially if that be true, which *Aristotle* (6), *Pliny* (7), and *Ælian* (8) report of their unnatural Affection and Cruelty to their young, “ That they expell them their Nests “ as soon as they can Fly, and then drive them “ out of the Country.

Thus having considered the wise Appointment of the Creator in suiting variety of Food to variety of Animals : Let us in the

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(5) *Job 38. 41. Psal. 147. 9.*

(6) *Aristot. l. 9. c. 31. Hist. Animal.*

(7) *Pliny* affirms this of the *Crow* as well as *Raven*, *Ceteræ omnes* [i. e. *Cornices*] *ex eodem genere pellunt nidis pullos, ac volare cogunt, sicut & Corvi, qui——robustos suos fœtus fugant longius.* *Nat. Hist. l. 10. c. 12.*

(8) *Var. Hist.*

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on the Earth, the large Swarms of Insects in the Air, with every other Food of the Creatures residing in the Earth, or flying in the Air. But I shall stop at the *Waters*, because the *Psalmist*, in the forecited 104 *Psalm*, speaks with Relation to the especial Provision for the Inhabitants of the Waters; and also by reason that many Land Animals have their chief Maintenance from thence.

Now one would think, that the Waters were a very unlikely Element to produce Food for so great a Number of Creatures as have their Subsistence from thence. But yet how rich a Promptuary is it, not only to large Multitudes of Fishes, but also to many amphibious Quadrupeds, Insects, Reptiles, and Birds! From the largest *Leviathan*, which the *Psalmist* saith (12), *playeth in the Seas*, to the smallest Mite in the Lakes and Ponds, all are plentifully provided for; as is manifest from the Fatness of their Bodies, and the Gayety of their Aspect and Actions.

And the Provision which the Creator hath made for this Service in the Waters is very observable; not only by the Germination of divers aquatick Plants there, but particularly by appointing the Waters to be the Matrix of many Animals, particularly of many of the Insect kind, not only of such as are peculiar to the Waters, but also of many appertaining to the Air and the Land, who, by their near Alliance to the Waters, delight to be about

“struum from Bread alone, that would work on Bodies more Compact than many hard Minerals, nay even on Glass it self, and do many things that *Aqua-fortis* could not do.—Yet by no means was this so corrosive a Liquor as A. F. or as the other acid Menstruums”. *Vid.* the ingenious and learned Dr. *Harris Lex. Tech. verbo Menstruum*, where the way of preparing it may be met with.

(12) *Psalm*. 104. 26.

(13) The

about them, and by that means become a Prey, and plentiful Food to the Inhabitants of the Waters. And besides these, what prodigious Sholes do we find of minute Animals, even sometimes discolouring the Waters (13)! Of these, (not only in the Water, but in the Air and on Land,) I have always thought there was some more than ordinary Use, intended by the All-wise Creator. And having bent many of my Observations that way, I have evidently found it accordingly to be. For be they never so numberless, or minute, those Animals serve

(13) The Insects that for the most part discolour the Waters, are the small Insects of the Shrimp-kind, called by Swammerdam, *Pulex aquaticus arborejens*. These I have often seen so numerous in stagnating Waters in the Summer Months, that they have changed the Colour of the Waters to a pale or deep Red, sometimes a Yellow, according to the Colour they were of. Of this Swammerdam hath a pretty Story, told him by Dr. Florence Schuyt, viz. *Se aliquando Studiis intentum, magno quodam & horribilo rumore fuisse turbatum, & simul ad causam ejus inquirendam excitatum; verum se vix eum in finem surrexisse, cum Ancilla ejus penè exanimis adcurreret, & multo cum singultu referret, omnem Lugduni [Batavorum] aquam esse mutatam in sanguinem*. The cause of which upon Examination he found to be only from the numerous Swarms of those *Pulices*. V. Swam. Hist. Insect. p. 70.

The cause of this great Concourse and Appearance of those little Insects I have frequently observed to be to perform their Coit; which is commonly about the latter end of May, and in June. At that time they are very venereous, frisking, and catching at one another; and many of them conjoined Tail to Tail, with their Bellies inclined one towards another.

At this time also they change their Skin or Slough; which I conceive their rubbing against one another mightily promoteth. And what if at this time they change their Quarters? V. Book VIII. Chap. 4. Note 6.

These small Insects, as they are very numerous, so are Food to many Water-Animals. I have seen not only Ducks shovel them up as they swim along the Waters, but divers Insects also devour them, particularly some of the middle-sized *Squilla aquatica*; which are very voracious Insects.

(14) Besides

serve for Food to some Creature or other. Even those Animalcules in the Waters, discoverable only with good Microscopes, are a Repast to others there, as I have often with no less admiration than pleasure seen (14).

But now the usual Objection is, that Necessity maketh Use (15). Animals must be fed, and they make use of what they find; In the desolate Regions, and in the Waters, for Instance, they feed upon what they can come at; but in greater plenty, pick and chuse.

But this Objection hath been already in some measure answered by what hath been said; which plainly

(14) Besides the *Pulices* last mentioned, there are in the Waters other Animalcules very numerous, which are scarce visible without a Microscope. In May, and the Summer Months, the green Scum on the top of stagnating Waters is nothing else but these Animalcules: So is likewise the green Colour in them, when all the Water seems Green. Which Animalcules, in all probability, serve for Food to the *Pulices aquatici*, and other the minuter Animals of the Waters. Of which I gave a pregnant Instance in one of the *Nymphae* of Gnats, to my Friend the late admirable Mr. Ray, which he was pleased to publish in the last Edition of his *Wisdom of God in the Creation*, pag. 430.

(15) *Nil adeo quoniam natum'st in Corpore, ut uti Possemus, sed quod natum'st, id procreat usum.*

And afterwards,

*Propterea capitur Cibus, ut suffulciat artus,
Et recreet vireis interdatus, atque patentem
Per membra ac venas ut amorem obturet edendi.*

And after the same manner he discourseth of Thirst, and divers other things. *Vid. Lucret. l. 4. v. 821, &c.*

Against this Opinion of the Epicureans, Galen ingeniously argues in his Discourse about the Hand. *Non enim Manus ipsa (saith he,) hominem artes docuerunt, sed Ratio. Manus autem ipse sunt artium organa; sicut Lyra musici.*—*Lyra musicum non docuit, sed est ipsius artifex per eam, qua præditus est, Rationem: agere autem non potest ex arte absque organis, ita & unaquælibet anima facultates quasdam a sua ipsius substantia obtinet.*—*Quod autem corporis particula animam non impellunt, — manifestè videre licet, si animalia recens nata consideres, quæ quidem prius agere*

plainly argues Design, and a super-intending Wisdom, Power, and Providence in this special business of Food. Particularly the different delight of divers Animals in different Food, so that what is Nauseous to one, should be Dainties to another, is a manifest Argument, that the allotment of Food is not a matter of mere Chance, but entailed to the very Constitution and Nature of Animals; that they chuse this, and refuse that, not by Accident, or Necessity, but because the one is a proper Food, agreeable to their Constitution, and so appointed by the infinite Contriver of their Bodies; and the other is disagreeable and injurious to them.

But all this Objection will be found frivolous, and the Wisdom and Design of the great Creator will demonstratively appear, if we take a Survey,

5thly. Of the admirable and curious Apparatus in all Animals made for the Gathering, Preparing, and Digestion of their Food. From the very first Entrance to the utmost Exit of the Food, we find every

agere conantur, quam perfectas habeant particulas. Ego namque Bovis vitulum cornibus petere conantem sæpenumero vidi, antequam ei nata essent cornua: Et pullum Equi calcitrantem, &c. Omne enim animal suæ ipsius Animæ facultates, ac in quos usus partes suæ polleant maximè, nullo doctore, præsentit. — Quâ igitur ratione dici potest, animalia partium usus a partibus doceri, cum & antequam illas habeant, hoc cognoscere videantur? Si igitur Ova tria acceperis, unum Aquilæ, alterum Anatis, reliquum Serpentis, & calore modico foveris, animaliaque excluderis; illa quidem alis volare conantia, antequam volare possint; hoc autem revolvi videbis, & serpere affectans, quamvis molle adhuc & invalidum fuerit. Et si, dum perfecta erunt, in una eademque domo nutritiveris; deinde ad locum subdialelem ducta emisseris, Aquila quidem ad sublime; Anas autem in paludem; — Serpens verò sub terrâ irrepet. — Animalia quidem mihi videntur Naturâ magis quam Ratione artem aliquam [τεχνην] artificiosa] exercere: Apes fingere alveolos, &c. Galen de usu Part. l. c. 3.

ry thing contrived, made, and disposed with the utmost Dexterity and Art, and curiously adapted to the place the Animal liveth in, and the Food it is to be nourished with.

Let us begin with the *Mouth*. And this we find, in every Species of Animals, nicely conformable to the Use of such a part; neatly sized and shaped for the catching of Prey, for the gathering or receiving Food (16), for the formation of Speech, and every other such-like Use (17). In some Creatures it is wide and large, in some little and narrow: in some with a deep Incisure up into the Head (18), for the better

(16) *Alia dentibus prædantur, alia unguibus, alia rostri aduncitate carpunt, alia latitudine [eiusdem] ruunt, alia acumine excavant, alia sugunt, alia lambunt, sorbent, mandunt, vorant. Nec minor varietas in Pedum ministerio, ut rapiant, distrabant, teneant, premant, pendeant, tellurem scabere non cessent. Plin. Nat. Hist. l. 10. c. 71.*

(17) Because it would be tedious to reckon up the Bones, Glands, Muscles, and other Parts belonging to the Mouth, it shall suffice to observe that, for the various Services of Man's Mouth, besides the Muscles in common with other Parts, there are five pair, and one single one proper to the Lips only, as Dr. Gibson reckons them: but my most diligent and curious Friend Mr. Comper discovered a sixth pair. And accordingly Dr. Drake reckons six pair, and one single one proper to the Lips. L. 3. c. 13.

(18) Galen deserves to be here consulted, who excellently argues against the casual Concourse of the Atoms of *Epicurus* and *Asclepiades*, from the provident and wise Formation of the Mouths of Animals, and their Teeth answerable thereto. In Man, his Mouth without a deep Incisure, with only one canine Tooth on a Side, and flat Nails, because, saith he, *Hic Natura certò sciebat se animal mansuetum ac civile effingere, cui robur & vires essent ex sapientiâ, non ex corporis fortitudine*. But for Lions, Wolves, and Dogs, and all such as are called *Καρχαρόδοντες*, (or having sharp, ferrated Teeth,) their Mouths are large, and deep cut; Teeth strong and sharp; and their Nails sharp, large, strong and round, accommodated to holding and tearing. V. *Galen de Uf. Part. l. 11. c. 9.*

(19) Among

better catching and holding of Prey, and more easy Commintion of hard, large, and troublesome Food; in others with a much shorter Incisure, for the gathering and holding of herbaceous Food.

In *Insects* it is very notable. In some forcipated; to catch, hold, and tear their Prey (19). In some aculeated; to pierce and wound Animals (20), and suck their Blood. And in others strongly rigged with Jaws and Teeth; to gnaw, and scrape out their

(19) Among *Insects* the *Squilla aquatica*, as they are very rapacious, so are accordingly provided for it. Particularly the *Squilla aquatica maxima recurva*, (as I call it,) who hath somewhat terrible in its very Aspect, and in its Posture in the Water, especially its Mouth, which is armed with long sharp Hooks; with which it boldly and greedily catcheth any thing in the Waters, even one's Fingers. When they have seized their Prey, they will so tenaciously hold it with their forcipated Mouth, that they will not part therewith, even when they are taken out of the Waters, and jumbled about in one's Hand. I have admired at their peculiar way of taking in their Food; which is done by piercing their Prey with their *Forcipes*, (which are hollow,) and sucking the Juice thereof through them.

The *Squilla* here mentioned, is the first and second in *Mouffet's Theat. Insect. l. 2. c. 37.*

(20) For an instance of *Insects* endued with a Spear, I shall for its peculiarity pitch upon one of the smallest, if not the very smallest of all the *Gnat* kind, which, I call, *Culex minimus nigricans maculatus sanguisuga*. Among us in *Essex*, they are called *Nidiots*, by *Mouffet*, *Midges*. It is about $\frac{1}{10}$ of an Inch, or somewhat more long: with short *Antennæ*; plain in the Female, in the Male feathered, somewhat like a Bottle-brush. It is spotted with blackish Spots, especially on the Wings, which extend a little beyond the Body. It comes from a little slender Eel-like Worm, of a dirty white Colour, swimming in stagnating Waters by a wrigling Motion: as in *Fig. 5.*

Its *Aurelia* is small with a black Head, little short Horns, a spotted, slender, rough Belly. *Vid. Fig. 6.* It lies quietly on the top of the Water, now and then gently wagging it self this way, and that.

These *Gnats* are greedy Blood-suckers, and very troublesome where numerous, as they are in some places near the *Thames*, parti-

their Food, to carry Burdens (21), to perforate the Earth, yea the hardest Wood, yea even Stones themselves, for Houses (22) to themselves, and Nests for their young.

And lastly in *Birds* it is no less remarkable. In the first place it is neatly shaped for piercing the Air, and making way for the Body through the airy Regions. In the next place it is hard and horny, which is a good Supplement to the want of Teeth, and causeth the Bill to have the Use and Service of the Hand. It's hooked Form is of great Use to the rapacious Kind (23), in catching and holding their Prey, and in the Communion thereof by tearing; to others it is no less serviceable to their climbing, as well as neat and nice Communion

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particularly in the Breach-waters that have lately befallen, near us, in the Parish of *Dagenham*; where I found them so vexatious, that I was glad to get out of those Marshes. Yea, I have seen Horses so stung with them, that they have had drops of Blood all over their Bodies, where they were wounded by them.

I have given a Figure (in *Fig. 7.*) and more particular Description of this *Gnat*, because, although it be common, it is no where taken notice of by any Author I know of, except *Mouffet*, who I suppose means these *Gnats*, which he calls *Midges*. c. 13. p. 82.

(21) *Hornets* and *Wasps* have strong Jaws, Toothed, wherewith they can dig into Fruits, for their Food; as also gnaw and scrape Wood, whole Mouthfuls of which they carry away to make their Combs. *Vid. infr. Chap. 13. Note 2.*

(22) *Monsieur de la Vaye* tells of an ancient Wall of Free Stone in the *Benedictines-Abbey* at *Caen* in *Normandy*, so eaten with Worms, that one may run ones Hand into most of the Cavities; that these Worms are small and black, lodging in a greyish Shell; that they have large flattish Heads, a large Mouth, with four black Jaws, &c. *Phil. Transact. Nr. 18.*

(23) *Pro iis [Labris] cornea & acuta Volucris Rostra. Eadem rapto viventibus adunca: collecto resta: herbas ruentibus limumque lata, ut suum generi. Fumentis vice manûs ad colligenda pabula: ora apertiora laniatu viventibus.* *Plin. Nat. Hist. l. 11, c. 37.*

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(24) *Parrots*

tion of their Food (24). Its extraordinary Length and Slenderness is very useful to some, to search and grope for their Food in moorish places (25); as its Length and Breadth is to others, to hunt and search in muddy places (26): and the contrary Form, namely, a thick, short, and sharp-edged Bill is as useful to other Birds, who have occasion to husk and flay the Grains they swallow. But it would be endless and tedious to reckon up all the various Shapes, and commodious Mechanism of all; the Sharpness and Strength of those who have occasion to perforate Wood, and Shells (27); the Slenderness and Neatness of such as pick up small Insects; the Cross-form of such as break up Fruits (28); the

(24) *Parrots* have their Bills nicely adapted to these Services, being hooked for climbing, reaching for what they have occasion for; and the lower Jaw being compleatly fitted to the Hooks of the upper, they can as minutely break their Food, as other Animals do with their Teeth.

(25) Thus in *Woodcocks*, *Snipes*, &c. who hunt for Worms in moorish Ground, and, as Mr. Willughby saith, live also on the fatty unctuous Humour they suck out of the Earth. So also the Bills of *Curlews*, and many other Sea-Fowl, are very long to enable them to hunt for the Worms, &c. in the Sands on the Sea-shore, which they frequent.

(26) *Ducks*, *Geese*, and divers others, have such long broad Bills to quaffer and hunt in Waters, and Mud; to which we may reckon the uncouth Bill of the *Spoon-bill*: but that which deserves particular Observation in the Birds named in these two last Notes is, the Nerves going to the end of their Bills, enabling them to discover their Food out of sight, of which see *Book VII. Chap. 2. Note 5.*

(27) The *Picus viridis*, or *Green Woodspite*, and all the *Wood-Peckers* have Bills, curiously made for digging Wood, strong, hard, and sharp. A neat Ridge runs along the top of the *Green-Wood-Pecker's* Bill, as if an Artist had designed it for Strength and Neatness.

(28) The *Loxia*, or *Cross-Bill*, whose Bill is thick and strong, with the Tips crossing one another, with great readiness breaks open Fir-cones, Apples, and other Fruit to come at their Kernels,

the compressed Form of others (29), with many other curious and artificial Forms, all suited to the way of living, and peculiar Occasions of the several Species of Birds. Thus much for the Mouth.

Let us next take a short View of the *Teeth* (30). In which their peculiar Hardness (31) is remarkable, their Growth (32) also, their firm Insertions and Bandage in the Gums and Jaws, and their various Shape and Strength suited to their various Occasion and Use (33); the foremost weak, and farthest

nels, which are its Food, as if the crossing of the Bill was for this Service.

(29) The *Sea-Pie* hath a long, sharp, narrow Bill, compressed Side-ways, and every way so well adapted to the raising *Limpets* from the Rocks, (which are its chief, if not only Food,) that Nature (or rather the Author of Nature) seems to have framed it purely for that Use.

(30) *Those Animals which have Teeth on both Jaws, have but one Stomach; but most of those which have no upper Teeth, or none at all, have three Stomachs: as in Beasts, the Panch, the Reard, and the Feck: and in all granivorous Birds, the Crop, the Echinus, and the Gizard. For as chewing is to an easy Digestion, so is swallowing whole to that which is more laborious.* Dr. Grew's *Cosmol. Sacr.* c. 5. §. 24.

(31) *J. Peyer* saith, the Teeth are made of convolved Skins hardened; and if we view the Grinders of *Deer, Horses, Sheep, &c.* we shall find great Reason to be of his Mind. His Observations are, *Mirum autem eos [i. e. Dentes] cum primum e pelliculis imbricatis convolutis & mucos viscido constarent, in tantam dirigescere soliditatem, quæ ossa cuncta superet. Idem fit etiam in Officulis Cerasorum, &c.*—Separatione factâ, per membranas conditur Magma locellis, quos formant laminae tenues, ac duriusculæ ad Dentis figuram antea divinitus compositæ. *J. Peyer, Merycol.* l. 2. c. 8.

(32) *Qui autem [i. e. Dentes] renascuntur, minimè credendi sunt a facultate aliquâ plasticâ Brutorum denuo formari, sed latentes tantummodo in conspectum producuntur augmento molis ex effluente succo.* Id. *ibid.*

(33) From these, and other the like Considerations of the Teeth. *Galen* infers, that they must needs be the Work of some wise provident Being, not Chance, not a fortuitous Concourse of

farthest from the Center, as being only Preparers to the rest; the others, being to grind and mince, are accordingly made stronger, and placed nearer the Center of Motion and Strength. Likewise their various Form (34) in various Animals is considerable, being all curiously adapted to the peculiar Food (35) and Occasions of the several Species of Animals.

Atoms. For the Confirmation of which he puts the case, that suppose the order of the Teeth should have been inverted, the *Grinders* set in the room of the *Incisors*, &c. (which might as well have been, had not the Teeth been placed by a wise Agent,) in this case, what Use would the Teeth have been of? What Confusion by such a slight Error in their disposal only? Upon which he argues, *At si quis choream hominum 32* (the number of the Teeth) *ordine disposuit, eum ut hominem industrium laudaremus: cum verò Dentium choream Natura tam bellè exornarit, nonne ipsam quoque laudabimus?* And then he goes on with the Argument from the Sockets of the Teeth, and their nice fitting in them, which being no less accurately done, than what is done by a Carpenter or Stone-cutter in fitting a Tenon into a Mortice, doth as well infer the Art and Act of the wise *Maker* of Animal Bodies, as the other doth the Act and Art of Man. And so he goes on with other Arguments to the same Effect. *V. Galen de Us. Part. l. 11. c. 8.*

(34) A curious Account of this may be found in an *Extract of a Letter concerning the Teeth of divers Animals*. Printed at Paris, in *M. Vauguion's Compleat Body of Chirurg. Oper. Chap. 53.*

(35) As it hath been taken notice of, that various Animals delight in various Food; so it constantly falls out, that their Teeth are accordingly fitted to their Food; the Rapacious to catching, holding and tearing their Prey; the Herbacious to gathering and comminution of Vegetables: and such as have no Teeth, as Birds, their Bill, Claw, and Gizzard, assisted with Stones supply the defect of Teeth. But the most considerable Example of this kind is in some Families of the Insect-Tribes, as the *Papilio-kind*, &c. who have Teeth, and are voracious, and live on tender Vegetables in their *Nympha* or *Caterpillar-state*, when they can only creep; but in their mature, *Papilio-state*, they have no Teeth, but a *Proboscis* or *Trunk* to suck up Honey, &c. their parts for gathering Food, as well as their Food being changed, as soon as they have Wings to enable them to fly to it.

Animals (36). And lastly, the temporary Defect of them (37) is no less observable in Children, and such young Creatures, where there is no occasion for them, but they would be rather an Annoyance to the tender Nipples and Breasts.

From the Teeth, the grand Instruments of Mastication, let us proceed to the other ministerial Parts. And here the *Parotid*, *Sublingual*, and *Maxillary Glands*, together with those of the Cheeks and Lips are considerable, all lodged in the most convenient Places about the Mouth and Throat, to afford that noble digestive salival Liquor to be mixed with the Food in Mastication, and to moisten and lubricate the Passages, to give an easy descent to the Food. The commodious Form also of the Jaws deserves our notice, together with the strong Articulation of the lowermost, and its Motion. And lastly, the curious Form, the great Strength, the convenient Lodgment and Situation of the several

(36) It is remarkable in the Teeth of Fishes, that in some they are sharp, as also jointed, so as to fall back, the better to catch and hold their Prey, and to facilitate its Passage into the Stomach: So in others they are broad and flat, made to break the Shells of Snails and Shell-fish devoured by them. These *Teeth* or *Breakers* are placed, in some, in the Mouth; in some, in the Throat; and in *Lobsters*, &c. in the Stomach it self; in the bottom of whose Stomachs are three of those *Grinders*, with peculiar Muscles to move them.

(37) What is there in the World can be called an Act of Providence and Design, if this temporary Defect of Teeth be not such; that Children, for Instance, should have none whilst they are not able to use them, but to hurt themselves, or the Mother; and that at the very Age when they can take in more substantial Food, and live without the Breast, and begin to need Teeth for the sake of Speech; that then, I say, their Teeth should begin to appear, and gradually grow, as they more and more stand in need of them.

veral Muscles and Tendons (38), all ministring to this so necessary an Act of Life, as Mastication is, they are such Contrivances, such Works, as plainly set forth the infinite Workman's Care and Skill.

Next to the Mouth, the Gullet presenteth it self, in every Creature well-sized to the Food it hath occasion to swallow; in some but narrow, in others as large and extensive (39); in all exceedingly remarkable for the curious Mechanism of its Muscles, and the artificial Decussation and Position of their Fibres (40).

And

(38) It would be endless to particularize here, and therefore I shall refer to the Anatomists; among the rest, particularly to Galen, for the sake of his Descant upon this Subject. For having described the great accuracy of the Contrivance and Make of these Parts, he saith, *Haud scio an hominum sit sobriorum ad Fortunam opificem id revocare: alioqui quid tandem erit, quod cum Providentia atque Arte efficitur? Omnino enim hoc ei contrarium esse debet, quod casu ac fortuito fit.* Galen de Us. Part. l. 11. c. 7. ubi plura.

(39) The Bore of the Gullet is not in all Creatures alike answerable to the Body or Stomach. As in the Fox, which both feeds on Bones, and swallows whole, or with little chewing; and next in a Dog, and other ossivorous Quadrupeds, 'tis very large, viz. to prevent a Contusion therein. Next in a Horse, which though he feeds on Grass, yet swallows much at once, and so requires a more open Passage. But in a Sheep, Rabbit, or Ox, which bite short, and swallow less at once, 'tis smaller. But in a Squirrel, still lesser, both because he eats fine, and to keep him from disgorging his Meat upon his descending Leaps. And so in Rats and Mice, which often run along Walls with their Heads downwards. Dr. Grew's Comp. Anat. of Stom. and Guts, Chap. 5.

(40) Of this see Dr. Willis's Pharm. Rat. Part 1. Sect. 1. c. 2. Steno also, and Peyer Mery. L. 2.

The Description these give of the muscular Part of the Gullet, the late ingenious and learned Dr. Drake saith is very exact in Ruminants, but not in Men. In Men, this Coat [the second of the Gullet] consists of two fleshy Lamelle, like two distinct Muscles. The outward being composed of straight longitudinal Fibres. — The inner Order of Fibres is annular, without any observable Angles. — The use of this Coat, and these Orders of Fibres

And now we are arrived to the grand Receptacle of the Food, the *Stomach*; for the most part as various, as the Food to be conveyed therein. And here I might describe the admirable Mechanism of its Tunicks, Muscles, Glands, Nerves, Arteries, and Veins (41), all manifesting the super-eminent Contrivance and Art of the infinite Workman (42); they being all nicely adjusted to their respective Place, Occasion and Service. I might also insist upon that most necessary Office of *Digestion*; and here consider that wonderful Faculty of the Stomachs of all Creatures, to dissolve (43) all the several sorts of Food appropriated to their Species; even sometimes things of that consistency as seem insoluble (44), especially by such seemingly simple and weak *Menstruums*, as we find in their Stomach;

is to promote Deglutition; of which the Longitudinal, — shorten the Oesophagus, and so make its Capacity larger, to admit of the Matter to be swallowed. The Annular, on the contrary, contract the Capacity, and closing behind the descending Aliment, press it downwards. Drake's Anat. v. 1. l. 1. c. 9.

(41) See Willis, *ibid.* Cowper's Anat. Tab. 35. and many other Authors.

(42) *Proptuarium autem hoc, alimentum universum excipiens, ceu Divinum, non Humanum sit opificium.* Galen de Us. Part. 1. 4. c. 1.

(43) How great a Comprehension of the Nature of things, did it require, to make a *Menstruum*, that should corrode all sorts of Flesh coming into the Stomach, and yet not, the Stomach it self, which is also Flesh? Dr. Grew's Cosmol. Sacr. c. 4.

(44) The Food of the Castor being oftentimes, if not always dry things, and hard of Digestion, such as the Roots and Bark of Trees, 'tis a wonderful Provision made in that Creature's Stomach, by the digestive Juice lodged in the curious little Cells there. A Description of whose admirable Structure and Order may be found in Blasius from Wepfer; concerning which he saith, *In quibus Mucus reconditus, non secus ac Mel in Favis.* — *Nimirum, quia Castoris alimentum exsuccum & coctum difficillimum est, sapientissimus & summè admirandus in suis operibus rerum Conditor. T. O. M. ipsi pulcherrimâ istâ & assabrè factâ structurâ benignissimè*

mach: But I shall only give these things a bare mention, and take a more peculiar Notice of the special Provision made in the particular Species of Animals, for the Digestion of that special Food appointed them.

And in the first place it is observable, that, in every Species of Animals, the Strength and Size of their Stomach (45) is conformable to their Food. Such whose Food is more delicate, tender, and nutritive, have commonly this Part thinner, weaker, and less bulky: whereas such whose Aliment is less nutritive, or whose Bodies require larger Supplies to their Bulk, their Labours, and wast of Strength and Spirits, in them it is large and strong.

Another very remarkable thing in this Part is the number of Ventricles in divers Creatures. In many but one; in some two or more (46). In such
as

nignissime prospexit, ut nunquam deesset Fermentum, quod ad solvendum & comminuendum alimentum durum & asperum par foret. Vid. Blas. Anat. Animal. c. 10. Confer etiam Aët. Erud. Lips. Ann. 1684. p. 360.

Most of our Modern Anatomists and Physicians attribute Digestion to a dissolving *Menstruum*; but Dr. Drake takes it to be rather from Fermentation dissolving Principles in the Aliment it self, with the Concurrence of the Air and Heat of the Body; as in Dr. Papin's Digester. V. Dr. Anat. v. 1. c. 14.

(45) All carnivorous Quadrupeds have the smallest Ventricles, Flesh going farthest. Those that feed on Fruits and Roots have them of a middle Size. Yet the Mole, because it feeds unclean, hath a very great one. Sheep and Oxen, which feed on Grass, have the greatest. Yet the Horse, (and for the same reason the Coney and Hare,) though Graminivorous, yet comparatively have but little ones. For that a Horse is made for Labour, and both this and the Hare for quick and continued Motion: for which, the most easy Respiration, and so the freest Motion of the Diaphragme is very requisite; which yet could not be, should the Stomach lie big and cumbersome upon it, as in Sheep and Oxen it doth. Grew. ib. Chap. 6.

(46) The Dromedary hath four Stomachs, one whereof is peculiarly endowed with about twenty Cavities, like Sacks in all probability

as make a sufficient Commintion of the Food in the Mouth, one is sufficient. But where Teeth are wanting, and the Food dry and hard, (as in granivorous Birds,) there the Defect is abundantly supplied by one thin membranaceous Ventricle, to receive and moisten the Food, and another thick, strong, muscular one, to grind and tear (47) it. But in Birds, and other Creatures, whose Food is not Grain, but Flesh, Fruits, Insects, or partly one, partly the other, there their Stomachs are accordingly conformable to their Food (48), stronger or weaker, membranous or muscular.

But as remarkable a thing as any in this part of Animals is the curious Contrivance and Fabrick of the several Ventricles of ruminating Creatures. The very Act it self of *Rumination* is an excellent Provision for the compleat Mastication of the Food, at the resting, leisure times of the Animal. But the Apparatus for this Service, of divers Ventricles for its various Uses and Purposes, together with their curious Mechanism, deserves great Admiration (49).

Having

probability for the holding of Water. Concerning which, see *Book VI. Chap. 4. Note 1.*

(47) To assist in which Office they swallow small angular Stones, which are to be met with in the Gizzards of all granivorous Birds: but in the Gizzard of the *Fynx*, or *Wryneck*, which was full only of *Ants*, I found not one Stone. So in that of the *Green Wood-pecker*, (full of *Ants* and *Tree-maggots*,) there were but few Stones.

(48) In most *carnivorous Birds*, the third Ventricle is *Membranous*; where the Meat is concocted, as in a *Man*: Or somewhat *Tendinous*, as in an *Owl*; as if it were made indifferently for *Flesh*, or other Meat, as he could meet with either. Or most thick and tendinous, called the *Gizzard*; wherein the Meat, as in a *Mill* is ground to pieces. *Grew, ubi supra. Chap. 9.*

(49) It would be much too long a Task to insist upon it here as it deserves, and therefore concerning the whole Business of *Rumination*,

Having thus far pursued the Food to the place, where, by its Reduction into Chyle, it becomes a proper Aliment for the Body ; I might next trace it through the several Meanders of the *Guts*, the *Lacteals*, and so into the *Blood* (50), and afterwards into the very Habit of the Body ; I might also take notice

Rumination, I shall refer to *J. Caur. Peyer's Merycolog. seu de Ruminantibus & Ruminatione commentar* ; where he largely treateth of the several Ruminating-Animals, of the Parts ministering to this Act, and the great Use and Benefit thereof unto them.

(50) There are too many Particulars to be insisted on observable in the Passages of the *Chyle*, from the *Guts* to the *Left Subclavian Vein*, where it enters into the *Blood* ; and therefore I shall only for a Sample of this admirable Oeconomy take notice of some of the main and more general Matters. And,

1. After the Food is become *Chyle*, and gotten into the *Guts*, it is an excellent Provision made not only for its Passage through the *Guts*, but also for its Protrusion into the *Lacteals*, by the *Peristaltick Motion* and *Valvula conniventes* of the *Guts*. 2. It is an admirable Provision that the Mouths of the *Lacteals*, and indeed the *Lacteals primi generis* themselves are small and fine, not wider than the *Capillary Arteries* are, lest by admitting Particles of the Nourishment grosser than the *Capillaries*, dangerous Obstructions might be thereby produced. 3. After the reception of the Aliment into the *Lacteals primi generis*, it is a noble Provision for the promotion of its Motion, that in the *Mesenterick Glands* it meets with some of the *Lymphæ Ducts*, and receives the Impregnations of the *Lymphæ*. And passing on from thence, it is a no less Advantage, 4. That the *Lacteals* and *Lymphæ Ducts* meet in the *Receptaculum Chyli*, where the Aliment meeting with more of the *Lymphæ* is made of a due Consistence and Temperament for its farther Advancement through the *Thoracick Duct*, and so into the *Left Subclavian Vein* and *Blood*. Lastly, This *Thoracick Duct* it self is a part of great Consideration. For, (as Mr. Cowper saith,) If we consider in this Duct its several Divisions and Inosculations, its numerous Valves looking from below upwards, its advantageous Situation between the great Artery and Vertebra of the Back, together with the Ducts discharging their reflux *Lymphæ* from the Lungs and other neighbouring Parts, we shall find all conduce to demonstrate the utmost Art of Nature used in furthering the steep and perpendicular Ascent of the *Chyle*. Anat. Introduct.

(51) These

notice of the Separation made in the *Intestines*, of what is nutritive, (which is received,) and what is feculent, (being ejected,) and the Impregnations there from the *Pancreas* and the *Gall*: and after it hath been strained through those curious Colanders, the *Lacteal Veins*, I might also observe its Impregnations from the *Glands* and *Lymphæducts*: and to name no more, I might farther view the exquisite Structure of the Parts ministring to all these delicate Offices of Nature; particularly the artificial Conformation of the *Intestines* might deserve a special enquiry, their *Tunicks*, *Glands*, *Fibres* traversing one another (51), and peristaltick Motion in all Creatures; and their cochleous Passage (52) to retard the Motion of the *Chyle*, and to make amends for the shortness of the *Intestines*, in such Creatures who have but one Gut; together with many other Accommodations of Nature in particular Animals that might be mentioned. But it shall suffice to have given only a general Hint of those curious and admirable Works of God. From whence it is abundantly manifest how little weight there is in the former Atheistical Objection. Which will receive a farther Confutation from the

6. and

(51) These, although noble Contrivances and Works of God, are too many to be insisted on, and therefore I shall refer to the Anatomists, particularly Dr. *Willis Pharmaceut*, Dr. *Cole in Phil. Trans. Nr. 125.* and Mr. *Cowper's* elegant Cuts in his *Anat. Tab. 34, 35.* and *Append. Fig. 39, 40.*

(52) In the *Thornback*, and some other Fishes it is a very curious Provision that is made to supply the Paucity and Brevity of the Guts; by the Perforation of their single Gut going not straight along, but round round like a pair of Winding-Stairs; so that their Gut, which seems to be but a few Inches long, hath really a Bore of many Inches. But of these, and many other noble Curiosities and Discoveries in Anatomy, the Reader will, I hope, have a better and larger Account from the curious and ingenious Dr. *Dowglas*.

(53) *Quibus*

6. and last thing relating to Food, that I shall speak of, namely, *The great Sagacity of all Animals in finding out, and providing their Food.* In Man perhaps we may not find any thing very admirable, or remarkable in this kind, by means of his Reason and Understanding, and his Supremacy over the inferiour Creatures; which answereth all his Occasions relating to this Matter. But then even here the Creator hath shewed his Skill, in not over-doing the Matter, in not providing Man with an unnecessary Apparatus to effect over and over again what is feasible by the reach of his Understanding, and the power of his Authority.

But for the inferiour Creatures, who want Reason, the power of that natural Instinct, that Sagacity (53) which the Creator hath imprinted upon them, do amply make up for that Defect. And here we shall find a glorious Scene of the Divine Wisdom, Power, Providence, and Care, if we view the various Instincts of Beasts, great and small, of Birds, Insects, and Reptiles (54). For among every Species of them we may find notable Acts of Sagacity, or Instinct, proportional to their Occasions

(53) *Quibus bestiis erat is cibus, ut alius generis bestiis vescerentur, aut vires natura dedit, aut celeritatem: data est quibusdam etiam machinatio quædam, atque solertia, &c. Cicer. de Nat. Deor. L. 2.*

(54) Among Reptiles that have a strange Faculty to shift for Food, &c. may be reckoned *Eels*, which, although belonging to the Waters, can creep on the Land from Pond to Pond, &c. Mr. Moseley of Moseley, saw them creep over the Meadows, like so many Snakes from Ditch to Ditch; which he thought was not only for bettering their Habitation, but also to catch Snails in the Grass. *Plot's Hist. Stafford. c. 7. §. 32.*

And as early as the Year 1125, the Frost was so very Intense, that the *Eels* were forced to leave the Waters, and were frozen to Death in the Meadows. *Vid. Hakewil's Apol. L. 2. Chap. 7. S. 2.*

(55) *Enumerare*

ons for Food. Even among those whose Food is near at hand, and easily come at, as Grass and Herbs, and consequently have no great need of Art to discover it; yet among these, that faculty of their accurate Smell and Taste, so ready at every turn to distinguish between what is salutary, and what pernicious (55), doth justly deserve Praise. But for such Animals whose Food is not so easily come at, a variety of wonderful Instinct may be met with, sufficient to entertain the most curious Observer. With what entertaining Power and Artifice do some Creatures hunt (56) and pursue their Game and Prey! And others watch and way-lay
theirs

(55) *Enumerare possum, ad pastum capeffendum conficiendumque, quæ sit in figuris animantium & quam solers, subtilisque descriptio partium, quamque admirabilis fabrica membrorum. Omnia enim quæ intus inclusa sunt, ita nata, atque ita locata sunt, ut nihil eorum supervacaneum sit, nihil ad vitam retinendam non necessarium. Dedit autem eadem Natura belluis & sensum, & appetitum, ut altero conatum haberent ad naturales pastus capeffendos; altero severnerent pestifera a salutaribus. Cicer. de Nat. Deor. L. 2: See Book IV. Chap. 4.*

(56) It would be endless to give Instances of my own and others Observations of the prodigious Sagacity of divers Animals in Hunting, particularly Hounds, Setting-Dogs, &c. one therefore shall suffice of Mr. Boyl's, viz. *A Person of Quality——to make a tryal, whether a young Blood-Hound was well instructed,——caused one of his Servants——to walk to a Town four Miles off, and then to a Market-Town three Miles from thence.——The Dog, without seeing the Man he was to pursue, followed him by the Scent to the above-mentioned Places, notwithstanding the Multitude of Market-People that went along in the same way, and of Travellers that had occasion to cross it. And when the Blood-Hound came to the chief Market-Town, he passed through the Streets, without taking Notice of any of the People there, and left not till he had gone to the House, where the Man he sought, rested himself, and found him in an Upper-Room, to the wonder of those that followed him. Boyl determ. Nat. of Effluv. Chap. 4.*

(57) There

theirs (57)! With what prodigious Sagacity do others grope for it under Ground, out of Sight, in moorish Places, in Mud and Dirt (58); and others dig and delve for it both above (59) and under the Surface of the drier Lands (60)! And how curious, and well-designed a Provision is it of particular large

(57) There are many Stories told of the Craft of the *Fox* to compass his Prey; of which *Ol. Magnus* hath many such, as feigning the barking of a *Dog*, to catch Prey near Houses; feigning himself Dead, to catch such Animals as come to feed upon him; laying his Tail on a *Wasp*-Nest, and then rubbing it hard against a Tree, and then eating the *Wasps* so killed: ridding himself of *Fleas*, by gradually going into Water, with a lock of Wool in his Mouth, and so driving the *Fleas* up into it, and then leaving it in the Water: by catching *Crab*-Fish with his Tail, which he saith he himself was an Eye-witness of; *Vidi & ego in Scopulis Norvegiae Vulpem, interrupes immissâ caudâ in aquas, plures educere Cancros, ac demum devorare.* Vid. *Ol. Mag. Hist.* l. 18. c. 39, 40.

But *Pliny's* fabulous Story of the *Hyena* out-does these Relations of the *Fox*, *Sermonem humanum inter pastorum stabula assimulare, nomenque alicujus addiscere, quem evocatum foras laceret. Item Vomitionem hominis imitari ad sollicitandos Canes quos invadat.* *Plin. Nat. Hist.* l. 8. c. 30.

(58) This do *Ducks*, *Woodcocks*, and many other Fowls which seek their Food in dirty, moorish Places. For which Service they have very remarkable Nerves reaching to the end of their Bills. Of which see *Book VII. Chap. 2. Note 5.*

(59) *Swine*, and other Animals that dig, have their Noses made more tendinous, callous, and strong for this Service, than others that do not dig. They are also edged with a proper Border for penetrating and lifting up the Earth; and their Nostrils are placed well, and their Smell is very accurate to discover whatsoever they pursue by digging.

(60) The *Mole*, as its Habitation is different from that of other Animals, so hath its Organs in every respect curiously adapted to that way of Life; particularly its Nose made sharp, and slender, but withal tendinous and strong, &c. But what is very remarkable, it hath such Nerves reaching to the end of its Nose and Lips, as *Ducks*, &c. have, mentioned above in *Note 58.* Which pair of Nerves I observed to be much larger than any other Nerves proceeding out of the Brain.

(61) Predacious.

large Nerves in such Creatures, adapted to that especial Service !

What an admirable Faculty is that of many Animals to discover their Prey at vast Distances; some by their Smell some Miles off (61); and some by their sharp and piercing Sight, aloft in the Air, or at other great Distances (62)! An instance of the later of which GOD himself giveth, (*Job* 39. 27, 28, 29.) in the Instinct of the *Eagle*. *Doth the Eagle mount up at thy command? and make her Nest on high? She dwelleth and abideth on the Rock, upon the crag of the Rock, and the strong Place* (63). *From thence she seeketh the Prey, and her Eyes behold afar off.* What a commodious Provisi-
on

(61) Predacious Creatures, as *Wolfs*, *Foxes*, &c. will discover Prey at great Distances; so will *Dogs* and *Ravens* discover Carri- on a great way off by their Smell. And if (as the Superstitious imagine) the latter flying over and haunting Houses be a sign of Death, it is no doubt from some cadaverous Smell those *Ravens* discover in the Air by their accurate Smell, which is emitted from those diseased Bodies, which have in them the Principles of a speedy Death.

(62) Thus *Hawkes* and *Kites* on Land, and *Gulls* and other Birds that prey upon the Waters, can at a great Height in the Air see *Mice*, little Birds and Insects on the Earth, and small Fishes, *Shrimps*, &c. in the Waters; which they will dart down upon and take.

(63) Mr. Ray gives a good Account of the Nidification of the *Chrysaetos caudâ annulo albo cinctâ*. *Hujus Nidus* A°. 1668. in *silvosis prope Derwentiam*, &c. inventus est e bacillis seu virgis ligneis grandioribus compositus, quorum altera extremitas rupis cujusdam eminentiæ, altera duabus *Betulis* innitebatur. — *Erat Nidus quadratus, duas ulnas latus.* — In eo pullus unicus, adjacentibus cadaveribus unius agni, unius leporis, & trium *Grygallorum* pullo- rum. Synop's Method. Avium. p. 6. And not only *Lambs*, *Hares*, and *Grygalli*, but Sir Robert Sibbald tells us they will seize *Kids* and *Fawns*, yea, and Children too: Of which he hath this Story of an *Eagle* in one of the *Orcades* Islands, *Quæ Infantulum unius anni pannis involutum arripuit (quem Mater tessellas ustibiles pro igne allatura momento temporis deposuerat in loco*

on hath the Contriver of Nature made for Animals that are necessitated to climb for their Food; not only in the Structure of their Legs and Feet, and in the Strength of their Tendons and Muscles acting in that particular Office (64), but also in the peculiar Structure of the principal Parts acting in the acquist of their Food (65)! What a Provision also is that in nocturnal Birds and Beasts, in the peculiar Structure of their Eye (66), (and we may perhaps add the accuracy of their Smell too,) whereby they are enabled to discover their Food in the dark? But among all the Instances we have of natural Instinct, those Instincts and especial Provisions made to supply the Necessities of helpless Animals, do in a particular manner demonstrate the

Houton-Head dicto) eumque deportasse per 4 milliaria passuum ad Hoiam; quâ re ex matris ejulatu cognita, quatuor viri illuc in naviculâ profecti sunt, & scientes ubi Nidus esset, Infantulum illæsum & intactum deprehenderunt. Prod. Nat. Hist. Scot. l. 3. p. 2. p. 14.

(64) See in Book VII. Chap. 1. Note II. the Characteristics of the Wood-pecker kind.

(65) The contrivance of the Legs, Feet, and Nails [of the Opossum] seems very advantageous to this Animal in climbing Trees, (which it doth very nimbly,) for preying upon Birds. But that which is most singular in this Animal is the Structure of its Tail to enable it to hang on Boughs. The Spines, or Hooks——in the middle of the under Side of the Vertebrae of the Tail, are a wonderful piece of Nature's Mechanism. The first three Vertebrae had none of these Spines, but in all the rest they were to be observed.——They were placed just at the Articulation of each Jynt, and in the middle from the Sides.——For the performing this Office [of hanging by the Tail] nothing, I think, could be more advantageously contrived. For when the Tail is twirled or wound about a Stick, this hook of the Spine easily sustains the Weight, and there is but little Labour of the Muscles required, only enough for bowing or crooking the Tail. This and more to the same purpose, see in Dr. Tyson's Anat. of the Opossum in Phil. Trans. Nr. 239.

(66) See before Chap. 2. Notes 24, 25, 26.

(67) Quid

the great Creator's Care. Of which I shall give two Instances.

I. The Provision made for young Creatures. That *Στοργή*, that natural Affection, so connatural to all, or most Creatures towards their Young (67), what an admirable, noble Principle is it, implanted in them by the wise Creator! By means of which, with what Alacrity do they transact their Parental Ministry? With what Care do they nurse up their Young? think no Pains too great to be

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taken

(67) *Quid dicam quantus amor bestiarum sit in educandis custodiendisque iis, quæ procreaverint, usque ad eum finem, dum possint se ipsa defendere?* And having instanced in some Animals, where this Care is not necessary, and accordingly is not employed, he goes on, *Fam Gallinæ, avesque reliquæ & quietum requirunt ad pariendum locum, & cubilia sibi, nidusque construunt, eosque quam possunt mollissimè substernunt, ut quàm facillimè ova servantur. Ex quibus pullos cum excluderint, ita tuentur, ut & pennis foveant, ne frigore lædantur, & si est calor, a sole se opponant.* Cicer. de Nat. Deor. L. 2.

To this natural Care of Parent-Animals to their Young, we may add returns made by the Young of some towards the Old ones. Pliny saith of Rats, *Genitores suos fessos senectâ, alunt insigni pietate.* Nat. Hist. l. 8. c. 57. So Cranes, he saith, *Genetricum senectam invicem educant.* l. 10. c. 23. This St. Ambrose takes Notice of in his *Hexameron*, and Ol. Magnus after him, *Depositi patris artus, per longævum senectutis plumis nudatos, circumstant soboles pennis propriis fovet, — collatitio cibo pascit, quando etiam ipsa naturæ reparatdissendia, ut hinc inde senem sublevantes, fulcro alarum suarum ad volandum exerceant, & in pristinos usus desueta membra reducant.* For which Reason this Bird is denominated *Pia*. Vid. Ol. Mag. Hist. l. 19. c. 14.

Hereto may be added also the conjugal *Στοργή* of the little green *Æthiopian Parrot*, which Mr. Ray describes from *Clusius*. *Femellæ senescentes (quod valdè notabile) vix edere volebant, nisi cibum jam a mare carptum, & aliquandiu in prolobo retentum, & quasi coctum rostro suo exciperent, & Columbarum pulli a matre aliosolent.* Synop. Method. Av. p. 32.

taken for them, no Dangers (68) too great to be ventured upon for their Guard and Security. How carefully will they lead them about in places of Safety? carry them into places of Retreat and Security, yea, some of them admit them into their own Bowels (69)? How will they caress them with their affectionate Notes? lull and quiet them with their tender parental Voice? put Food into their Mouths? suckle them? cherish and keep them warm? teach them to pick, and eat, and gather Food for themselves? And in a word, perform the whole Part of those deputed by the sovereign Lord and Preserver of the World, to help such young and shiftless Creatures, till they are come to that Maturity as to be able to shift for themselves?

And as for other Animals, (particularly Insects, whose Sire is partly the Sun, and) whose numerous Off-spring would be too great for their Parent-Animal's Care and Provision, these are so generated as to need none of their Care; by reason they arrive immedi-

(68) The most timid Animals, that at other times abscond, or hastily fly from the Face of Man, Dogs, &c. will, for the sake of their Young, expose themselves. Thus among Fowls, *Hens* will assault, instead of fly from such as meddle with their Brood. So *Partridges*, before their Young can fly, will drop frequently down, first at lesser, and then at greater Distances to dodge and draw off *Dogs* from pursuing their Young.

(69) The *Opossum* hath a curious Bag on purpose for the securing and carrying about her Young. There are belonging to this Bag two Bones, (not to be met with in any other Skeleton,) and four pair of Muscles; and some say the Teats lie therein also. Dr. *Tyson's Anat. of the Opossum*. in *Phil. Transact.* Nr. 239. where he also, from *Oppian*, mentions the *Dog-Fish* that upon any Storm, or Danger receives the young Ones into her Belly, which come out again when the fright is over. So also the *Squatina* and *Glaucus*, the same Author saith have the same Care for their Young, but receive them into different Receptacles.

(70) See

immediately to their *ἡλικία*, their perfect, adult State, and are able to shift for themselves. But yet, thus far their parental Instinct (equivalent to the most rational Care and Fore-sight) doth extend that they do not wildly drop their Eggs and Sperm any where, at all Adventures, but so cautiously repose it in such commodious Places, some in the Waters, some on Flesh, some on Plants proper and agreeable to their Species (70), and some shut up agreeable Food in their Nests, partly for Incubation, partly for Food (71), that their Young in their *Aurelia*, or *Nympha* State, may find sufficient and agreeable Food to bring them up, till they arrive to their Maturity.

Thus far the parental Instinct and Care.

Next we may observe no less in the Young themselves, especially in those of the irrational Animals. Forasmuch as the Parent-Animal is not able to bear them about, to cloth them, and to dandle them, as Man doth; how admirably hath the Creator contrived their State, that those poor young Creatures can soon walk about, and with the little helps of their Dam, shift for, and help themselves? How naturally do they hunt for their Teat, suck, pick (72), and take in their proper Food?

But

(70) See Book VIII. Chap. 6.

(71) See Chap. 13. Note 2.

(72) There is manifestly a superintending Providence in this Case, that some Animals are able to suck as soon as ever they are born, and that they will naturally hunt for the Teat before they are quite gotten out of the Secundines, and parted from the Navel-String, as I have seen. But for *Chickens*, and other young Birds, they not being able immediately to pick till they are stronger, have a notable Provision made for such a time, by a part of the yolk of the Egg being inclosed in their Belly a lit-

But for the young of Man, their Parent's Reason, joined with Natural Affection, being sufficient to Help, to Nurse, to Feed, and to Cloth them; therefore they are Born helpless, and are more absolutely, than other Creatures, cast upon their Parent's Care (73). A manifest Act and Designation of the Divine Providence.

2. The other Instance I promised, is the Provision made for the Preservation of such Animals as are sometimes destitute of Food, or in danger of being so. The Winter is a very inconvenient, improper Season, to afford either Food or Exercise to Insects, and many other Animals. When the flowry Fields are divested of their Gayety; when the fertile Trees and Plants are stript of their Fruits, and the Air instead of being warmed with the cherishing Beams of the Sun, is chilled with rigid Frost; what would become of such Animals as are impatient of Cold? What Food could be found by such as are subsisted by the Summer-Fruits? But to obviate all this Evil, to stave off the Destruction and Extirpation of divers Species of Animals, the infinitely wise Preserver of the World hath as wisely ordered the matter; that, in the first place, such as are impatient of Cold, should have such a special Structure of their Body, particularly of their Heart, and Circulation of their Blood,

tle before their Exclusion or Hatching, which serves for their Nourishment till they are grown strong enough to pick up Meat. *Vid. Book VII Chap. 4. Note 1.*

(73) *Qui [Infantes] de ope nostrâ ac de divinâ misericordiâ plus merentur, qui in primo statim nativitatis suæ ortu plorantes ac flentes, nil aliud faciunt quam deprecantur. Cyprian. Ep. ad Fid.*

(74) I might

Blood (74), as during that Season, not to suffer any waste of their Body, and consequently not to need any Recruits; but that they should be able to live in a kind of sleepy, middle State, in their places of safe Retreat, until the warm Sun revives both Them, and their Food together.

The next Provision is for such as can bear the Cold, but would want Food then; and that is in some by a long Patience of Hunger (75), in others by their notable Instinct in laying up Food beforehand against the approaching Winter (76). Of this many entertaining Examples may be given; particu-

(74) I might name here some of the Species of Birds, the whole Tribe almost of Insects, and some among other Tribes, that are able to subsist for many Months without Food, and some without Respiration too, or very little: but it may suffice to instance only in the *Land-Tortoise*, of the Structure of whose Heart and Lungs, see *Book VI. Chap. 5. Note 2.*

(75) *Inediam diutissime tolerat Lupus, ut & alia omnia carnivora, licet voracissima; magna utique naturæ providentiâ, quoniam esca non semper in promptu est.* Ray Synop. Quadr. p. 174.

To the long Abstinence mentioned of Brute-Animals, I hope the Reader will excuse me if I add one or two Instances of extraordinary Abstinence among Men. One *Martha Taylor*, born in *Derbyshire*, by a blow on the Back, fell into such a Prostration of Appetite, that she took little Sustenance, but some drops with a Feather, from *Christmas 1667.* for thirteen Months, and slept but little too all the time. Dr. *Sampson's* Account thereof in *Ephem. German. T. 3. Obs. 173.*

To this we may add the Case of *S. Chilton* of *Tinsbury*, near *Bath*, who in the Years 1694, 1696, and 97. slept divers Weeks together. And although he would sometimes in a very odd manner take Sustenance, yet would lie a long time without any, or with very little, and all without any considerable Decay. See *Philos. Trans. Nr. 304.*

(76) They are admirable Instincts which the *Sieur de Beauplan* relates, of his own Knowledge, of the little Animals called *Bobages* in *Ukraine*, They make Burroughs like Rabbits, and in October shut themselves up, and do not come out again till April. — They spend all the Winter under Ground, eating what they laid up

particularly we may at the proper Season, observe not only the little Treasures and Holes well-stocked with timely Provisions, but large Fields (77) here and there throughout bespread with considerable Numbers of the Fruits of the neighbouring Trees, laid carefully up in the Earth, and covered safe by the provident little Animals inhabiting thereabouts. And not without Pleasure have I seen and admired the Sagacity of other Animals hunting out those subterraneous Fruits, and pilaging the Treasures of those little provident Creatures.

And

in Summer.—Those that are lazy among them, they lay on their Backs, then lay a great handful of dry Herbage upon their Bellies, &c. then others drag those Drones to the Mouths of their Burroughs, and so those Creatures serve instead of Barrows, &c. I have often seen them practise this, and have had the Curiosity to observe them whole Days together.—Their Holes are parted like Chambers; some serve for Store-houses, others for Burying-places, &c. Their Government is nothing inferiour to that of Bees, &c. They never go abroad without posting a Centinel, upon some high Ground, to give notice to the others whilst they are feeding. As soon as the Centinel sees any Body, it stands upon his Hind-legs, and Whistles. Beauplau's Description of Ukraine, in Vol. I. of the Collection of Voyages, &c.

A like Instance of the Northern *Galli Sylvestres*, see in Chap. 13. Note 6.

As for the Scriptural Instance of the *Ant*, see hereafter Book VIII. Chap. 5. Note 4.

(77) I have in *Autumn*, not without Pleasure observed, not on the great Sagacity and Diligence of *Swine* in hunting out the Stores of the *Field-Mice*; but the wonderful Precaution also of those little Animals in hiding their Food before-hand against Winter. In the time of Acorns falling, I have, by means of the *Hogs*, discovered, that the *Mice* had, all over the neighbouring Fields, treasured up single Acorns in little Holes they had scratched, and in which they had carefully covered up the Acorn. These the *Hogs* would Day after Day hunt out by their Smell.

(1) Concerning

And now from this bare transient View of this Branch of the great Creator's Providence and Government, relating to the *Food* of his Creatures, we can conclude no less, than that since this grand Affair hath so manifest Strokes of admirable and wise Management, that since this is demonstrated throughout all Ages, and Places, that therefore it is God's Handy-work. For how is it possible that so vast a World of Animals should be supported, such a great Variety equally and well supplied with proper Food in every place fit for Habitation, without an especial Super-intendency and Management, equal to, at least, that of the most prudent Steward and Householder? How should the Creatures be able to find out their Food when laid up in secret Places? and how should they be able to gather even a great deal of the common Food, and at last to macerate and digest it, without peculiar Organs adapted to the Service? And what less than an infinitely wise God could form such a Set of curious Organs, as we find every Species endowed with for this very Use? Organs so artificially made, so exquisitely fitted up, that the more strictly we survey them, the more accurately we view them, (even the meanest of them with our best Glasses,) the less fault we find in them, and the more we admire them: whereas the best polish'd, and most exquisite Works made by Humane Art, appear through our Glasses, as rude and bungling, deformed and monstrous; and yet we admire them, and call them Works of Art and Reason. And lastly, what less than Rational and Wise could endow irrational Animals with various Instincts, equivalent in their special way to Reason it self? Inasmuch that some from thence have absolutely concluded that those Creatures had some glimmerings of Reason. But it is manifestly Instinct, not Reason they Act by, because we find no varying,

but that every Species doth naturally pursue at all times the same way, without any Tutorage or Learning : whereas *Reason*, without Instruction, would often vary, and do that by many Methods, which *Instinct* doth by one alone. But of this probably more hereafter.

C H A P. XII.

Of the Clothing of Animals.

HAVING in the foregoing Chapter somewhat largely taken a View of the infinite Creator's Wisdom and Goodness towards his Creatures in ordering their Food, I shall be more brief in this Chapter in my View of their *Clothing* (1); another necessary Appendage of Life, and in which we have plain Tokens of the Creator's Art, manifested in these two particulars; the *Suitableness of Animal's Clothing to their Place and Occasions*: and the *Garniture and Beauty thereof*.

1. The Clothing of Animals is suited to their place of Abode, and Occasions there; a manifest Act of Design and Skill. For if there was a possibility that Animals could have been accoutered any other way, than by God that made them, it must needs have come to pass, that their Clothing would have been at all Adventures, or all made the

(1) Concerning the *Clothing* of Animals, *Aristotle* observes, That such Animals have Hair, as go on Feet, and are viviparous; and that such are covered with a Shell, as go on Feet, and are oviparous. Hist. Anim. l. 3. c. 10.

(2) *Cujus*

the same mode and way, or, some of it at least, inconvenient and unsuitable. But on the contrary we find all is curious and compleat, nothing too much, nothing too little, nothing bungling, nothing but what will bear the Scrutiny of the most exquisite Artist, yea, and so far out-do his best Skill, that his most exquisite Imitations even of the meanest Hair, Feather, Scale, or Shell, will be found only as so many ugly, ill-made Blunders and Botches, when strictly brought to the Test of good Glasses. But we shall find an Example remarkable enough in the present Case, if we only compare the best of Clothing which Man makes for himself, with that given by the Creator for the covering of the irrational Creatures. Of which it may be said, as our Saviour doth of the Flowers of the Field, *Mat. 6. 29. That even Solomon in all his Glory was not arrayed like one of these.*

But let us come to Particulars, and consider the suitableness of the different Method the Creator hath taken in the Clothing of Man, and of the Irrational Animals. This Pliny (2) pathetically laments, and says, *It is hard to Judge whether Nature hath been a kinder Parent, or more cruel Stepmother to Man. For, says he, Of all Creatures, he alone is covered with other's Riches, whereas Nature hath*
given

(2) *Cujus [Hominis] causâ videtur cuncta alia genuisse Natura, magnâ & sevâ mercede contra tanta sua munera : ut non sit satis æstimare, Parens melior homini, an tristior Noverca fuerit. Ante omnia unum Animantium cunctorum alienis velat opibus : ceteris variè tegumenta tribuit, testas, cortices, coria, spinas, villos, setas, pilos, plumam, pennas, squamas, vellera. Truncos etiam arboreque cortice, interdum gemino, a frigoribus & calore tutata est. Hominem tantum nudum, & in nuda humo, natali die abjicit ad vagitus statim & ploratum, nullumque tot animalium aliud ad lachrymas, & has protinus vitæ principio. Plin. Nat. Hist. L. 7. Proem.*

given various Clothing to other Animals, Shells, Hides, Prickles, Shag, Bristles, Hair, Down, Quills, Scales, Fleeces; and Trees she hath fenced with a Bark or two against the injuries of Cold and Heat. Only poor naked Man, he says, is in the day of his Birth cast into the wide World, to immediate crying and squalling; and none of all Creatures besides, so soon to Tears in the very beginning of their Life.

But here we have a manifest Demonstration of the Care and Wisdom of God towards his Creatures; that such should come into the World with their Bodies ready furnished and accommodated, who had neither Reason nor Forecast to contrive, nor Parts adapted to the Artifices and Workmanship of Clothing: but for Man, he being endowed with the transcending Faculty of Reason, and thereby made able to help himself, by having Thought to contrive, and withal Hands to effect, and sufficient Materials (3) afforded him from the Skins and Fleeces of Animals, and from various Trees
and

Let Seneca answer this complaint of Pliny, although perhaps what he saith might be more properly noted in another place: *Quisquis es iniquus aestimator sortis humanae, cogita quanta nobis tribuerit Parens noster, quanto valentiora animalia sub jugum miserimus, quanto velociora assequamur, quam nihil sit mortale non sub ictu nostro positum. Tot virtutes accepimus, tot artes, animum denique cui nihil non eodem quo intendit momento pervium est, Syderibus velociorem, &c. Senec. de Benef. l. 2. c. 29.*

(3) *Mirantur plurimi quomodo tute, & sanè vivant homines in horrendis frigoribus plagæ Septentrionalis; hancque levem questionem ultra 30 annos audieram in Italiâ, præsertim ab Æthiopibus, & Indis, quibus onerosus videtur vestitus sub Zonâ torrida. — Quibus respondetur, — Gaudet Indus multiplici plumarum genere, magis forsan pro tegumento, quam necessitate: rursus Scythia villosa vestitu. — Ita sub polo Arctico adversus asperrimas hyemes — opportuna remedia faciliter administrat [Natura] Ligna videlicet in maxima copia, & levissimo pretio, & demum Pelles diversorum animalium, tam Sylvestrium quam domesticorum.* Then he gives a
Catalogue

and Plants: Man, I say, having all this Provision made for him, therefore the Creator hath wisely made him naked, and left him to shift for himself, being so well able to help himself.

And

Catalogue of them, and saith, *Quarum omnium experti pellifices ita ingeniosè noverunt mixturas componere, ut pulcherrimum decorem ostendat varietas, & calidissimum fomentum adjuncta mollities.* Ol. Mag. Hist. l. 6. c. 20.

To this guard against the Cold, namely, of Fire and Clothing, I hope the Reader will excuse me, if I take this opportunity of adding some other Defensatives Nature, (or rather the great Author of Nature,) hath afforded these Northern Regions: Such are their high Mountains, abounding, as Ol. Magnus saith, through all parts; also their numerous Woods, which besides their Fire, do with the Mountains serve as excellent Screens against the cold piercing Air and Winds. Their vast Quantities of Minerals and Metals also afford Heat, and warm Vapours, *Mineræ Septentrionalium regionum satis multæ, magnæ, diversæ, & opulentiæ sunt*, saith the same curious and (for his time) learned Arch-bishop, l. 6. c. 1. and in other places. And for the warmth they afford, the *Vulcano's* of those Parts are an evidence; as are also their terrible Thunder and Lightening, which are observed to be the most severe and mischievous in their Metalline Mountains, in which large Herds of Cattle are sometimes destroyed; the Rocks so rent and shattered, that new Veins of Silver are thereby discovered; and a troublesome kind of Quinsy is produced in their Throats, by the stench and poisonous Nature of the sulphureous Vapours; which they dissolve by drinking warm Beer and Butter together, as Olaus tells us in the same Book, Chap. 11.

To all which Defensatives, I shall in the last place add the warm Vapours of their Lakes; some of which are prodigiously large, of 130 Italian Miles in Length, and not much less in Breadth; also of their Rivers, especially the Vapours arising from the Sea. Of which guard against severe Cold, we have lately had a convincing Proof in the great Frost in 1708. where-in when England, Germany, France, Denmark, yea the more Southerly Regions of Italy, Switzerland, and other Parts suffered severely, Ireland and Scotland felt very little of it, hardly more than in other Winters; of the Particulars of which having given an Account in the *Philos. Transact.* Nr. 324. I shall thither refer

the

And a notable Act this is of the Wisdom of God, not only as the more setting forth his Care and Kindness to them that most needed his Help, the helpless irrational Animals, and in his not overdoing his Work; but also as it is most agreeable to the Nature and State of Man (4), both on natural and political Accounts. That Man should cloth himself is most agreeable to his Nature, particularly (among other things) as being most salutary, and most suitable to his Affairs. For by this means, Man can adapt his Clothing to all Seasons, to all Climates, to this, or to any Business. He can hereby keep himself sweet and clean, fence off many Injuries; but above all, by this Method of Clothing, with the natural Texture of his Skin adapted to it, it is that that grand means of Health, namely,

the Reader. But it seems this is what doth ordinarily befall those Northern Parts, particularly the *Islands of Orkney*, of which the learned Dr. Wallace gives this Account: *Here the Winters are generally more subject to Rain than Snow; nor doth the Frost and Snow continue so long here as in other Parts of Scotland, but the Wind in the mean time will often blow very boisterously, and it Rains sometimes, not by Drops, but by Spouts of Water, as if whole Clouds fell down at once. In the Year 1680, in the Month of June, after great Thunder, there fell Flakes of Ice near a Foot thick.* Wall. Account of Ork. Chap. 1. p. 4. From which last Passage I observe, that although, in those Parts, the Atmosphere near the Earth be warm, it is excessively cold above, so as to freeze some of those Spouts of Water in their descent, into such great, and almost incredible Masses of Hail. And whence can this Warmth proceed, but from the Earth or Sea emitting Heat sufficient to stave off the Cold above? Consult Book II. Chap. 5. Note 3.

(4) *Sicut enim si innata sibi [i. e. Homini] aliqua haberet arma, illa ei sola semper adessent, ita & si artem aliquam Natura sortitus esset, reliquas sanè non haberet. Quia vero ei melius erat omnibus armis, omnibusque artibus uti, neutrum eorum a natura ipsi propterea datum est.* Galen de Us. Part. 1. 1. c. 4.

ly, *Insensible Perspiration* (5) is performed, at least greatly promoted, without which an humane Body would be soon over-run with Disease.

In the next place there are good political Reasons for Man's clothing himself, inasmuch as his Industry is hereby employed in the Exercises of his Art and Ingenuity; his Diligence and Care are exerted in keeping himself sweet, cleanly, and neat; many Callings and Ways of Life arise from thence; and (to name no more) the Ranks and Degrees of Men are hereby in some measure rendered visible to others, in the several Nations of the Earth.

Thus it is manifestly best for Man that he should clothe himself.

But for the poor shiftless Irrationals, it is a prodigious Act of the great Creator's Indulgence, that they are all ready furnished with such Clothing, as is proper to their Place and Business (6). Some covered

(5) Concerning *Insensible Perspiration*, *Sanctorius* observes, that it much exceeds all the Sensible put together. *De Stat. Med. Aph. 4.* That as much is evacuated by *Insens. Perspiration* in one Day, as is by *Stool* in fourteen Days. Particularly that, in a Night's time, about sixteen Ounces is commonly sent out by *Urine*, four Ounces by *Stool*; but above forty Ounces by *Insensible Perspiration*. *Aphor. 59, 60.* That if a Man eats and drinks 8 *l.* in a Day, 5 *l.* of it is spent in *Insensible Perspiration*. *Sect. 1. Aph. 6.* And as to the times, he saith, *Ab assumpto cibo 5 horis 1 l. circiter perspirabilis — exhalare solet; a 5a ad 12am 3 l. circiter; a 12a ad 16am vix selibram.* *Aph. 56.*

And as to the wonderful Benefits of *Insensible Perspiration*, they are abundantly demonstrated by the same learned Person, *ubi supra*; as also by *Borelli* in his second *Part. de Mot. Animal. Prop. 188.* who saith, *Necessaria est insensibilis Transpiratio, ut vita Animalis conservetur.*

(6) *Animantium vero quanta varietas est? quanta ad eam rem vis, ut in suo quæque genere permaneant? quarum aliæ coriis testæ sunt, aliæ villis vestitæ, aliæ spinis hirsutæ: plumâ alias, alias squammâ*

covered with Hair (7), some with Feathers (8),
some

squamma videmus obductas, alias esse cornibus armatas, alias habere effugia pennarum. Cicer. de Nat. Deor. L. 2.

(7) From Malpighi's curious Observations of the Hair, I shall note three things. 1. Their Structure is fistulous, or tubular; which hath long been a Doubt among the curious. *Fistulosum [esse Pilum] demonstrat lustratio pilorum a caudâ & collo Equorum, &c. — præcipuè setarum Apri, quæ patentiores ex fistulis compositionem exhibent. Est autem dictus Apri pilus cylindricum corpus quasi diaphanum — fistularum aggerie conflatum, & speciem columnæ striatæ præ se fert. Componentes fistulæ in gyrum situate in apice patentiores redduntur; nam hians pilus in geminas dividitur partes, & componentes minimæ fistulæ — liberiorès redditæ manifestantur, ita ut enumerari possint; has autem 20, & ultra numeravi. — Expositæ fistulæ — tubulosæ sunt, & frequentibus tunicis transversaliter situatis, veluti valvulis pollent. Et quoniam Spine, in Erinaceis præcipui, &c. nil aliud sunt, quam duri, & rigidi pili, ideo, &c.* And then he describes the Hedge-hog's Spines, in which those Tubes manifestly appear, together with medullary Valves and Cells, not inelegant, which he hath figured in *Tab. 16*, at the end of his Works.

That which this sagacious, and not enough to be commended Observer took notice of in the Structure of Hair, and its parity to the Spines, I have my self observed in some measure to be true in the Hair of *Cats, Rats, Mice*, and divers other Animals; which look very prettily when viewed with a good Microscope. The Hair of a *Mouse*, (the most transparent of any I have viewed,) seems to be one single transparent Tube, with a Pith made up of a fibrous Substance running in dark Lines, in some Hairs transversely, in others spirally, as in *Fig. 14, 15, 16, 17*. These darker medullary Parts, or Lines I have observed, are no other than small Fibres convolved round round, and lying closer together than in other Parts of the Hair. They run from the bottom to the top of the Hair, and I imagine serve to the gentle Evacuation of some Humour out of the Body; perhaps the Hair serves as well for the *Insensible Perspiration* of hairy Animals, as to fence against Cold, and Wet. In *Fig. 14, 16*, is represented the Hair of a *Mouse*, as it appears through a small Magnifier; and in *Fig. 15, 17*, as it appears when viewed with a large Magnifier.

Upon another Review, I imagine, that although in *Fig. 14, 15*, the dark Parts of the Pith seem to be transverse, that they as well as in the two other Figures, run round in a screw-like Fashion.

(8) See *Book*

Chap. 1. Note 4, 5.

(9) See

some with Scales, some with Shells (9), some only with Skin, and some with firm and stout Armature; all nicely accommodated to the Element in which the Creature liveth, and its Occasions there (10). To *Quadrupeds* Hair is a commodious Clothing. Which, together with the apt Texture of their Skin, fitteth them for all Weathers, to lie on the Ground, and to do the Offices of Man: and the thick and warm Furrs and Fleeces of others, are not only a good Defensative against the Cold and Wet, but also a soft Bed to repose themselves in, and to many of them a comfortable covering to nurse and cherish their tender Young.

And as Hair to *Quadrupeds*, so Feathers are as commodious a dress to such as fly in the Air, to Birds, and some Insects; not only a good guard against Wet and Cold, and a comfortable Covering to such as hatch and brood their Young; but also most commodious for their Flight. To which purpose they are nicely and neatly placed every where on the Body, to give them an easy Passage through the Air (11), and to assist in the waisting their Body through that thin Medium. For which Service,

(9) See Chap. 14. Note 3.

(10) It is a sign some wise Artist was the Contriver of the Clothing of Animals, not only as their Clothing varies as their Way of living doth; but also, because every part of their Bodies is furnished with proper suitable Clothing. Thus divers Animals that have their Bodies covered for the most part with short, smooth Hair, have some Parts left naked, where Hair would be an Annoyance; and some Parts beset with long Hair, as the Mane and Tail; and some with stiff, strong Bristles, as about the Nose, and sometimes within the Nostrils, to guard off, or give warning of Annoyances.

(11) The Feathers being placed fromward the Head toward the Tail, in close and neat Order, and withal preened and dressed from the Oil-bag, afford as easy a Passage through the Air,

vice, how curious is their Texture for Lightness, and withal for Strength? hollow and thin for Lightness, but withal context and firm, for Strength. And where 'tis necessary they should be filled, what a light and strong medullary Substance is it they are filled with? By which curious Contrivances, even the very heaviest Parts made for Strength, are so far from being a load to the Body, that they rather assist in making it light and boyant, and capacitate it for Flight. But for the Vanes, the lightest part of the Feather, how curiously are they wrought with capillary Filaments, neatly interwoven together (12), whereby they are not only light, but also sufficiently close and strong to keep the Body warm, and guard it against the Injuries of Weather, and withal to empower the Wings, like so many Sails, to make strong Impulses upon the Air in their Flight (13). Thus curious, thus artificial, thus commodious is the Clothing of Beasts and Birds: Concerning which, more in proper place.

And no less might I shew that of Reptiles and Fishes (14) to be, if it was convenient to enlarge upon this Branch of the Creator's Works. How well

Air, as a Boat new cleaned and dressed finds in its Passage through the Waters. Whereas, were the Feathers placed the contrary, or any other way, (as they would have been, had they been placed by Chance, or without Art,) they would then have gathered Air, and been a great Encumbrance to the Passage of the Body through the Air. See *Book VII. Chap. 1. Note 2.*

(12) In *Book VII. Chap. 1. Note 5.* There is a particular Account of the Mechanism of their Vanes, from some nice Microscopical Observations, and therefore I shall take no farther Notice of it here.

(13) *Vid. Borel. de Mot. Animal. Prop. 182. Vol. 1.*

(14) See *Book IX.*

well adapted are the *Annuli* of some Reptiles, and the Contortions of the Skin of others, not only to fence the Body sufficiently against outward Injuries; but to enable them to creep, to perforate the Earth (15), and in a word, to perform all the Offices of their Reptile State, much better than any other Tegument of the Body would do? And the same might be said of the covering of the Inhabitants of the Waters, particularly the Shells of some, which are a strong guard to the tender Body that is within, and consistent enough with their slower Motion; and the Scales and Skins of others, affording them an easy and swift Passage through the Waters. But it may be sufficient to give only a hint of these things, which more properly belong to another place.

Thus hath the indulgent Creator furnished the whole Animal World with convenient, suitable Clothing.

Q

2. Let

(15) For a Sample of this Branch of my Survey, let us chuse the Tegument of *Earth-Worms*, which we shall find compleatly adapted to their way of Life and Motion, being made in the most compleat manner possible for terebrating the Earth, and creeping where their Occasions lead them. For their Body is made throughout of small Rings, and these Rings have a curious Apparatus of Muscles, enabling those Creatures with great Strength to dilate, extend, or contract their *Annuli*, and whole Body; those *Annuli* also are each of them armed with small, stiff, sharp *Beards*, or *Prickles*, which they can open, to lay hold on; or shut up close to their Body: And lastly, under the Skin there lies a *slimy Juice*, that they emit, as occasion is, at certain Perforations between the *Annuli*, to lubricate the Body, and facilitate its Passage into the Earth. By all which means they are enabled with great speed, ease, and safety to thrust, and wedge themselves into the Earth; which they could not do, had their Bodies been covered with Hair, Feathers, Scales, or such like Clothing of the other Creatures. See more concerning this Animal, *Book IX. Chap. I. Note 1.*

Q

(16) *Aristotle*

2. Let us in the next place take a short View of the *Garniture* (16) and *Beauty* thereof. And here we shall thus far at least descry it to be beautiful, that it is Compleat and Workman-like. Even the Clothing of the most sordid Animal, those that are the least beautified with Colours, or rather whose Clothing may regrate the Eye (17); yet when we come strictly to view them, and seriously consider the nice Mechanism of one Part, the admirable Texture of another, and the exact Symmetry of the whole, we discern such Strokes of inimitable Skill, such incomparable Curiosity, that we may say with *Solomon*, Eccles. 3. 11. [God] *hath made every thing beautiful in his time.*

But for a farther Demonstration of the super-eminent Dexterity of his Almighty Hand, he hath been pleased as it were on purpose to give surprising Beauties to divers Kinds of Animals. What radiant Colours are many of them, particularly some Birds and Insects (18), bedecked with ! What a prodigious Combination is there often of these, yea, how nice an Air frequently of meaner Colours,

(16) *Aristotle* in his *Hist. Anim.* l. 3. c. 12. names several Rivers that by being drank of, change the Colour of the Hair.

(17) For an example, let us take the Clothing of the *Tortoise* and *Viper*, because by an incurious View it rather regradeth than pleaseth the Eye : but yet by an accurate Survey, we find the Shells of the former, and the Scales of the latter to be a curious piece of Mechanism, neatly made, and so compleatly and well put and tacked together, as to exceed any humane Composures. Of the latter, see more in *Book IX. Chap. 1. Note 3.*

(18) It would be endless to enter into the Particulars of the beautiful *Birds* and *Insects* of our *European* Parts ; but especially those inhabiting the Countries between the Tropicks, which are observed as much to exceed our Birds in their Colours, as ours do theirs in their Singing.

(19) The

lours (19), as to captivate the Eye of all Beholders, and exceed the Dexterity of the most exquisite Pencil to Copy ?

And now, when we thus find a whole World of Animals clothed in the wisest Manner, the most suitable to the Element in which they live, the Place in which they reside, and their State and Occasions there ; when those that are able to shift for themselves are left to their own Discretion and Diligence ; but the Helpless well accoutered and provided for ; when such incomparable Strokes of Art and Workmanship appear in all, and such inimitable Glories and Beauties in the Clothing of others ; who can without the greatest Obstinacy and Prejudice deny this to be *GOD's* Handy-work ? The gaudy, or even the meanest Apparel which Man provideth for himself, we readily enough own to be the Contrivance, the Work of Man : and shall we deny the Clothing of all the Animal World besides, (which infinitely surpasseth all the Robes of earthly Majesty ; shall we, dare we deny that) to be the Work of any thing less than of an infinite, intelligent Being, whose Art and Power are equal to such glorious Work !

(19) The *Wryneck* at a distance is a Bird of mean Colour ; neither are indeed its Colours radiant, or beautiful singly considered : but in the Hand, we see its light and darker Colours so curiously mixed together, as to give the Bird a surprizing Beauty. The same is also observable in many Insects, particularly of the *Phalena-kind*.

C H A P. XIII.

Of the Houses, and Habitations of Animals.

HAVING in the last Chapter as briefly as well I could, surveyed the *Clothing* of Animals, I shall in this take a view of their *Houses*, *Nests*, their *Cells*, and *Habitations* : another thing no less necessary to their Well-being than the last ; and in which the great Creator hath likewise signalized his Care and Skill, by giving Animals an architectonick Faculty, to build themselves convenient places of Retirement, in which to repose and secure themselves, and to nurse up their Young.

And here, as before, we may consider the case of Man, and that of the Irrational Animals. Man having (as I said) the Gift of Reason and Understanding, is able to shift for himself, to contrive and build, as his Pleasure leads him, and his Abilities will admit of. From the meanest Huts and Cottages, he can erect himself stately Buildings, bedeck them with exquisite Arts of Architecture, Painting, and other Garniture, enoble them, and render them delightful with pleasant Gardens, Fountains, Avenues, and what not? For Man therefore the Creator hath abundantly provided in this respect, by giving him an Ability to help himself. And a wise Provision this is, inasmuch as it is an excellent Exercise of the Wit, the Ingenuity, the Industry and Care of Man.

But since Ingenuity without Materials would be fruitless, the Materials therefore which the Creator hath provided the World with for this very service of Building, deserves our notice. The great varieties

rieties of Trees (1), Earth, Stones, and Plants answering every Occasion and Purpose of Man for this Use, in all Ages, and Places, all the World over, is a great Act of the Creator's Goodness, as manifesting, that since he had left Man to shift for himself, it should not be without sufficient Helps to enable him to do so, if he would but make use of them, and the Sense and Reason which God had given him.

Thus sufficient Provision is made for the Habitation of Man.

And no less shall we find is made for the rest of the Creatures; who although they want the power of Reason to vary their Methods, and cannot add to, or diminish from, or any way make Improvements upon their natural way; yet we find that natural Instinct, which the Creator's infinite Understanding hath imprinted in them, to be abundantly sufficient, nay, in all probability the very best or only Method they can take, or that can be invented for the respective Use and Purpose of each peculiar Species of Animals (†). If some Creatures make their Nests in Houses, some in Trees, some

(1) — *Dant utile lignum*

Navigiis Pinos, domibus Cedrosque, Cupressosque :

Hinc radios trivèrè Rotis, hinc tympana plaustriis

Agricolæ, & pandas ratibus posuère carinas.

Viminibus Salices fœcundæ, frondibus Ulmi ;

At Myrtus validis hastilibus, & bona bello

Cornus ; Ityros Taxi torquentur in arcus.

Nec Tilie leves, aut torno rasile Buxum,

Non formam accipiunt, ferroque cavantur acuto :

Necnon & torrentem undam levis innatat Alnus

Missa Pado : necnon & apes examina condunt

Corticibusque cavis, vitiosæque Illicis alvo.

Virgil. Georg. L. 2.

(†) See Chap. 15. and Book VIII. Chap. 6.

some in Shrubs, some in the Earth (2), some in Stone, some in the Waters, some here, and some there, or have none at all; yet we find, that that Place, that Method of Nidification doth abundantly answer the Creature's Use and Occasions. They can there sufficiently and well repose, and secure themselves, lay, and breed up their Young. We are so far from discerning any Inconvenience in any of their respective Ways, from perceiving any Loss befall the Species, any decay, any perishing of their Young; that in all probability, on the contrary,

(2) Many of the *Vespa-Ichneumones* are remarkable enough for their Nidification and Provision for their Young. Those in Earth, who commonly have golden and black Rings round their *Alvi*, having lined the little Cells they have perforated in the Earth, lay therein their Eggs, and then carry in to them Maggots from the Leaves of Trees, and seal them up close and neatly. And another *Ichneumon*, more of the *Vespa* than *Musca-Ichneumon* Kind, (having a little Sting in its Tail, of a black Colour,) gave me the Pleasure one Summer of seeing it build its Nest in a little Hole in my Study-Window. This it coated about with an odoriferous resinous Gum, collected, I suppose, from some Fir-Trees near: after which it laid two Eggs, (I think the Number was,) and then carried in divers Maggots, some bigger than it self. These it very sagaciously sealed close up into the Nest, leaving them there doubtless partly to assist the Incubation; and especially for Food to the future Young, when hatched.

Of this Artifice of these *Ichneumons*, Aristotle himself takes notice, 'Οι δὲ Σφήκες Ιχνεύμονες καλέμενοι, &c. As to the *Vespa* called *Ichneumones*, (less than others,) they kill Spiders, and carry them into their Holes, and having sealed them up with Dirt, they therein hatch, and produce those of the same Kind. Hist. An. l. 5. c. 20.

To what hath been said about these *Ichneumon-Wasps*, I shall add one Observation more concerning the providential Structure of their Mouth in every of their Tribes, viz. Their Jaws are not only very strong, but nicely sized, curved, and set for gnawing and scraping those compleat little Holes they perforate in Earth, Wood, yea Stone it self.

contrary, in that particular way they better thrive, are more secure, and better able to shift for, and help themselves. If, for instance, some Beasts make to themselves no Habitations, but lie abroad in the open Air, and there produce their Young; in this case we find there is no need it should be otherwise, by reason they are either taken care of by Man (3), or in no Danger, as other Creatures, from abroad. If others reposit their Young in Holes (4) and Dens, and secure themselves also therein, it is, because such Guard, such Security is wanting, their Lives being sought either by the Hostility of Man, or to satisfy the Appetite of rapacious Creatures (5). If among Birds, some build their Nests close, some open, some with this, some with another Material, some in Houses, some in Trees, some on the Ground (6), some on Rocks and Craggs on high, (of which God himself hath given

(3) Tully having spoken of the Care of some Animals towards their Young, by which they are nursed, and brought up, saith, *Accedit etiam ad nonnullorum animantium, & earum rerum quas terra gignit, conservationem, & salutem, hominum etiam solertia & diligentia. Nam multe & pecudes, & stirpes sunt, quæ sine procuracione hominum salvæ esse non possunt. Cicer. de Nat. Deor. L. 2.*

(4) Prov 30. 26. *The Conies are but a feeble Folk, yet make they their Houses in the Rocks.*

(5) See Note 10.

(6) It is a notable Instinct which Ol. Magnus tells of the Galli Sylvestres in his Northern Country, to secure themselves against the Cold and Storms of the Winter. *Cum nives instar collium terræ superficiem ubique cooperiunt, ramosque arborum diutius deprimunt, & condensant, certos fructus Betulæ arboris — in forma longi Piperis vorant, & glutunt indigestos; idque tanta aviditate, ac quantitate, ut repletum guttur toto corpore majus appareat. Deinde partitis agminibus sese inter medios nivium colles immergunt, præsertim in Jan. Febr. Martio, quando nives ut turbines, typhones, vel tempestates gravissimæ e nubibus descendunt. Cumque cooperta sunt, — certis hebdomadis cibo in gutture collecto,*

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Thus admirable is the natural Sagacity and Instinct (7) of the irrational Animals in the Convenience and Method of their Habitations. And no less is it in the Fabrick of them. Their architectonick Skill, exerted in the Curiosity and Dexterity of their Works, and exceeding the Skill of Man to imitate; this, I say, deserves as much or more Admiration and Praise, than that of the most exquisite Artist among Men. For with what inimitable Art (8) do these poor untaught Creatures lay a parcel of rude and ugly Sticks and Straws, Moss and Dirt together, and form them into commodious Nests? With what Curiosity do they line them within, wind and place every Hair, Feather, or Lock of Wool, to guard the tender Bodies of themselves and their Young, and to keep them warm? And with what Art and Craft do many of them thatch and coat their Nests without, to dodge and deceive the Eye of Spectators, as well as to guard and fence against the Injuries of Weather (9)? With what prodigious Subtilty do
some

(7) It is a very odd Story, (if it be true,) which Dr. Lud. de Beaufort relates, *Vir fide dignus narravit mihi, quod cum semel, animi gratia, nidum aviculæ ligno obturasset, seque occultasset, cupidus videndi quid in tali occasione præstaret; illa cum frustra sæpius tentasset rostro illud auferre, casus admodum impatiens, abiit, & post aliquod temporis spatium reversa est, rostro gerens plantulam, quâ obturamento applicatâ, paulo post, illud veluti tellus erupit tanta vi, ut dispersa impetu herbula ac occasionem ipsi ab avicula ejus virtutem discendi, præripuerit.* Cosmop. divina. Sect. 5. C. 1. Had he told us what the Plant was, we might have given better Credit to his Story.

(8) Of the Subtilty of Birds in Nidification, see Pliny's Nat. Hist. l. 10. c. 33.

(9) Among many Instances that might be given of this Subtilty of Birds, and other Creatures, that of the long-tailed Titmouse deserves Observation, who with great Art builds her Nest with Mosses, Hair, and the Webs of Spiders, cast out from them
when

some foreign Birds (10), not only plat and weave the fibrous Parts of Vegetables together, and curiously tunnel them, and commodiously form them into Nests; but also artificially suspend them on the tender Twigs of Trees to keep them out of the reach of rapacious Animals?

And so for *Insects*, those little, weak, those tender Creatures; yet, what admirable Artists are they in this business of Nidification! With what great Diligence doth the little *Bee* gather its Combs from various Trees (11) and Flowers, the *Wasp* from solid

when they take their Flight, (see *Book VIII. Chap. 4. Note 5.*) with which the other Materials are strongly tied together. Having neatly built, and covered her Nest with these Materials; without, she thatcheth it on the top with the *Muscus arboreus ramosus*, or such like broad, whitish Moss, to keep out Rain, and to dodge the Spectator's Eye: and within, she lineth it with a great Number of soft Feathers; so many, that I confess I could not but admire how so small a Room could hold them, especially that they could be laid so close and handsomly together to afford sufficient Room for a Bird with so long a Tail, and so numerous an Issue as this Bird commonly hath, which Mr. Ray saith, (*Synops. Method. Avium. p. 74.*) *Ova inter omnes aviculas numerosissima ponit.* See more of the Nest of this Bird from Aldrovand, in Willugh. *Ornith. p. 243.*

(10) The Nest of the *Guira tangeima*, the *Icterus minor*, and the *Jupijuba*, or whatever other Name the American Hang-Nests may be called by, are of this Kind. Of which see Willughby's *Ornith. Lib. 2. Chap. 5. §. 12, 13.* Also Dr. Grew's *Museum Reg. Soc. Part 1. Sect. 4. Chap. 4.* These Nests I have divers times seen, particularly in great Perfection in our R. S. Repository, and in the noble and well-furnished Museum of my often commended Friend Dr. Sloane; and at the same time I could not but admire at the neat Mechanism of them, and the Sagacity of the Bird, in hanging them on the Twigs of Trees, to secure their Eggs and Young from the Apes.

(11) I mention Trees, because I have seen Bees gather the Gum of Fir-Trees, which at the same time gave me the Pleasure of seeing their way of loading their Thighs therewith.

solid (12) Timber; and with what prodigious Geometrical Subtilty do those little Animals work their deep hexagonal Cells, the only proper Figure that the best Mathematician could chuse for such a Combination of Houses (13)! With with Accuracy do other Insects perforate the Earth (14), Wood, yea Stone it self (15)! For which Service the compleat Apparatus of their Mouths (16) and Feet (17), deserves

(12) Wasps at their first coming may be observed to frequent Posts, Boards, and other Wood that is dry and sound, but never any that is rotten. These they may be heard to scrape and gnaw; and what they so gnaw off, they heap close together between their Chin and Fore-Legs, until they have gotten enough for a Burden, which they then carry away in their Mouths, to make their Cells with.

(13) Circular Cells would have been the most capacious, but this would by no means have been a convenient Figure, by reason much of the Room would have been taken up by Vacancies between the Circles: therefore it was necessary to make Use of some of the rectilinear Figures. Among which only three could be of use; of which *Pappus Alexandrin.* thus discourseth, *Cum igitur tres figurae sunt, quae per seipsas locum circa idem punctum consistentem replere possunt, Triangulum scil. Quadratum & Hexagonum, Apes illam quae ex pluribus angulis constat sapienter delegerunt, utpote suspicantes eam plus mellis capere quam utramvis reliquarum. Et Apes quidem illud tantum quod ipsis utile est cognoscunt, viz. Hexagonum Quadrato & Triangulo esse majus & plus Mellis capere posse, nimirum aequali materia in constructionem uniuscujusque consumptâ. Nos vero qui plus sapientiae quam Apes habere profite-mur, aliquid etiam magis insigne investigabimus. Collect. Math. L. 5.*

(14) See before, Note 2.

(15) See Chap. 11. Note 22.

(16) See Chap. 11. Note 21.

(17) Among many Examples, the Legs and Feet of the Mole-Cricket, (*Gryllotalpa*,) are very remarkable. The Fore-Legs are very brawny and strong; and the Feet armed each with four flat strong Claws, together with a small Lamina with two larger Claws, and a third with two little Claws: which Lamina is joynted to the bottom of the Foot, to be extended, to make the Foot wider, or withdrawn within the Foot. These Feet are placed to scratch somewhat sideways, as well as downward after the

deserves particular Observation, as hath been, and will be hereafter observed. And further yet, with what Care and Neatness do most of those little sagacious Animals line those their Houses within, and seal them up, and fence them without (18)! How artificially will others fold up the Leaves of Trees and Plants (19), others house themselves in Sticks and Straws, others glew light and floating Bodies together (20), and by that Artifice make themselves floating Houses in the Waters, to transport

the manner of *Moles Feet*, and they are very like them also in Figure.

Somewhat of this nature *Swammerdam* observes of the Worms of the *Ephemeron*. To this purpose [to dig their Cells] the wise Creator hath furnished them (saith he) with fit Members. For, besides that their two Fore-Legs are formed somewhat like those of the ordinary Moles, or *Gryllotalpa*, he hath also furnished them with two toothy Cheeks, somewhat like the Sheers of Lobsters, which serve them more readily to bore the Clay. *Swammerdam's Ephem. Vit.* published by Dr. *Tyson*. Chap. 3.

(18) See the before-cited Note 2.

(19) They are for the most part some of the *Phalæna* Tribe which inhabit the tunnelled, convolved Leaves that we meet with on Vegetables in the Spring and Summer. And it is a somewhat wonderful Artifice, how so small and weak a Creature, as one of those newly hatched Maggots, (for doubtless it is they, not the Parent-Animal, that emits no Web, nor hath any textrine Art,) can be able to convolve the stubborn Leaf, and then bind it, in that neat round Form, with the Thread or Web it weaves from its own Body; with which it commonly lines the convolved Leaf, and stops up the two Ends, to prevent its own falling out, and *Ear-wigs*, and other noxious Animals getting in.

(20) The several sorts of *Phryganea*, or *Cadeus* in their Nympha, or Maggot-state, thus house themselves; one sort in Straws, called from thence *Straw-Worms*; others in two or more Sticks laid parallel to one another, creeping at the bottom of Brooks; others with a small bundle of pieces of Rushes, Duck-weed, Sticks, &c. glewed together, wherewith they float on the Top, and can row themselves about the Waters. Both these are called *Cod-bait*. Divers other sorts there are, which the Reader may

sport themselves at Pleasure after their Food, or other necessary occasions of Life? And for a Close, let us take the Scriptural Instance of the *Spider*, Prov. 30. 28. which is one of the four little things which v. 24. *Agur* says, is *exceeding Wise*. *The Spider taketh hold with her Hands, and is in Kings Palaces* (21). I will not dispute the Truth of our *English* Translation of this Text, but supposing the Animal mentioned to be that which is meant; it is manifest, that the Art of that Species of Creatures in spinning their various Webs, and the Furniture their Bodies afford to that purpose, are an excellent Instinct and Provision of Nature, setting forth its glorious Author.

And

may see a Summary of, from Mr. *Willughby*, in *Raii Method. Insect.* p. 12. together with a good, though very brief Description of the *Papilionaceous* Fly, that comes from the *Cod-bait Cadew*. It is a notable architectonick Faculty these Animals have, to gather such Bodies, and then to glue them together; some to be heavier than Water, that the Animal may remain at the bottom, where its Food is, for which purpose they use Stones, as well as Sticks, Rushes, &c. and some to be lighter than Water, to float on the Top, and gather its Food from thence. These little Houses look coarse, and shew no great Artifice outwardly; but are well tunnelled and made within with a hard tough Paste; into which the hind part of the Maggot is so fixed, that it can draw its Cell after it any where, without danger of leaving it behind; as also thrust its Body out, to reach what it wanteth; or withdraw it into its Cell, to guard it against Harms.

(21) Having mentioned the *Spider*, I shall take this Occasion (although it be out of the way) to give an Instance of the Poyson of some of them, *Scaliger Exerc.* 186. relates, that in *Gascony*, his Country, there are Spiders of that virulency, that if a Man treads upon them, to crush them, their Poyson will pass through the very Soles of his Shoes. *Boyl Subtil. of Efflav.* c. 4.

Mr. *Leenwenhoek* put a *Frog* and *Spider* together into a Glass, and having made the *Spider* sting the *Frog* divers times, the *Frog* died in about an Hour's time. *Philos. Transact.* Nr. 272.

In

And now from this short and transient View of the architectonick Faculty of Animals, especially the Irrationals, we may easily perceive some superiour and wise Being was certainly concerned in their Creation or Original. For how is it possible that an irrational Creature should with ordinary and coarse, or indeed any Materials, be ever able to perform such Works, as exceed even the Imitation

In the same *Transaſtion* is a curious Account of the manner how *Spiders* lay, and guard their Eggs, viz. they emit them not out of the hindmoſt part of the Body, but under the upper part of her Belly near the hind Legs, &c. Alſo there is an Account of the Parts from which they emit their Webs, and divers other things worth Obſervation, with Cuts illustrating the whole.

But in *Philof. Tranſ. Nr. 22.* Dr. *Nath. Fairfax* from *S. Redi*, and his own Obſervations thinks *Spiders* not Venemous, ſeveral Perſons, as well as Birds ſwallowing them without hurt; which I my ſelf have known in a Perſon of Learning, who was adviſed to take them medicinally at firſt, and would at any time ſwallow them, affirming them to be ſweet, and well taſted. And not only Innocuous, but they are very Salutiſerous too in ſome of the moſt ſtubborn Diſeaſes, if the pleaſant Story in *Mouſet* be true, of a rich *London* Matron, cured of a deſperate *Tympany* by a certain Debauchee, that hearing of her Caſe, and that ſhe was given over by the Docters, went to her, pretending to be a Phyſician, and confidently affirming he could cure her; which ſhe being willing to believe, agrees with him for ſo much Money, one half to be paid down, the other upon Cure. Upon which he gives her a *Spider*, promiſing her Cure in three Days. Upon which, (not doubting but he had poiſoned her, and fearing he might be called to Account for it,) he gets out of Town as faſt as he could. But inſtead of being poiſoned, ſhe ſoon recovered. After ſome Months the Quack gets privately to Town, when he thought the Buſtle might be over; and enquiring how his Patient did, was informed of her Cure; and thereupon viſiting her, and making an excuſe for his Abſence, he received his Pay with great Applauſe and Thanks. *Mouſ. Inſect. l. 2. c. 15.*

Having ſaid ſo much of *Spiders*, I might here add their Flight: But of this, ſee *Book VIII. Chap. 4. Note 5.*

(1) *Callent*

tion of a rational Creature? How could the Bodies of many of them (particularly the last mentioned) be furnished with architectiv Materials? How could they ever discover them in their Bodies, or know what Use to make of them? We must therefore necessarily conclude, that the Irrationals either have Reason and Judgment, not only Glimmerings thereof, but some of its superiour Acts, as Wisdom and Foresight, Discretion, Art, and Care; or else, that they are only passive in the Case, and act by Instinct, or by the Reason of some superiour Being imprinted in their Nature, or some way or other (be it how it will) congenial with them. That they are Rational, or excell Man in Art and Wisdom, none surely will be so foolish as to say. And therefore we must conclude, that those excellent Ends they pursue, and that admirable Art they exert, is none of their own, but owing to that infinitely wise and excellent Being, of whom it may be said with reference to the Irrational, as well as Rational creatures, as it is, *Prov. 2. 6. The Lord giveth Wisdom; out of his Mouth cometh Knowledge and Understanding.*

C H A P. XIV.

Of Animal's Self-Preservation.

HAVING thus considered the Food, Clothing, and Houses of Animals; let us in this Chapter take a Glance of another excellent Provision the wise Creator hath made for the good of the Animal World, and that is the Methods which all Animals naturally take for their *Self-Preservation* and *Safety*. And here it is remarkable, (as in the Cases before,) that *Man*, who is endowed with Reason, is born without Armature, and is destitute of many Powers which irrational Creatures have in a much higher Degree than he, by reason he can make himself Arms to defend himself, can contrive Methods for his own Guard and Safety, can many ways annoy his Enemy, and stave off the Harms of noxious Creatures.

But for others, who are destitute of this super-eminent Faculty, they are some way or other provided with sufficient Guard (1), proportionate to their place of Abode, the Dangers they are like to incur

(1) *Callent in hoc cuncta animalia, sciuntque non sua modo com-
moda, verum & hostium adversa; norunt sua tela, norunt occa-
siones, partesque dissidentium imbelles. In ventre mollis est tenuis-
que cutis Crocodilo: ideoque se, ut territi, mergunt Delphini, sub-
euntesque alvum illa secant spina. Plin. Nat. Hist. l. 8. c.
25.*

incur there (2); and in a word, to their greatest occasions and need of Security. Accordingly some are sufficiently guarded against all common Dangers by their natural Clothing, by their Armature of Shells, or such like hard and impregnable Covering of their Body (3). Others destitute of this

R

Guard,

(2) *Omniibus aptum est Corpus Animæ moribus & facultatibus: Equo fortibus unguis & juba est ornatum (etenim velox & superbum & generosum est animal.) Leoni autem, utpote animoso & feroci, dentibus & unguibus validum. Ita autem & Tauro & Apro; illi enim Cornua, huic exerti Dentes. — Cervo autem & Lepori (timida enim sunt animalia) velox corpus, sed inerme. Timidis enim velocitas, arma audacibus conveniebant. — Homini autem (sapiens enim est —) manus dedit, instrumentum ad omnes artes necessarium, paci non minus quam bello idoneum. Non igitur indiguit Cornu sibi innato, cum meliora Cornibus arma manibus, quodocunque volet, possit accipere: etenim Ens & Hasta majora sunt Arma, & ad incidendum promptiora. — Neque Cornu, neque Ungula quicquam nisi cominus agere possunt; Hominum vero arma eminens juxta ac cominus agunt: telum quidem & sagitta magis quam cornua. — Non igitur est nudus, neque inermis, — sed ipsi est Thorax ferreus, quodocunque libet omnibus Coriis difficiliter sauciatur organum. — Nec Thorax solum sed & Domus, & Murus, & Turris, &c. Galen de Usu. Part. I. I. c. 2.*

(3) Shells deserve a place in this Survey, upon the Account of their great Variety, the curious and uncouth Make of some, and the beautiful Colours and pretty Ornaments of others; but it would be endless to descend to Particulars. Omitting others, I shall therefore only take Notice of the *Tortoise-Shell*, by reason a great deal of Dexterity, appears even in the simplicity of that Animal's Skeleton. For, besides, that the Shell is a stout guard to the Body, and affords a safe Retreat to the Head, Legs, and Tail, which it withdraws within the Shell upon any Danger, besides this, I say, the Shell supplieth the place of all the Bones in the Body, except those of the extreme Parts, the Head, and Neck, and the four Legs, and Tail. So that at first sight, it is somewhat surprizing to see a compleat Skeleton consisting of so small a number of Bones, and they abundantly sufficient for the Creature's use.

R

(4) Dente

Guard, are armed, some with Horns (4), some with sharp Quills and Prickles (5), some with Claws, some with Stings (||); some can shift and change

(4) *Dente timentur Apri; defendunt cornua Tauros:*

Imbelles Dama quid nisi præda sumus? Mart. l. 13. Epig. 94.

(5) The *Hedgehog* being an helpless, slow, and patient Animal, is accordingly guarded with Prickles, and a Power of rolling it self in them. *Clavis terebrari sibi pedes, & discindi viscera patientissimè ferebat, omnes cultri ictus sine gemitu plusquam Sardanâ nobilitate concoquens.* Borrichius in Blas. de Echino. *Panniculum carnosum amplexabatur Musculus penè circularis, admirandæ fabricæ, lacinias suas ad pedes, caudam, caput, variè exporrigens, cujus ministerio Echinus se ad arbitrium in orbem contrahit.* Act. Dan. in Blasio.

Iste licet digitos testudine pungat acuta,

Cortice deposito mollis Echinus erit. Martial. L. 13. Epigr. 86.

(||) The *Sting* of a *Wasp*, or *Bee*, &c. is so pretty a piece of Work, that it is worth taking Notice of so far as I have not found others to have spoken of it. Others have observed the *Sting* to be an hollow Tube, with a bag of sharp penetrating Juice (its Poyson) joined to the end of it within the Body of the *Wasp*, which is, in Stinging, injected into the Flesh through the Tube. But there are besides this, two small, sharp, bearded Spears, lying within this Tube or *Sting*, as in a Sheath. In a *Wasp's* *Sting* I counted eight Beards on the side of each Spear, somewhat like the Beards of Fish-hooks. These Spears in the *Sting*, or Sheath lie one with its Point a little before that of the other; as is represented in Fig. 21. to be ready (I conceive) to be first darted into the Flesh; which being once fixed, by means of its foremost Beard, the other then strikes in too, and so they alternately pierce deeper and deeper, their Beards taking more and more hold in the Flesh; after which the Sheath or *Sting* follows, to convey the Poyson into the wound. Which that it may pierce the better it is drawn into a Point, with a small slit a little below that Point, for the two Spears to come out at. By means of this pretty Mechanism in the *Sting* it is, that the *Sting* when out of the Body, and parted from it, is able to pierce and sting us: and by means of the Beards being lodged deep in the Flesh, it comes to pass that *Bees* leave their *Stings* behind them, when they are disturbed before they have time to withdraw their Spears into their Scabbard. In Fig. 21. is represented

change their Colours (6), some can make their escape by the help of their Wings, and others by the swiftness of their Feet, some can screen themselves by diving in the Waters, others by tinging and disordering the Waters (7) can make their escape; and some can guard their Bodies even in the very Flames, by the Ejection of the Juyce of their

represented the two Spears as they lie in the Scing. In Fig. 22^e the two Spears are represented when squeezed out of their Scabbard, the Scing; in which latter, Fig. *Ac b* is the Scing, *ed*, and *be* the two-bearded Spears thrust out.

(6) The *Chameleon* is sufficiently famed on this Account. Besides which, *Pliny* tells us of a Beast as big as an Ox, called the *Tarandus*, that when he pleaseth assumes the Colour of an *Asse*, and *Colorem omnium fruticum, arborum, florum, locorumque reddit in quibus latet metuens, ideoque raro capitur.* Plin. l. 8. c. 34.

How true this is there may be some Reason to doubt; but if any Truth be in the Story, it may be from the Animals chusing such Company, or Places, as are agreeable to its Colour: as I have seen in divers *Caterpillars*, and other Insects, who I believe were not able to change their Colour, from one Colour to another, yet I have constantly observed to fix themselves to such things as were of the same Colour; by which means they dodge the Spectator's Eye. Thus the *Caterpillar* that feeds on *Elder*, I have more than once seen so cunningly adhering to the small Branches of the same Colour, that it might be easily mistaken for a small Stick, even by a careful View. So a large green *Caterpillar* that feeds on *Buckthorn*, and divers others. To which I may add the prodigious Sagacity of the *Ichneumon-Flies* that make the *Kermes*, (for of that Tribe all I ever saw, are,) how artificially they not only inclose their Eggs within that gummy Skin or Shell, but also so well humour the Colour of the Wood they adhere to by various Streaks and Colours, that it is not easy to distinguish them from the Wood it self.

(7) *Contra metum & vim, suis se armis quæque defendit. Cornibus Tauri, Aprî dentibus, morsu Leones, aliæ fugâ se, aliæ occultatione tutantur: atramenti effusione Sepiæ, torpore Torpedines. Multa etiam insectantes odoris intollerabili fœditate depellunt.* Cicer. de Nat. Deor. L. 2.

their Bodies (8), some by their accurate Smell, Sight, or Hearing, can foresee Dangers (9); others by their natural Craft can prevent or escape them (10); others by their uncouth Noise (11), by the horrid Aspect, and ugly Gesticulations of their Body (12); and some even by the Power of their Excrements, and their Stink (13) can annoy their Enemy, and secure

(8) A Knight called *Corvini* at *Rome*, cast a *Salamander* into the Fire, which presently swelled, and then vomited store of thick slimy Matter, which put out the Coals, to which the *Salamander* presently retired, putting them out again in the same manner, as soon as they rekindled, and by this means saved it self from the force of the Fire for the space of two Hours. After which it lived nine Months. *Vid. Philos. Transact. Nr. 21. in Lowth. Abridg. Vol. 2. p. 816.*

(9) *Pliny* gives an Instance in each, *l. 10. c. 69. Aquilæ clavius cernunt, [quam homines;] Vultures sagacius odorantur: liquidius audiunt Talpæ obrutæ terrâ, tam denso atque surdo naturæ elemento.*

(10) The *Doubling* of the *Hare* before she goes to Form, thereby to dodge and deceive Dogs, although a vulgar Observation, is a notable Instinct, for an Animal less famed for cunning than the *Fox*, and some others.

(11) It is natural for many *Quadrupeds*, *Birds*, and *Serpents*, not only to put on a torvous angry Aspect, when in Danger; but also to snarl, hiss, or by some other Noise deter their Adversary.

(12) The *Fynx* or *Wryneck*, although a Bird of very beautiful Feathers, and consequently far enough from being any way terrible; yet being in Danger, hath such odd Contortions of its Neck, and Motions of its Head, that I remember have scared me, when I was a Boy, from taking their Nests, or touching the Bird; daring no more to venture my Hand into their Holes, than if a *Serpent* had lodged in it.

(13) *Bonafus tuetur se calcibus & stercore, quod ab se quaternis passibus [trium jugerum longitudine, Plin. Nat. Hist. l. 8. c. 15.] ejaculatur, quod sæpe comburit adeo ut deglabrentur canes.* Ray Synopf. Quadr.

secure themselves: And against some (14) the Divine Providence it self hath provided a Guard.

By such Shifts and Means as these, a sufficient Guard is ministered to every Species of Animals, in its proper respective Place; abundantly enough to secure the Species from Destruction, and to keep up that Balance, which I have formerly shewed, is in the World among every, and all the Species of Animals; but yet not enough to secure Individuals from becoming a Prey to Man, or to other Creatures,

Camelus Peruvianus Glama dictus neminem offendit, sed miræ admodum ingenio se ab illatâ vindicat injuriâ, nimirum vomitu vel cibi, vel humoris in vexantem retrorsum cum impetu ejaculato, ob protensam colli longitudinem. Id. ib. p. 146.

Yzquiepatl, (Anglicè Squunk Pref.) and one that I saw they called a Stonck) cum quis eam insectatur, fundit cum ventris crepitu halitum fœtidissimum: quin ipsa tota teterrimum exhalat odorem, & urina stercusque est fœtidissimum, atque adeo pestilens, ut nihil sit reperire in nostro orbe, cui in hac re possit comparari: quo fit, ut in periculo constituta, urinam & fæces ad 8 pluriumve passuum intervallum ejiciat, hoc modo se ab omnibus vindicans injurijs, ac vestes inficiens maculis luteis indelebilibus, & nunquam satis perspirante odore: aliàs innoxium Animal eduleque, hac solâ ratione horrendissimum. Id. ib. p. 182.

Si Accipiter Ardeam in sublimi molestat, stercore immisso in pennas ejus, eas putrescere facit: uti Solinus scribit de Bonaso, &c. Ita & Lupus urinam spargit in persequentem, Olaus Mag. Hist. l. 19. c. 14.

(14) Thus against the Crocodile, which can catch its Prey only before it, not on one side. So the Shark, of which take my often commended Friend Dr. Sloane's Observation: *It hath this particular to it, with some others of its own Tribe, that the Mouth is in its under Part, so that it must turn the Belly upwards to prey. And was it not for that time that it is in turning, in which the pursued Fishes escape, there would be nothing that could avoid it; for it is very quick in Swimming, and hath a vast Strength, with the largest Swallow of any Fish, and is very devouring. Sloane's Voyage to Jamaica, pag. 23.*

Creatures, as their Necessities of Life require. To which purpose the natural Sagacity and Craft of the one in entrapping (15) and captivating, being in some Measure equivalent to that of the other in evading, is as excellent a means for the maintaining the one, as preserving the other ; and if well considered, argues the Contrivance of the infinitely wise Creator and Preserver of the World.

C H A P. XV.

Of the Generation of Animals.

THERE is now only one thing more of the ten Things in common to Animals, and that is what relates to their Generation (1), and Conservation

(15) See Chap. II. Note 57.

(1) *Spontaneous Generation* is a Doctrine so generally exploded, that I shall not undertake the disproof of it. It is so evident, that all Animals, yea and Vegetables too, owe their Production to Parent-Animals and Vegetables, that I have often admired at the Sloth and Prejudices of the ancient Philosophers, in so easily taking upon trust the *Aristotelian*, or rather the *Aegyptian* Doctrine of *Aequivocal Generation* ; that when they saw *Flies*, *Frogs*, and *Lice*, for instance, to be Male and Female, and accordingly to engender, lay Eggs, &c. they could ever imagine any of these Creatures should be spontaneously produced, especially in so Romantick a manner, as in the Clouds ; as they particularly thought *Frogs* were, and that they dropped down in Showers of Rain. For an answer to this case of *Frogs*, I shall refer to a Relation of my own, which my late most ingenious and learned Friend, the great Mr. Ray requested of me, and was pleased to publish in his last Edition of his *Wisdom of God manifested*, &c. p. 365.

But some will yet assert the Raining of *Frogs*; among which the curious Dr. Plot is somewhat of this Opinion; telling us of *Frogs* found on the Leads of the *Ld Aston's* Gatehouse at *Tixal* in *Staffordshire*, which he thinks by some such means came there, as also on the *Bowling-Green* frequently after a Shower of Rain. *Plot's Hist. Staff. c. 1. §. 47.*

But we may take a Judgment of this, and an Hundred such like Reports, to be met with in considerable Authors, from other the like Reports that have been better inquired into. In a Scarcity in *Silesia*, a mighty Rumour was spread of its raining *Millet-Seed*. But the Matter being enquired into, 'twas found to be only the Seeds of the *Ivy-leaved Speedwel*, or *small Henbit* growing in the place in great plenty. *Ephe. Germ. An. 3. Obser. 40.* So in the *Archipelago* it was thought *Ashes* were rained, Ships being covered therewith at one Hundred Leagues distance. But in all probability it was from an Eruption of *Vesuvius*, that then happened. About *Warmister* in *Wilts*, 'twas reported it rained *Wheat*. But an ingenious Observer, Mr. Cole, found it to be only *Ivy-Berries* blown thither in a considerable Quantity by a Tempest. In the Year 1696. at *Cranstead* near *Wrotham* in *Kent*, a Pasture-Field was overspread with little young *Whittings*, supposed to fall from the Clouds in a Tempest of Thunder and Rain. But doubtless they were brought thither with Waters from the Sea, by the Tempest. *Vid. the fore-commended Mr. Lowth. Abridg. Phil. Transf. V. 2. p. 143, 144.*

Neither needeth it to seem strange, that *Ashes*, *Ivy Berries*, small Fishes, or young *Frogs*, (which yet may have some other Conveyance,) should be thus transported by tempestuous Winds, considering to what Distance, and in what Quantities the Sea-Waters were carried by the *Great Storm*, Nov. 26. 1703. of which an ingenious Friend sent me these Accounts from *Lewes* in *Sussex*, viz. That a Physician travelling soon after the Storm, to *Titchhurst*, twenty Miles from the Sea, as he rode along pluckt some Tops of Hedges, and chewing them, found them Salt: that some Grapes hanging on the Vines at *Lewes*, were so too; that Mr. Williamson, Rector of *Ripe*, found the Twigs in his Garden Salt the Monday after the Storm, and others observed the same a Week after; that the Grass of the Downs about *Lewes*, was so Salt, that the Sheep would not feed till Hunger compelled them: and that the Miller of *Berwick*, (three Miles from the Sea,) attempting, with his Man, to secure his Mill, were so washed with Flashes of Sea-water, like the Breakings of Waves against the Rocks, that they were almost strangled therewith, and forced to give over their Attempt.

vation of their Species (2) by that means. It would not be seemly to advance far in this admirable Work of God ; neither shall I at all insist upon that of Man for the same reason. And as for the Irrationals (3), I shall confine my self to these five Matters.

I. Their

I called this Doctrine of *Æquivocal Generation*, an *Egyptian Doctrine*, because probably it had its Rise in *Ægypt*, to salve the Hypothesis of the Production of Men and other Animals out of the Earth, by the help of the Sun's Heat. To prove which, the *Egyptians*, (as *Diodor. Sicul.* saith,) produce this Observation, That about Thebes, when the Earth is moistened by the Nile, by the intense Heat of the Sun, an innumerable multitude of Mice, do spring out. From whence he infers, that all kind of Animals might as well at first come likewise out of the Earth. And from these the learned Bishop *Stillingfleet* thinks other Writers, as *Ovid*, *Mela*, *Pliny*, &c. have, without examining its Truth, taken up the same Hypothesis. *V. Stillingfleet's Orig. Sacr.* Part 2. Book I. Chap. 1.

The before-commended *Dr. Harris*, from the Observations of *Dr. Harvey*, *Sr. Malpighi*, *Dr de Graaf*, and *Mr. Leewenhoeck* infers three Things concerning Generation as highly probable. 1. That Animals are ex Animalculo. 2. That the Animalcules are originally in semine Maxium, & non in Fœminis. 3. That they can never come forward, or be formed into Animals of the respective Kind, without the Ova in Fœminis. His Proofs and Illustrations, see under the word Generation in his *Lex. Techn.* Vol. 2.

(2) *At certè Natura, si fieri potuisset, maximè optasset suum opificium esse immortale : quod cum per materiam non liceret (nam quod — ex carne est compositum, incorruptibile esse non potest) subsidium quod potuit ipsi ad immortalitatem est fabricata, sapientis cujusdam urbis conditoris exemplo, &c. Nam mirabilem quandam rationem invehit, quo modo in demortui animalis locum, novum aliud sufficiat.* *Galen de Us. Part. 1. 14. c. 2.*

(3) *Animantia Bruta Obstetricibus non indigent in edendo Partu, cum indita Nature vi Umbilicus seipsum occludat.* *Ol. Rudbeck in Blasii Anat. Felis.*

1. Their natural Sagacity in chusing the fittest Places to reposite their Eggs and Young.

2. The fittest Times and Seasons they make Use of for their Generation.

3. The due and stated Number of their Young.

4. Their Diligence and earnest Concern in their Breeding up.

5. Their Faculty of feeding them, and their Art and Sagacity exerted therein.

1. The natural Sagacity of irrational Animals in chusing the fittest Places to reposite their Eggs and Young. Of this I have given larger Hints already than I needed to have done, when I spake of the Architecture (4) of Animals, intending then to have wholly passed by this Business of Generation. I shall therefore now only superadd a few other Instances, the more to illustrate this matter.

It hath been already shewed, and will hereafter (5) further appear, that the Places in which the several Species of Animals lay up their Eggs and Young are the best for that purpose; Waters (6)

for

(4) Chap. 13.

(5) Book VIII. Chap. 6.

(6) The *Ephemeron*, as it is an unusual and special Instance of the Brevity of Life, so I take to be a wonderful Instance of the Special Care and Providence of God in the Conservation of the Species of that Animal. For, 1. As an Animal, whose Life is determined in about five or six Hours time, (*viz.* from about six in the Evening, till about eleven a Clock at Night,) needs no Food; so neither doth the *Ephemeron* eat, after it is become a Fly. 2. As to its Generation. In those five Hours of its Life, it performs that, and all other necessary Offices of its Life. For in the beginning of its Life, it sheds its Coat; and that being done, and the poor little Animal thereby rendered Light and Agile, it spends the rest of its short time in frisking over the Waters.

for one, Flesh for another, Holes in Wood (7), Earth, or Stone (8) for others, and Nests for others; and we shall find, that so ardent is the Propensity of all Animals, even of the meanest Insects to get a fit place for the Propagation of their Young, that, as will hereafter appear, there is scarce any thing that escapeth the Inquest of those little subtile Creatures. But besides all this, there are two or three things more observable, which plainly argue the Instinct of some superiour rational Being. As,

1. The compleat and neat Order which many Creatures observe in laying up their Seed or Eggs in proper place. Of which I shall speak in another place (9).

2. The suitable Apparatus in every Creature's Body for the laying up its Eggs, Seed, or Young in their proper place. It would be as endless as needless to name all Particulars, and therefore an Instance or two of the Insect Tribe may serve for a Specimen in this place, till I come to other Particulars. Thus Insects, who have neither Feet adapted to scratch, nor Noses to dig, nor can make artificial

Waters, and at the same time the Female droppeth her Eggs on the Waters, and the Male his spern on them to impregnate them. These Eggs are spread about by the Waters, descend to the bottom by their own Gravity, and are hatched by the warmth of the Sun into little Worms, which make themselves Cases in the Clay, and feed on the same without any need of parental Care. *Vid. Ephem. vita*, translated by Dr. Tyson from *Swammerdam*. See also *Book VIII. Chap. 6. Note 17.*

(7) *V. Chap. 13. Note 2. and Book VIII. Chap. 6.*

(8) The Worms in *Chap. 11. Note 22.* breed in the Holes, they gnaw in Stone, as is manifest from their Eggs found therein.

(9) See *Book VIII. Chap. 6. Note 16.*

(10) Many

artificial Nests to lay up their Young ; yet what abundant amends is there made them, in the power they have either to extend the *Abdomen* (10), and

(10) Many, if not most Flies, especially those of the *Flesh-Fly*-kind, have a Faculty of extending their *Uropygia*, and thereby are enabled to thrust their Eggs into convenient Holes, and Receptacles for their Young, in Flesh, and whatever else they Fly-blow. But none more remarkable than the *Horse Fly*, called by *Pennius* in *Mouffet*, (p. 62.) Σκολεξ, i. e. *Curvicauda*, and the *Whame* or *Burrel-Fly*, which is vexatious to Horses in Summer, not by stinging them, but only by their bombilyous Noise, or tickling them in laying their Nits, or Eggs on their Hair ; which they do in a very dextrous manner, by thrushting out their *Uropygia*, bending them up, and by gentle, slight Touches, sticking the Eggs to the Hair of the Legs, Shoulders, and Necks, commonly of Horses ; so that Horses which go abroad, and are seldom dressed, are somewhat discoloured by the numerous Nits adhering to their Hair.

Having mentioned so much of the Generation of this Insect, although it be a little out of the way, I hope I shall be excused for taking Notice of the long-tailed Maggot, which is the Product of these Nits or Eggs, called by Dr. Plot. *Eruca glabra* [or rather *Eula Scabra*, it should be] *caudata aquatico-arborea*, it being found in the Water of an hollow Tree. This I mention, as being a singular and remarkable Work of God, not so much for its being utterly unlike to its Parent *Bee-like-Fly*, as for the wise Provision made for it by its long Tail : which is so joynted at certain distances from the Body, as that it can be withdrawn, or sheathed one Part within another to what length the Maggot pleaseth, so as to enable it to reach the bottom of very shallow, or deeper Waters, for the gathering of Food. At the end of this tapering Tail is a Ramification of *Fibrillæ*, or small Hairs, representing (when spread) a Star ; with the help of which spread out on the top of the Waters, it is enabled to Hang, making by that means a small Depression or Concavity on the Surface of the Water. In the midst of this Star, I imagine the Maggot takes in Air, there being a Perforation, which with a Microscope I could perceive to be open, and by the Star to be guarded against the Incursion of the Water.

and thereby reach the commodious Places they could not otherwise come at; or else they have some aculeous Part or Instrument to terebrate, and make way for their Eggs into the Root (11), Trunk (12), Fruit (13), Leaves (14), and the tender

(11) The Excrescences on the Roots of *Cabbages*, *Turneps*, and divers other Plants have always a Maggot in them: but what the Animal is that thus makes its way to the Root under Ground, whether *Ichneumon*, *Phalana*, or rather *Scarab*, which I most suspect, I could never discover, being not able to bring them to any thing in Boxes.

(12) I presume they are only of the *Ichneumon-Fly-kind*, that have their Generation in the Trunks of Vegetables. In *Malpighi de Gallis*, Fig. 61, is a good Cut of the goury Excrescences, or rather Tumors of the *Briar-stalk*: from which proceeds a small black *Ichneumon-Fly*, with red *Legs*; black, smooth, joyned *Antennæ*; pretty large *Thorax*; and short, round *Belly*, of the shape of an Heart. It leapeth as a *Flea*. The *Male*, (as in other Insects,) is lesser than the *Female*, and very venereous; in spite of Danger, getting upon the *Female*, whom they beat and tickle with their *Breeches* and *Horns*, to excite them to a *Coit*.

Another example of Generation in the Trunks of Vegetables, shall be from the Papers of my often commended Friend Mr. Ray, which are in my Hands, and that is an Observation of the ingenious Dr. Nath. Wood: I have (saith he) lately observed many Eggs in the common *Rush*. One sort are little transparent Eggs, in shape somewhat like a *Pear*, or *Retort*, lying within the *Skin*, upon, or in the *Medulla*, just against a brownish Spot on the out-side of the *Rush*; which is apparently the *Cicatrix* of the wound made by the *Fly*, when she puts her Eggs there. Another kind is much longer, and not so transparent, of a long oval, or rather cylindrical Form: six, eight, or more, lie commonly together, across the *Rush*, parallel to each other like the *Teeth* of a *Comb*, and are as long as the Breadth of the *Rush*. Letter from *Kilkenny* in *Ireland*, Apr. 28. 1697.

(13) See Book VIII. Chap. 6. Note 4.

(14) I have in Chap. 13. Note 19, and Book VIII. Chap. 6. Notes 5, 6, taken notice of the Nidification and Generation of some Insects on the Leaves of Vegetables, and shall therefore for

der Buds of Vegetables (15), or some other such curious and secure Method they are never destitute of. To which we may add,

3. The natural Poyson (||), (or what can I call it,) which many or most of the Creatures, last intended, have to cause the Germination of such Balls, Cases, and other commodious Repositories as are an admirable Lodgment to the Eggs and Young, that particularly assist in the Incubation and Hatching the Young, and then afford them sufficient Food and Nourishment in all their *Nympha-State*, in which they need Food; and are afterwards commodious

for the Illustration of this place, chuse an uncommon Example out of the *Scarab-kind*, (the Generation of which Tribe hath not been as yet mentioned,) and that is of a small *Scarab* bred in the very Tips of *Elm-leaves*. These Leaves in Summer may be observed to be, many of them, dry and dead, as also turgid: in which lieth a dirty, whitish, rough Maggot. From which proceeds a *Beetle* of the smallest kind, of a light *Weefle* colour, that leapeth like a *Grashopper*, although its Legs are but short. Its Eyes are blackish, Vaginae thin, and prettily furrowed, with many Concavities in them; small club-headed Antennae, and a long Rostrum like a Proboscis.

The same, or much like this, I have met with on the Tips of *Oaken* and *Holly-leaves*. How the *Scarab* lays its Eggs in the Leaf, whether by terrebrating the Leaf, or whether the *Maggot*, when hatched, doth it, I could never see. But with great Dexterity it makes its way between the upper and under Membranes of the Leaf, feeding upon the parenchymous Part thereof. Its Head is slenderer and sharper than of most *Maggots*, as if made on purpose for this Work; but yet I have often wondered at their Artifice in so nicely separating the Membranes of the *Elm-leaf*, without breaking them, and endangering their own tumbling out of them, considering how thin and very tender the Skins of that Leaf (particularly) are.

(15) See Book VIII. Chap. 6. Note 24.

(||) See Book VIII. Chap. 8. to Note 26, &c.

commodious Houses and Beds for them in their *Aurelia-State*, till they are able to break Prison, fly abroad, and shift for themselves. But this shall be taken Notice of, when I come to treat of Insects.

2. As irrational Animals chuse the fittest Place, so also the fittest Times and Seasons for their Generation. Some indeed are indifferent to all Times, but others make use of peculiar Seasons (16). Those, for instance, whose Provisions are ready at all Seasons, or who are under the Tuition of Man, produce their Young without any great regard to Heat or Cold, Wet or Dry, Summer or Winter. But others, whose Provisions are peculiar, and only to be met with at certain Seasons of the Year, or who, by their Migration and Change of Place, are tied up to certain Seasons; these (as if endowed with a natural Care and Foresight of what shall happen) do accordingly lay, hatch, and nurse up their Young in the most proper Seasons of all the Year for their purpose: as in Spring, or Summer, the times of plenty of Provisions, the times of warmth for Incubation, and the most proper Seasons to breed up their Young, till they are able to shift for themselves, and can range about for Food, and seek places of Retreat and Safety, by flying long Flights as well as their Progenitors, and passing into far distant Regions, which (when others fail) afford those helpless Creatures the Necessaries of Life.

3. To

(16) Πολλὰ δὲ καὶ πρὸς τὰς ἐντεροῦς τῶν τέκνων σοχαζόμενα, ποιῶνται τὸ σῶμασμον ἐν τῇ ἀπείρῳ τῇ ὥρᾳ. Arist. Hist. An. l. 5. c. 8. ubi plura.

3. To the special Seasons, I may add the peculiar Number of Young produced by the Irrational Creatures. Of which I have already taken some notice, when I spake of the Balance of Animals (17). Now, if there was not a great deal more than Chance in this Matter, even a wise Government of the Creation, it could never happen that every Species of Animals should be tied up to a certain Rate and Proportion of its Increase; the most useful, would not be the most fruitful, and the most pernicious produce the fewest Young, as I have observed it commonly is. Neither would every Species produce such a certain Rate as it is only able to breed up. But all would be in a confused, huddled State. Instead of which, on the contrary, we find every thing in compleat Order; the Balance of Genera, Species and Individuals always proportionate and even; the Balance of Sexes the same; most Creatures tied up to their due Stint and Number of Young, without their own Power and Choice, and others (particularly of the winged Kind (18)) producing their due Number at their Choice and Pleasure;

(17) Chap. 10

(18) Mr. Ray alledges good Reasons to conclude, that although Birds have not an exact Power of numbering, yet, that they have of distinguishing many from few, and knowing when they come near to a certain Number; and that they have it in their Power to lay many or few Eggs. All which he manifesteth from *Hens*, and other domestick Fowls, laying many more Eggs when they are withdrawn, than when not. Which holds in wild as well as domestick Birds, as appears from Dr. Lister's Experiment in withdrawing a *Swallow's* Eggs, which by that means laid nineteen Eggs successively before she gave over. *V. Ray's Wisdom of God, &c. p. 137.*

(19) *Palumbes*

Pleasure ; some large Numbers, but not more than they can cover, feed, and foster ; others fewer, but as many as they can well nurse and breed up. Which minds me,

4thly. Of the Diligence and earnest Concern which irrational Animals have of the Production, and Breeding up their Young. And here I have already taken notice of their *σπερμή*, or natural Affection, and with what Zeal they feed and defend their Young. To which may be added these two things.

1. The wonderful Instinct of Incubation. It is utterly impossible, that ever unthinking untaught Animals should take to that only Method of hatching their Young, was it not implanted in their Nature by the infinitely wise Creator. But so ardent is their Desire, so unwearied is their Patience when they are engaged in that Business, that they will abide their Nests for several Weeks, deny themselves the Pleasures, and even the Necessaries of Life ; some of them even starving themselves almost, rather than hazard their Eggs, to get Food, and others either performing the Office by turns (19), or else the one kindly seeking out, and carrying Food to the other (20), engaged in the Office of Incubation.

(19) *Palumbes incubat femina post meridianam in matutinum, cetero mas. Columbae incubant ambo, interdiu Mas, noctu Femina. Plin. Nat. Hist. l. 10. c. 58.*

(20) Of the common Crow, Mr. Willughby saith, *The Females only sit, and that diligently, the Males in the mean time bring them Viſtuals, as Aristotle saith. In most other Birds, which pair together, the Male and Female sit by turns. Ornithol. L. 2. Sect. 1. C. 2. §. 2.* And I have observed the Females to be much fatter than the Males.

cubation. But of these Matters in a more proper place (21).

2. When the young ones are produced, not only with what Care do they feed and nurse them, but with what surprizing Courage do all or most Creatures defend them! It is somewhat strange to see timid Creatures (22), who at other times are cowardly, to be full of Courage, and undaunted at that time; to see them furiously and boldly encounter their Enemy, instead of fly from him; and expose themselves to every Danger, rather than hazard, and forsake their Young.

With this earnest Concern of the irrational Animals for their Young, we may join in the

5th and last Place, Their Faculty and Sagacity of feeding them. Of which I shall take notice of three things.

1. The Faculty of suckling the Young, is an excellent Provision the Creator hath made for those helpless Creatures. And here the agreeableness and suitableness of that Food to young Creatures deserves particular Observation, as also their delight in it, and desire and endeavours after it, even as soon as born (23), together with the willingness of all, even the most savage and fierce Animals

S

to

(21) See Book VII. Chap. 4.

(22) *Volucris Natura novam quandam Pullos educandi, rationem excogitavit: ipsis enim præcipuum quendam amorem in ea quæ procrearunt, ingeneravit, quo impulsa bellum pro pullis cum ferocibus animalibus, quæ antè declinarunt, intrepidè suscipiunt, victumque ipsis convenientem suppeditant.* Galen de Us. Part. 1. 14. c. 4.

(23) *In iis animantibus quæ lacte aluntur, omnis ferè cibus matrum lactescere incipit: eaque quæ paulo ante nata sunt sine magistro, duce naturâ, mammas appetunt, earumque ubertate saturantur.*

S

tur.

to part with it, and to administer it to their Young, yea, to teach and institute them in the Art of taking it.

And lastly, To name no more, the curious Apparatus which is made for this Service in the divers Species of Animals by a due number of Breasts proportionable to the Occasions of each Animal, by curious Glands in those Breasts to separate that nutritive Juyce, the Milk, by Arteries and Veins to convey it to them, and proper Rivulets and Channels to convey it from them, with Duggs and Nipples placed in the most convenient part of the Body (24) of each Animal to administer it to their Young; all these things, I say, do manifestly proclaim the Care and Wisdom of the great Creator.

2. As

tur. Atque ut intelligamus nihil horum esse fortuitum, & hæc omnia esse provida, solertisque naturæ, quæ multiplices fœtus procreant, ut Sues, ut Canes, his Mammarum data est multitudo; quas easdem paucas habent ex bestia, quæ pauca gignunt. Cicero de Nat. Deor. L. 2. Consule quoque Galen de Us. Part. l. 14. c. 4. and l. 15. c. 7.

(24) *Animalia solidipeda & ruminantia vel cornigera inter femora Mammas habent, quorum Fœtus statim a partu pedibus insistant, quod matres inter lactandum non decumbant, ut Equæ, Asina, &c. Animalia digitata & multipara in medio ventre, scilicet spatio ab inguine ad pectus (in Cuniculo usque ad jugulum) duplicem mammarum seriem sortita sunt, quæ omnia decumbentia ubera fœtibus admovent, ut Ursa, Leona, &c. Si vero hæc in solo inguine Mammas geverent, propria crura inter decumbendum fœtus accessum ad mammas nonnihil præpedirent. Mulieribus Mammae binæ sunt, ut & Papillæ, nimirum ut latus lateri conformiter respondeat, & ut alternatim infans a latere in latus inter sugendum transferatur, ne corpus ejus uni lateri nimis assuescens quoquo modo incurvatur. Simia, homo Sylvestris, &c. Blas. Anat. Animal. Par.*

2. As for such Animals as do in another manner breed up their Young, by finding out Food, and putting it into their Mouths, the Provision made in them for this Service to strike, catch, to pouch, and convey their Prey and Food to their Young (25), is very considerable. And so is also
their

1. Cap. 6. *de Canē ex Whartono.* See here what *Pliny* hath also, L. 11. Chap. 40.

In the *Elephant*, the Nipples are near the Breast, by reason the old one is forced to suck her self, and by the help of her Trunk conveys the Milk into the Mouth of her Young. *Vid. Phil. Transact. Nr. 336.*

(25) For an Exemplification I might name many Animals, particularly Birds, whose Parts are compleatly suited to this Service. They are Characteristicks of Rapacious birds, to have aduncous Bills and Talons to hold and tear, and strong brawny Thighs to strike and carry their Prey, as well as a sharp piercing Sight to spy it afar off. *Ray Synops. Method. Av. p. 1.* The *Pelecanē* also might be here named for its prodigious Bag under its Bill and Throat, big enough to contain thirty Pints. *Id. ibid. p. 122.* And to name no more, the common *Heron* hath its most remarkable Parts adapted to this Service; long Legs for wading, and a long Neck answerable thereto to reach Prey, a wide extensive Throat to pouch it; long Toes, with strong hooked Talons, one of which is remarkably ferrate on the Edge, the better to hold their Prey: a long sharp Bill to strike their Prey, and ferrate towards the Point, with sharp hooked Beards standing backward, to hold their Prey fast when struck; and lastly, large, broad, concave Wings (in appearance much too large, heavy, and cumbersome for so small a Body, but) of greatest Use to enable them to carry the greater Loads to their Nests at several Miles Distance: as I have seen them do from several Miles beyond me, to a large Heronry above three Miles distant from me. In which I have seen *Plaife*, and other Fish, some Inches long, lying under the high Trees in which they build: and the curious and ingenious Owner thereof hath seen a large *Eel* conveyed by them, notwithstanding the great Annoyance it gave them in their Flight, by its twisting this way, and that way about their Bodies.

their Sagacity in equally distributing it among them, that among many, all shall be duly, equally, and in good Order, fed.

3. There is yet another Instinct remaining, of such Animals as can neither administer Suck to their Young, neither lay them in places affording Food, nor can convey and bring them Food, but do with their Eggs lay up Provisions for their future Young. Somewhat of this is reported of some Birds (26); but I have my self with Pleasure frequently seen some of the Species of Insects to carry ample Provisions into their dry and barren Cells, where they have sealed them carefully and cautiously up with their Eggs, partly, 'tis like, for Incubation sake, and partly as an easy Bed to lodge their Young; but chiefly for future Provision for their Young, in their Nympha-state, when they stand in need of Food (27).

(26) This is reported of the *American Ostrich*, mentioned by *Acavette*, in *Philos. Transact.* Nr. 89. Of which see, *Book VII. Chap. 4. Note 4.*

(27) *Hornets Wasps*, and all the kinds of *Bees* provide Honey; and many of the *Pseudospheceæ*, and *Ichneumon-Wasps* and *Flies* carry in *Maggots*, *Spiders*, &c. into their Nests; of which see above, *Note 2. Chap. 13.*

CHAP.

C H A P. XVI.

The Conclusion.

THUS I have as briefly as well I could, (and much more briefly than the Matters deserved,) dispatched the Decad of things I proposed in common to the sensitive Creatures. And now let us pause a little, and reflect. And upon the whole Matter, what less can be concluded than that there is a Being infinitely Wise, Potent, and Kind, able to Contrive and Make this glorious Scene of things, which I have given only a Glance of? For what less than Infinite, could stock so vast a Globe with such a noble Set of Animals? all so contrived, as to minister to one another's Help some way or other, and most of them serviceable to Man peculiarly, the Top of this lower World; made as 'twere on purpose to observe, and survey, and set forth the Glory of the infinite *Creator*, manifested in his Works! Who! What but the great *GOD* could so admirably provide for the whole Animal World every thing serviceable to it, or that can be wished for, either to conserve its Species, or to minister to the Being or Well-being of Individuals! Particularly, who could *Feed* so spacious a World, who could please so large a number of Palates, or suit so many Palates to so great a variety of Food, but the infinite Conservator of the World! And who but the same great *HE*, could provide such commodious *Clothing* for every Animal; such proper *Houses*, *Nests*, and *Habitations*; such suitable *Armature* and *Weapons*;

Weapons ; such *Subtilty*, *Artifice*, and *Sagacity*, as every Creature is more or less armed and furnished with, to fence off the Injuries of the Weather, to rescue it self from Dangers, to preserve it self from the Annoyances of its Enemies ; and, in a word, to conserve its Self, and its Species ! What but an infinite superintending Power could so equally *balance* the several Species of Animals, and conserve the *Numbers* of the Individuals of every Species so even, as not to over or under people the Terraqueous Globe ! Who but the infinite wise Lord of the World could allot every Creature its most suitable *Place* to live in, the most suitable Element to *breathe*, and *move*, and *act* in ! And who but *HE* could make so admirable a Set of *Organs*, as those of Respiration are, both in Land and Water-Animals ! Who could contrive so curious a Set of Limbs, Joynts, Bones, Muscles, and Nerves, to give to every Animal the most commodious *Motion* to its State and Occasions ! And to name no more, what Anatomist, Mathematician, Workman, yea Angel could contrive, and make so curious, so commodious, and every way so exquisite a Set of Senses, as the *five Senses* of Animals are ; whose *Organs* are so dexterously contrived, so conveniently placed in the Body, so neatly adjusted, so firmly guarded, and so compleatly suited to every Occasion, that they plainly set forth the Agency of the infinite Creator and Conservator of the World !

So that here upon a transient View of the Animal World in general only, we have such a throng of Glories, such an enravishing Scene of things, as may excite us to admire, praise, and adore the infinitely wise, powerful, and kind CREATOR ; to condemn all atheistical Principles ;

ples; and with holy *David*, *Psal.* 14. 1. to conclude that he is in good earnest a *Fool*, that dares to say, *There is no God*, when we are every where surrounded with such manifest Characters, and plain Demonstrations of that infinite Being.

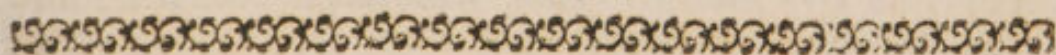
But in the next Book we shall still find greater Tokens, if possible, in my View of Animals in particular.

A SURVEY

A
S U R V E Y
Of the Particular
Tribes of *ANIMALS*.



IN the foregoing Book, having taken a View of the things in common to Animals, my Business in the next, will be to inspect the particular Tribes, in order to give further Manifestations of the infinite Creator's Wisdom, Power and Goodness, towards the Animal World.



B O O K V.

A SURVEY of MAN.

THE first *Genus* of Animals that I shall take Notice of, shall be *Man*, who may justly claim the Precedence in our Discourse, inasmuch as God hath given him Superiority in the Animal World ; Gen. 1. 26. *And God said, Let us make Man in our Image, after our Likeness : and let them have Dominion over the Fish of the Sea, and over the*

Fowl of the Air, and over the Cattel, and over all the Earth, and over every creeping thing that creepeth upon the Earth.

And as to Man, we have so excellent a Piece of Workmanship, such a Microcosm, such an Abridgment of the Creator's Art in him, that is able alone to demonstrate the Being and Attributes of God, as will appear by considering the *Soul*, and the *Body* of Man.

CHAP. I.

Of the SOUL of Man.

MY Survey of Man, I shall begin with the Soul of Man, by reason it is his most noble Part (1), the Copy of the Divine Image in us (2); in which we have enough to fill us with Admiration of the Munificence, Power, and Wisdom of the Infinite Creator (3), when we contemplate

(1) *Fam vero Animum ipsum, Mentemque hominis, Rationem, Consilium, Prudentiam, qui non divina cura perfecta esse perspicit, is his ipsis rebus mihi videtur carere. Cicer. de Nat. Deor. L. 2.*

(2) *Sensum a Cœlesti demissum traximus arce,
Cujus egent prona, & terram spectantia : mundi
Principio indulsit communis Conditor ; illis
Tantum Animas ; nobis quoque Animum.*

Juven. Sat. 15.

*Et cum non aliter possent mortalia fingi,
Adjunxit geminas, illæ cum corpore lapsæ
Intereunt : hæc sola manet, bustoque superstes
Evolat.*

Claudian. de 4. Consul. Honor.

(3) *Nam si quis nulli sectæ addictus, sed libera sententia rerum considerationem inierit, conspicatus in tanta carniū ac succorum colluvie tantam Mentem habitare : conspicatus item & cujusvis animalis constructionem (omnia enim declarant*
Opifi-

template the noble Faculties of this our superior part, the vast Reach and Compass of it's *Understanding*, the prodigious Quickness and Piercingness of it's *Thought*, the admirable Subtilty of it's *Invention*, the commanding Power of it's *Wisdom*, the great Depth of it's *Memory* (4), and in a Word it's Divine Nature and Operations.

But I shall not dwell on this, tho' the superiour part of Man, because it is the least known. Only there are two things I can't easily pass by, because they manifest the especial Concurrence and Design of the Infinitely wise Creator, as having

a

Opificis Sapientiam) Mentis, quæ homini inest, excellentiam intelliget, tum opus de partium utilitate, quod prius exiguum esse sibi videbatur, perfectissimæ Theologiæ verum principium constituet: quæ Theologia multo est major atque præstantior tota Medicina. Galen. de usu Part. L. 17. c. 1.

(4) Among many Examples that I could give of Persons famous for *Memory*, *Seneca's* Account of himself may be one, *Hanc [Memoriam] aliquando in me floruisse, ut non tantum ad usum sufficeret, sed in miraculum usque procederet, non nego. Nam & 2000 nominum recitata, quo ordine erant dicta, reddebam: & ab his qui ad audiendum præceptorem nostrum convenierunt, singulos versus a singulis datos, cum plures quam 200 efficerentur, ab ultimo incipiens usque ad primum recitabam.* After which, Mention is made of the great Memory of *Latro Porcius* (*carissimi mihi sodalis Seneca* calls him) who retained in his Memory all the Declamations he had ever spoken, and never had his Memory fail him, not so much as in one single Word. Also he takes Notice of *Cyneas* Ambassador to the Romans from King *Pyrrhus*, who in one Day had so well learnt the Names of his Spectators, that *postero die novus homo & Senatum, & omnem urbanam circumfusam Senatui plebem, nominibus suis persalutavit.* *Senec. controvers. L. 1. init. Vid. quoque Plin. L. 7. c. 24.* where he also adds other Examples, viz. *Cyrus rex omnibus in exercitu suo militibus nomina reddidit; L. Scipio populo Rom. Mithridates 22 gentium rex, totidem linguis jura dedit, pro concione singulas sine interprete affatus. Charmidas (seu potius Carneades) — quæ quis exegerat volumina in bibliothecis, legentis modo representavit.*

a particular and necessary Tendency to the Management and good Order of the World's Affairs. The

1. Of which is the various Genii, or Inclinations of Men's Minds to this, and that, and the other Business (5). We see how naturally Men betake themselves to this and that Employment : some delight most in Learning and Books, some in Divinity, some in Physick, Anatomy and Botany, some in Critical Learning and Philology, some in Mathematicks, some in Metaphysicks, and deep Researches ; and some have their Delight chiefly in Mechanicks, Architecture, War, Navigation, Commerce, Agriculture ; and some have their Inclinations lie even to the servile Offices of the World, and an hundred things besides.

Now all this is an admirably wise, as well as most necessary Provision for the easy, and sure transacting the World's Affairs ; to answer every End and Occasion of Man, yea, to make Man helpful to the poor helpless Beasts, as far as his Help is needful to them ; and all, without any great Trouble, Fatigue or great Inconvenience to Man ; rather as a Pleasure, and Diversion to him. For so far it is from being a Toyl, that the greatest

(5) *Diversis etenim gaudet natura ministris,
Ut fieri diversa queant ornantia terras.
Nec patitur cunctos ad eandem currere metam,
Sed varias jubet ire vias, variosque labores
Suscipere, ut vario cultu sit pulchrior orbis.*

Paling. in Scorp.

Οὐτως ἔ παντες Θεος χαρίεντα δίδωσι
Ἀνθρώποις. &c. *Ita non omnibus hominibus sua dona dat Deus ;
neque bonam indolem, neque prudentiam, nec eloquentiam :
alius namque vultum habet deformem ; sed Deus formam elo-
quentia ornat, &c. Homer Odyf. 8. The like also in Iliad.
L. 13.*

(6) Al-

greatest Labours, (6) Cares, yea and Dangers too, become pleasant to him who is pursuing his *Genius*, and whose Ardour of Inclination eggs him forward, and buoys him up under all Opposition, and carrieth him through every Obstacle to the End of his Designs and Desires.

2. The next is the *Inventive* Power of the Soul. (7) Under which I might speak of many things, but I shall take Notice only of two, because they manifest the particular Concern and Agency of the infinitely wise Creator. The

1. Is that *Man's Invention* should reach to such a great Variety of Matters; that it should hit upon every thing, that may be of any Use, either to himself, or to human Society, or that may any ways promote (what in him lies) the Benefit of this lower part of the Creation.

For the Illustration of this, I might take a View of all the Arts and Sciences, the Trades, yea the very Tools they perform their Labours and Contrivances with, as numberless as their Occasions and Contrivances are various. Indeed what is there that falleth under the Reach of Man's
Sen-

(6) Although Solomon declares, Eccles. 12, 12. *that much Study is a weariness to the Flesh*, yet we see with what Pleasure and Assiduity many apply themselves to it. Thus Cicero tells of Cato, whom he casually found in Lucullus's Library, *M. Catonem vidi in Bibliotheca sedentem, multis circumfusus Stoicorum libris. Erat enim, ut scis, in eo inexhausta aviditas legendi, nec satiari poterat: quippe ne reprehensionem quidem vulgi inanem reformidans, in ipsa curia sole-ret legere saepe, dum senatus cogeretur — ut Helio librorum — videbatur.* Cic. de finib. L. 3. non longe ab initio.

(7) *Mentem hominis, quamvis eam non videas, ut Deum non vides, tamen ut Deum agnoscis ex operibus ejus, sic ex memoria rerum, & Inventionem, & celeritate motus, omnique pulchritudine virtutis vim divinam mentis agnoscito.* Cic. Tusc. quæst. L. 1.

Senses, that he doth not employ to some Use and Purpose for the World's Good? The Celestial Bodies, the Sun, the Moon, with the other Planets, and the fixt Stars, he employs to the noble Uses of Astronomy, Navigation and Geography. And what a noble Acumen, what a vast Reach must the Soul be endowed with, to invent those curious Sciences of Geometry, and Arithmetick, both Specious and in Numbers; and those nice and various Instruments made use of by the Geometrician, Astronomer, Geographer, and Sailor? And lastly, what a wonderful Sagacity is shewn in the Business of Opticks, and particularly in the late Invention of the Telescope? wherewith new Wonders are discovered among God's Works in the Heavens, as there are here on Earth with the Microscope, and other Glasses.

And as for this lower World, what Material is there to be found, what Kind of Earth, or Stone, or Metal, what Animal, Tree, or Plant, yea even the very Shrubs of the Field; in a Word, what of all the excellent Variety the Creator has furnish'd the World with, for all it's Uses and Occasions, in all Ages; What, I say, that Man's Contrivance doth not extend unto, and make some way or other advantageous to himself, and useful for Building, Cloathing, Food, Physick, or for Tools and Utensils, or for even only Pleasure and Diversion?

But now considering the great Power and Extent of human Invention.

2. There is another thing that doth farther demonstrate the Super-intendence of the great Creator and Conservator of the World, and that is, that things of great, and absolutely necessary Use, have soon, and easily occurred to the Invention of Man; but things of little Use, or very dangerous Use, are rarely and slowly discovered,

or still utterly undiscover'd. We have as early as the Mosaick History, an account of the Invention of the more useful Crafts and Occupations. Thus *Gen. 3, 23. Adam was sent forth from the Garden of Eden, by God himself, to till the Ground.* And in the next Chapter, his two Sons *Cain* and *Abel*, the one was of the same Occupation, a Tiller of the Ground; the other a Keeper of Sheep (8). And the Posterity of these are in the later End of this *Gen. 4.* recorded, *Jabal to have been the Father of such as dwell in Tents* (9); *i. e.* He was the *Inventer of Tents*, and pitching those moveable Houses in the Fields, for looking after, and depasturing their Cattel in the Desarts and uncultivated World: *Tubal-Cain was an Instructor of every Artificer in Brass and Iron*, or the first that found the Art of *Melting and Malleating* (11) *Metals*, and making them useful for Tools, and other necessary Implements. And his Sister *Naamah*, whose Name is only mention'd, is by some thought to have been the Inventor of *Spinning* and *Cloathing*. Yea the very Art of *Musick* is thus early ascribed to *Jubal*; so indulgent was the Creator to find a means to divert Melancholy, to cheer the Spirits, and to entertain and please Mankind. But for things of no use, or but little Use, or of pernicious Consequence, either they have been much later thought of, and with great Difficulty, and perhaps Danger too, brought to pass; or else they still are, and perhaps will always remain, Exercises of the Wit and Invention of Men.

(8) *Gen. IV. 2.* (9) *v. 20.* (10) *v. 22.*

(11) *Σφυροποιός* the LXX call him. *i. e.* A Worker with an Hammer.

(12) *v. 31.*

Of this we might give divers Instances: in Mathematicks, about squaring the Circle (13); in Mechanicks, (14) about the Art of Flying; and in Navigation, about finding the Longitude. These things,

(13) Altho' the *Quadrature of the Circle* hath in former Ages exercised some of the greatest Mathematical Wits, yet nothing hath been done therein so considerable, as in and since the middle of the last Century; when in the Year 1657 those very ingenious and great Men, Mr. *William Neile*, and My Lord *Brounker* and Sir *Christopher Wren* afterwards, in the same Year, geometrically demonstrated the Equality of some Curves to a strait Line. Soon after which, others at home and abroad did the like in other Curves. And not long afterwards this was brought under an *Anayltical Calculus*: the first Specimen whereof, that was ever publish'd, Mr. *Mercator* gave in 1668, in a Demonstration of my Lord *Brounker's* Quadrature of the *Hyperbola* by Dr. *Wallis's* Infinite Series. But the penetrating Genius of Sir *Isaac Newton* had discovered a Way of attaining the Quantity of all quadrable Curves analytically by his Method of *Fluxions* some time before the Year 1668, as I find very probable from an historical Account in a long Letter of Mr. *Collins*, written in his own Hand, and sent to *Richard Towneley Esq;* of *Lancashire*, whose Papers are in my Hands. In that Letter Mr. *Collins* saith, that in September 1668, Mr. *Mercator* publish'd his *Logarithmotechnia*, one of which he soon sent to Dr. *Barrow*, who thereupon sent him up some Papers of Mr. *Newton's* (now Sir *Isaac*) by which, and former Communications made thereof by the Author, to the Doctor, it appears that the said Method was invented some Years before by the said Mr. *Newton*, and generally applied. And then he goes on to give some Account of the Method, what it performs in the Circle, &c. what Mr. *Gregory* had done in that kind, who intended to publish somewhat in Latin about it, but would not anticipate Mr. *Newton*, the first Inventaer thereof, with much more of this Nature. The Design I find of that indefatigable Promoter of Mathematicks, Mr. *Collins*, was to acquaint Mr. *Towneley* in his Letter with what had been done, and to get the Assistance of that ingenious Gentleman towards the compleating a Body of *Algebra*.

(14) I do not mention here the *perpetual Motion*, which hath exercised the Mechanical Wits for many Ages, because it is a thing impossible, if not a Contradiction; as the before commended Dr. *Clarke* asserts in *Robaul. Phys.* p. 133.

(15) *Grews*

things, altho' some of them in Appearance innocent, yea perhaps very useful, yet remain for the most part secret, not because the Discovery of most of them is more impossible, or difficult than of many other things which have met with a Discovery, nor is it for want of Man's Diligence therein, or his careful Pursuit and Enquiry after them (for perhaps nothing already discovered hath been more eagerly sought after) but with much better Reason (I am sure with greater Humility and Modesty) we may conclude it is, because the infinitely wise Creator and Ruler of the World hath been pleased to lock up these things from Man's Understanding and Invention, for some Reasons best known to himself, or because they might be of ill Consequence, and dangerous amongst Men. As in all probability the Art of Flying would particularly be : an Art which in some Cases might be of good Use, as to the Geographer, and Philosopher ; but in other Respects might prove of dangerous and fatal Consequence ; as for Instance, by putting it in Man's Power to discover the Secrets of Nations and Families, more than is consistent with the Peace of the World for Man to know ; by giving ill Men greater Opportunities to do Mischief, which it would not lie in the Power of others to prevent ; and as one (15) observes, by making Man less sociable. " For upon every true or false Ground of Fear, " or Discontent, and other Occasions, he would " have been fluttering away to some other Place : " and Mankind, instead of cohabiting in Cities, " would, like the Eagle, have built their Nests " upon Rocks.

That

(15) *Gregus Cosmol. Sacr. L. 1. ch. 5. § 25.*

(16) *Nemo*

That this is the true reason of these Matters, is manifest enough from holy Scripture, and Reason (16) also gives it's Suffrage thereto. The Scriptures expressly tell us that *Every good Gift, and every perfect Gift is from above, and cometh down from the Father of Lights.* S. James 1. 17. Solomon, Prov. 2. 6. saith, *The Lord giveth Wisdom: out of his Mouth cometh Knowledge and Understanding.* And Elibu is very exprefs, Job. 32. 8. *But there is a Spirit in Man: and the Inspiration of the Almighty giveth them Understanding* Πνεῦμα παντοκράτειός ἐστιν ἡ διδάσκουσα, as the LXX render it, *The Inspiration, the Afflatus of the Almighty is their Instructor, Mistress or Teacher.* And in Scripture not only the more noble Superiour Acts of Wisdom or Science, but much Inferiour also, bear the Name of Wisdom, Knowledge and Understanding, and are ascribed unto G O D. 'Tis well known that Solomon's Wisdom is wholly ascribed unto G O D: and the Wisdom, and Understanding which G O D is said to have given him, 1 King. 4. 29, is particularly set forth in the following Verses, by his great Skill in moral and natural Philosophy, in Poetry, and probably in Astronomy, Geometry, and such other of the politer Sciences; for which Egypt, and the Eastern Nations were celebrated of old: (17) *And Solomon's Wisdom excelled the Wisdom of all the Children of the East-Countrey, and all the Wisdom of Egypt. For he was wiser than all Men: than Ethan, &c. And he spake*

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(16) *Nemo igitur vir magnus sine aliquo afflatu divino unquam fuit.* Cicer. de nat. Deor. L. 2.

(17) Egypt and some of the Eastern Nations are celebrated for their Skill in polite Literature both in Scripture and prophane Story. Job was of those Parts: so were the Σοφοί and Μάγοι, the Brachmans, and Gymnosophists. Moses and Daniel had their Education in these Parts, and Pythagoras, Democritus, and others travelled into these Parts for the sake of their Learning.

2000 Proverbs: and his Songs were 1005. And he spake of Trees from the Cedar to the Hyssop of the Wall, (i. e. of all sorts of Plants) also of Beasts, Fowl, Creeping-things, and Fishes. So likewise the Wisdom of Daniel and his three Companions is ascribed unto GOD, Dan. 1. 17. As for these four Children, God gavethem Knowledge, and Skill in all Learning and Wisdom, and Daniel had Understanding in all Visions and Dreams. And accordingly in the next Chapter, Daniel acknowledgeth and praiseth God, v. 20. 21. Daniel answered and said, Blessed be the Name of God for ever and ever, for Wisdom and Might are his. — He giveth Wisdom unto the Wise, and Knowledge to them that know Understanding. But not only Skill in the superiour Arts and Sciences, but even in the more inferiour Mechanick Arts, is called by the same Names, and ascribed unto GOD. Thus for the Workmanship of the Tabernacle. Exod. 31. 2. to 6. v. See, I have called by Name Bezaleel. And I have filled him with the Spirit of God, in Wisdom, and in Understanding, and in Knowledge, and in all manner of Workmanship. To devise cunning Works, to work in Gold, Silver, and Brass; and in cutting of Stones, to set them, and in carving of Timber, to work in all manner of Workmanship. So the Spinsters, Weavers, and other Crafts-people, are called Wise-hearted, Exod. 35. 10, 25. and other places. And in Exod. 36. 1. &c. the LORD is said to have put this Wisdom in them, and Understanding to know how to work all these manner of Works for the Service of the Sanctuary. And lastly, to name no more Instances, Hiram the chief Architect of Solomon's Temple, is in 1. King. 7. 14. and 2. Chron. 2. 14. called a cunning Man filled with Wisdom and Understanding, to work in Gold, Silver, Brass, Iron, Stone, Timber, Purple, Blue, fine Linnen, and Crimson; also to grave, and find out every Device which should be put to him.

Thus

Thus doth the Word of God ascribe the Contrivances and Crafts of Men, to the Agency or Influence of the *Spirit* of God upon that of Man. And there is the same Reason for the Variety of *Genii*, or *Inclinations* of Men also ; which from the same Scriptures may be concluded to be a Designation, and Transaction of the same Almighty Governour of the World's Affairs. And who indeed but He could make such a divine Substance, endowed with those admirable Faculties, and Powers as the Rational Soul hath ? a Being to bear the great Creator's Vice-gerency in this lower World ; to employ the several Creatures ; to make use of the various Materials ; to manage the grand Businesses ; and to survey the Glories of all the visible Works of God ! a Creature, without which this lower World would have been a dull, uncouth and desolate kind of Globe ! who I say, or what less than the *Infinite G O D*, could make such a Rational Creature, such a divine Substance as the Soul ! For if we should allow the Atheist any of his nonsensical Schemes, the *Epicurean* his Fortuitous Concourse of Atoms, or the *Cartesian* (18) his created Matter put in Motion, yet with what

(18) Although I charge here the Folly of the Atheist, that perverts the *Cartesian Scheme*, to the maintaining his Atheistical Principles, yet I am far from any way charging the great *Cartes* himself with Atheism ; who, as foreseeing what might be charged upon him, or perversely drawn from his Principles, seems to have taken a particular Care, to let the World know he was far enough from being an Atheist : that in treating of natural things, although for the sake of free Philosophizing, he doth (not deny, but only) exclude the Consideration of *Final Causes*, and of *G O D* the supreme Cause (that being rather the Business of a Christian Divine, than Philosopher ; I say although *Cartes* sets by these things, and, for that Reason chiefly, hath been thought by some to have been a Fautor of Atheism) yet in his *Principia Philosophiæ*, and other of his Works, he hath given sufficient Reason

what tolerable Sense could he, in his Way, produce such a divine, thinking, speaking, contriving Substance as the Soul is ; endowed exactly with such Faculties, Powers, and Dispositions as the various Necessities and Occasions of the World require from such a Creature ? Why should not rather all the Acts, the Dispositions, and Contrivances, of such a Creature as Man (if made in a mechanical Way, and not contrived by God) have been the same ? Particularly why should he not have hit upon all Contrivances of equal Use early as well as many Ages since ? Why not that Man have effected it, as well as this, some thousands of Years after ? Why also should not all Nations, and all Ages (19) improve in every thing as well as

Reason to the Learned World, to believe him to be so far from being an Atheist, that he was rather a Good, as well as Great Man.

(19) For Ages of *Learning* and *Ignorance* we may compare the present, and some of the Ages before the Reformation. The last Century, and the few Years of this, have had the Happiness to be able to vie with any Age for the Number of Learned Men of all Professions, and the Improvements made in all Arts and Sciences ; too many, and too well known to need a Specification.

But for Ignorance we may take the 9th Age, and so down to the Reformation. Even as low as *Q. Elizabeth*, although Learning began to flourish, yet we may guess how Matters stood, even among the Clergy, by her 53 *Injunct.* No. 1559. *Such as are but mean Readers, shall peruse over before, once or twice the Chapters and Homilies, to the intent they may read to the better Understanding of the People, the more Encouragement to Godliness.* Spar. Collect. pag. 82. But this is nothing in Comparison to the Ages before, when the Monk said, *Græcum non est legi*, or as *Espenceus* more elegantly hath it, *Græce nosse suspectum, Hebraice prope Hereticum.* Which Suspicion (said the learned *Hakewill*) *Rhemigius* surely was not guilty of, in commenting upon *diffamatus* 1. *Thef.* 1. 8. who saith that *St. Paul* somewhat improperly put that for *divulgatus*, not being aware that *St. Paul* wrote

as this or that Age or Nation (20) only? Why should the *Greeks*, the *Arabians*, the *Persians*, or the *Egyptians* of old, so far exceed those of the same Nations now? Why the *Africans* and *Americans* so generally ignorant and barbarous, and the *Europeans*, for the most part, polite and cultivated, addicted to Arts and Learning? How could

in Greek, and not in Latin. Nay so great was their Ignorance not only of Greek, but of Latin too, that a Priest baptized in *nomine Patria, & Filia, & Spiritua sancta*. Another suing his Parishioners for not paving his Church, proved it from Jer. 17. *Paveant illi, non paveam Ego*. Some Divines in *Erasmus's* time undertook to prove Hereticks ought to be burnt, because the Apostle said *Hereticum devita*. Two Fryars disputing about a Plurality of Worlds, one proved it from *Annon decem sunt facti mundi?* The other replied, *Sed ubi sunt novem?* And notwithstanding their Service was read in Latin, yet so little was that understood, that an old Priest in *Hen. VIII.* read *Mumpsimus Domine* for *Sumpsimus*: and being admonished of it, He said, he had done so for Thirty Years, and would not leave his old *Mumpsimus* for their new *Sumpsimus*. *Vid. Hakerw. Apol. L. 3. c. 7. Sect. 2.*

(20) *There is (it seems) in Wits and Arts, as in all things besides, a kind of circular Progress: they have their Birth, their Growth, their Flourishing, their Failing, their Fading; and within a while after, their Resurrection, and Reflourishing again. The Arts flourished for a long time among the Persians, the Chaldeans, the Egyptians. ----- But afterwards the Grecians got the Start of them, and are now become as barbarous themselves, as formerly they esteemed all besides themselves to be. About the Birth of Christ, Learning began to flourish in Italy, and spread all over Christendom, till the Goths, Hunns and Vandals ransacked the Libraries, and defaced almost all the Monuments of Antiquity; so that the Lamp of Learning seemed to be put out for near the Space of 1000 Years, till the first Mansor King of Africa and Spain raised up, and spurred forward the Arabian Wits, by great Rewards and Encouragements. Afterwards Petrarch opened such Libraries as were undermined. He was seconded by Boccace, and John of Ravenna, and soon after by Aretine, Philelphus, Valla, &c. And those were followed by Æneas Sylvius, Angelus Politanus,*

could it come to pass that the Use of the Magnet (21); Printing (22), Clocks (23), Telescopes (24), and

litanus, Hermolaus Barbarus, Marsilius Ficinus, and Joh. Picus of Mirandula. These were backed by Rud. Agricola, Reucline, Melancthon, Joach. Camerarius, Wolphlazius, Beat. Rheanus, Almaines: by Erasmus of Rotterdam; Vives, a Spaniard; Bembus, Sadoletus, Eugubinus, Italians: Turnebus, Muretus, Ramus, Pitheus, Budaeus, Amiot, Scaliger, Frenchmen: Sir Tho. More and Linaker, Englishmen. And about this time, even those Northern Nations yielded their great Men; Denmark yielded Olaus Magnus, Holster, Tycho Brahe, and Hemingius; and Poland, Hosius, Frixius, and Crumerus. But to name the Worthies that followed these, down to the present time, would be endless, and next to impossible. See therefore Hakewill's Apolog. L. 3, c. 6. § 2.

(21) Dr. Gilbert the most learned and accurate Writer on the Magnet, shews that it's *Attractive* Vertue was known as early as Plato and Aristotle: but it's *Direction* was a discovery of later Ages. He saith, *Superiori ævo 300 aut 400 labentibus annis, Motus Magneticus in Boream & Austrum repertus, aut ab hominibus rursus recognitus fuit. De Mag. L. 1. c. 1.* But who the happy Inventer of this lucky Discovery was, is not known. There is some, not inconsiderable, Reason, to think our famous Countrey-man, *Rog. Bacon* either discovered, or at least knew of it. But for it's Use in Navigation, Dr. Gilbert saith, *In regno Neapolitano Melphitani omnium primi (uti ferunt) pyxidem instruebant nauticam, — edocti a cive quodam fol. Goia A. D. 1300. ibid.* If the Reader hath a mind to see the Arguments for the Invention, being as old as Solomon's or *Plautus's* time, or of much younger date, he may consult *Hakewill. ib. c. 10. § 4.* or *Purchas Pilgr. L. 1. c. 1. § 1.*

As to the Magnetick Variation, Dr. Gilbert attributes the Discovery of it to *Sebastian Cabott*. And the Declination, or Dipping of the Needle, was the Discovery of our ingenious *Rob. Norman*. And lastly, the Variation of the Variation was first found out by the ingenious Mr. *H. Gellibrand* Astron. Prof. of *Gresham-Col.* about 1634. *Vid. Gellibr. Disc. Math. on the Variat. of the Magn. Need. and its Variat. Anno 1635.*

To these Discoveries, I hope, the Reader will excuse me if I add one of my own which I deduced some Years ago from some magnetical Experiments and Observations I made; which

which Discovery I also acquainted our Royal-Society with some time since, viz. That as the common, horizontal Needle is continually varying towards the E. and W. so is the Dipping-Needle varying up and down, towards or from-wards the Zenith, with the magnetick Tendency describing indeed a Circle round the Pole of the World, as I conceive or some other point. So that if we could procure a Needle so nicely made, as to point exactly according to it's magnetick Direction, it would, in some certain Number of Years, describe a Circle of about 13 gr. Radius round the magnetick Poles Northerly and Southerly. This I have for several Years suspected, and have had some Reason for it too, and three or four Years agoe mentioning it at a Meeting of our Royal-Society, they were pleased to cause it to be entered in the Journals: but I have not yet been so happy to procure a tolerably good Dipping-Needle, or other proper one to my Mind, to bring the thing to sufficient Test of Experience; as in a short time I hope to do, having lately hit upon a Contrivance that may do the thing.

(22) It is uncertain who was the Inventer of the Art of Printing, every Historian ascribing the Honour thereof to his own City or Country. Accordingly some ascribe the Invention of it to *John Guttenberg* a Knight of *Argentine* about 1440, and say that *Faustus* was only his Assistant. *Bertius* ascribes it to *Laurence John* of *Haerlem*, and saith *Fust* or *Faust* stole from him both his Art and Tools. And to name no more, some attribute it to *John Fust* or *Faust* and *Peter Schoeffer* (called by *Fust* in some of his *Imprimaturs*, *Pet. de Gernesheim puer meus*.) But there is now to be seen at *Haerlem* a Book or two printed by *Laur. Koster* before any of these, viz. in 1430 and 1432 (See *Mr. Ellis's Letter to Dr. Tyson in Phil. Transf.* No. 286.) But be the first Inventer who it will, there is however great Reason to believe, that the Art recieved great Improvements from *Faust* and his Son in Law *Schoeffer*; the latter being the Inventer of metalline Types, which were cut in Wood before, first in whole Blocks, and afterwards in single Types or Letters. See my learned Friend *Mr. Wanley's* Observations in *Philos. Transf.* No. 288 and 310.

(23) Concerning the Antiquity and Invention of Clocks and Clock-work, I refer the Reader to a little Book, called the *Artificial Clock-maker*. Ch. 6. Where there is some Account of the Ancients Inventions in Clock-work, as *Archimedes's Sphere*, *Ctesibius's Clock*, &c.

(24) The Invention of Telescopes, *Hieron. Syrturus* gives this Account of, *Prodiit Anno 1609 seu Genius, seu alter*
vir

and an hundred things besides should escape the Discovery of *Archimedes*, *Anaximander*, *Anaximenes*, *Posidonius*, or other great Virtuoso's of the early Ages, whose Contrivances of various Engines, Spheres, Clepsydræ and other curious Instruments are recorded (25)? And why cannot the

vir adhuc incognitus, Hollandi specie, qui Middleburgi in Zeelandia convenit Joh. Lippersein ———— Fuit perspicilla plura tam cava quam convexa, confici. Condicto die rediit, absolutum opus cupiens, atque ut statim habuit præ manibus, bina suscipiens, cavum scilicet & convexum, unum & alterum oculo admovebat, & sensim dimovebat, sive ut punctum concursus, sive ut artificis opus probaret, postea abiit. Artifex, ingenii minime expers, & novitatis curiosus, coepit idem facere & imitari, &c. Vid. Mus. Worm. L. 4. c. 7.

(25) Among the curious Inventions of the Antient, *Archytas's Dove* was much famed: of which *Aul. Gellius* gives this Account, *Scripserunt Simulachrum Columbe e ligno ab Archyta ratione quadam disciplinaque mechanica factum, volasse. Ita erat scilicet libramentis suspensum, & aura spiritus inclusa atque occulta concitum. Noct. Attic. L. 10. c. 12.* The same eminent Pythagorean Philosopher (as *Favorinus* in *Gellius* calls him) is by *Horace* accounted a notable Geometrician too, *Te maris et terræ, numeroque carentis arene Mensorem Archyta.* Among the rest of his Inventions *Children's Rattles* are ascribed to him. *Aristotle* calls them *Ἀρχυτῆ πλαταγῇ*. *Polit. 8. i. c. Archytas's Rattle.* And *Diogenianus* the Grammarian gives the Reason of his Invention, *Ἀρχυτῆ πλαταγῇ ἐπὶ τῶν &c.* That *Archytas's Rattle* was to quiet Children; for he having Children contrived the Rattle, which he gave them to prevent their [tumbling, *ἀσυλεύσῳσι*] other things about the House.

To these Contrivances of *Archytas* we may add *Regiomontanus's Wooden Eagle*, which flew forth of the City aloft in the Air, met the Emperor a good Way off, coming towards it, and having saluted him, returned again, waiting on him to the City Gates. Also his *Iron-fly*, which at a Feast flew forth of his Hands, and taking a Round, returned thither again. *Vid. Hakewill ub. sup. c. 10. §. 1.*

As to other Inventions of the Antients, such as of Letters, Bricks and Tiles and Building Houses, with the Saw, Rule and Plumbet, the Lath, Augre, Glue, &c. also the making

the present or past Age, so eminent for polite Literature, for Discoveries and Improvements in all curious Arts and Busineses (perhaps beyond any known Age of the World, why cannot it, I say) discover those hidden *Quæsitæ*, which may probably be reserved for the Discovery of future, and less learned Generations?

Of these Matters no satisfactory Account can be given by any mechanical Hypothesis, or any other way, without taking in the Superintendence

Brass, Gold, and other Metals; the Use of Shields, Swords, Bows, and Arrows, Boots, and other Instruments of War; the Pipe, Harp, and other musical Instruments; the building of Ships, and Navigation, and many other things besides; the Inventers of these (as reported by ancient Heathen Authors, may be plentifully met with in *Plin. Nat. Hist. L. 7. c. 56.*)

But in this Account of *Pliny*, we may observe whence the Ancients (even the *Romans* themselves in some Measure) had their Accounts of these Matters, viz. from the fabulous *Greeks*, who were fond of ascribing every thing to themselves. *The Truth is* (saith the most learned Bishop *Stillingfleet*) *there is nothing in the World useful or beneficial to Mankind, but they have made a Shift to find the Author of it among themselves. If we enquire after the Original of Agriculture, we are told of Ceres and Triptolemus; if of Pasturage, we are told of an Arcadian Pan; if of Wine, we presently hear of a Liber Pater; if of Iron Instruments, then who but Vulcan? if of Musick, none like to Apollo. If we press them then with the History of other Nations, they are as well provided here: if we enquire an account of Europe, Asia, or Libya; for the first we are told a fine Story of Cadmus's Sister; for the second of Prometheus's Mother of that Name; and for the third of a Daughter of Epaphus. And so the learned Author goes on with other particular Nations, which they boasted themselves to be the Founders of. Only the grave Athenians thought Scorn to have any Father assigned them, their only Ambition was to be accounted Aborigines & genuini Terra.* But the Ignorance and Vanity of the Greek History, that learned Author hath sufficiently refuted. *Vid. Stilling. Orig. Sacr. Part. 1. B. 1. Ch. 4.*

dence of the great Creator and Ruler of the World : who oftentimes doth manifest himself in some of the most considerable of those Works of Men, by some remarkable Transactions of his Providence, or by some great Revolution or other happening in the World thereupon. Of this I might instance in the Invention of Printing (26), succeeded first by a Train of Learned Men, and the Revival of Learning, and soon after that by the Reformation, and the much greater Improvements of Learning at this Day. But the most considerable Instance I can give is, the Progress of Christianity by means of the civilized Disposition, and large Extent of the *Roman Empire*. The later of which, as it made way for human Power ; so the former made way for our most excellent Religion into the Minds of Men. And so I hope, and earnestly pray, that the Omnipotent and Allwise Ruler of the World will transact the Affairs of our most holy Religion ere it be long in the Heathen World ; that the great Improvements made in the last, and present Age, in Arts and Sciences, in Navigation and Commerce, may be a means to transport our Religion as well as Name, through all the Nations of the Earth. For we find that our Culture of the more polite and curious Sciences, and our great Improvements in even the mechanick Arts, have already made

(26) Whether Printing was invented in 1440, as many imagine, or was sooner practised, in 1430 or 1432, as Mr. *Ellis's* Account of the Dutch Inscription in *Phil. Transf.* No. 286. doth import ; it is however manifest, how great an Influence (as it was natural) this Invention had in the promoting of Learning soon afterwards, mentioned before in Note 20. After which followed the Reformation about the Year 1517.

made a Way for us into some of the largest and farthest distant Nations of the Earth ; particularly into the great Empire of *China* (27).

And now before I quit this Subject, I cannot but make one Remark, by way of practical Inference from what hath been last said ; and that is, Since it appears that the Souls of Men are ordered, disposed and actuated by God, even in secular, as well as spiritual, Christian Acts ; a Duty ariseth therefrom on every Man, to pursue the Ends, and answer all the Design of the divine Providence in bestowing his Gifts and Graces upon him. Men are ready to imagine their Wit, Learning, Genius, Riches, Authority, and such like, to be Works of Nature, things of Course, or owing to their own Diligence, Subtilty, or Secondary Causes ; that they are Masters of them, and at Liberty to use them as they please, to gratify their Lust or Humor, and satisfy their depraved Appetites. But it is evident, that these things

(27) The *Chinese* being much addicted to Judicial Astrology, are great Observers of the Heavens, and the Appearances in them. For which Purpose they have an *Observatory* at *Pekin*, and Five Mathematicians appointed to watch every Night ; Four towards the four Quarters of the World, and One towards the Zenith, that nothing may escape their Observation. Which Observations are the next Morning brought to an Office to be registred. But notwithstanding this their Diligence for many Ages, and that the Emperor hath kept in his Service above 100 Persons to regulate the *Kalendar*, yet are they such mean Astronomers, that they owe the Regulation of their *Kalendar*, the Exactness in calculating Eclipses, &c. to the *Europeans* ; which renders the *European* Mathematicians so acceptable to the Emperor, that *Father Verbiest*, and divers others, were not only made Principals in the Observatory, but put into Places of great Trust in the Empire, and had the greatest Honours paid them at their Deaths. Vid. *La Comte Mem. of China*. Letter 2d. &c.

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cited, Matt. 25. 21. *Well done thou good and faithful Servant, thou hast been faithful over a few things, I will make thee Ruler over many things, enter thou into the Joy of thy Lord.* Since now the Case is thus, let us be persuaded to follow Solomon's Advice, Eccles. 9. 10. *Whatsoever thy Hand findeth to do, do it with thy Might* (29): "lay hold on every Oc-
 " cation that presents itself, and improve it with
 " the utmost Diligence; because now is the time
 " of Action, both in the Employments of the
 " Body, and of the Mind; now is the Season
 " of studying either Arts and Sciences, or Wis-
 " dom and Vertue, for which thou wilt have no
 " Opportunities in the Place whither thou art
 " going, in the other World. *For there is no Work
 " nor Device, nor Knowledge, nor Wisdom in the Grave
 " whither thou goest.*

CHAP. II.

Of Man's BODY, particularly it's POSTURE.

HAVING thus, as briefly as well as I could, surveyed the *Soul*, let us next take a View of *Man's Body*. Now here we have such a Multiplicity of the most exquisite Workmanship, and of the best Contrivance, that if we should strictly survey the Body from Head to Foot, and search only into the known Parts, (and many more lie undiscovered) we should find too large and tedious a Task to be dispatched. I shall therefore have time only to take a Transient, and general kind

(29) *Bishop Patrick in loc.*

kind of View of this admirable Machine, and that somewhat briefly too, being prevented by others, particularly two excellent Authors of our own (1), who have done it on the same Account as my self. And the

1. Thing that presents itself to our View, is the *Erect Posture* (2) of Man's Body : which is far the most, if not the only commodious Posture for a Rational Creature, for him that hath Dominion over the other Creatures, for one that can invent useful things, and practise curious Arts. For without this *Erect Posture*, he could not have readily turned himself to every Business, and on every Occasion. His Hand (3) particularly could
not

(1) *Mr. Ray in his Wisdom of God manifested in the Works Creation Part 2d. and Dr. Cockburn Essays Faith. Part. 1. Essay 5.*

(2) *Ad hanc providentiam Natura tam diligentem [of which he had been before speaking] tamque solertem adjungi multa possunt, e quibus intelligatur, quanta res hominibus a Deo, quamque eximia tributa sunt : qui primum eos humo excitatos, celsos & erectos constituit, ut Deorum cognitionem, cælum intueutes, capere possent. Sunt enim e terra homines non ut incolæ, atque habitatores, sed quasi spectatores superarum rerum, atque cælestium, quarum spectaculum ad nullum aliud genus animantium pertinet. Cic. de Nat. Deor. L. 2.*

(3) *Ut autem sapientissimum animalium est Homo, sic & Manus sunt organa sapienti animali convenientia. Non enim quia Manus habuit, propterea est sapientissimum, ut Anaxagoras dicebat ; sed quia sapientissimum erat, propter hoc Manus habuit, ut rectissime censuit Aristoteles. Non enim Manus ipsæ hominem artes docuerunt, sed Ratio. Manus autem ipsæ sunt artium organa, &c. Galen. de Us. Part. L. 1. c. 3. After which in the rest of this first Book, and part of the second, he considers the Particulars of the Hand, in order to enquire, as he saith ch. 5. Num eam omnino Constitutionem habeat [manus] qua meliorem aliam habere non potuit ?*

Of this Part, (and indeed of the other Parts of human Bodies) he gives so good an Account, that I confess I could not but admire the Skill of that ingenious and famed Hea-

not have been in so great Readiness to execute the Commands of the Will, and Dictates of the Soul. His Eyes would have been the most prone, and incommodiously situated of all Animals; but by this Situation, he can cast his Eyes upwards, downwards, and round about him: he hath a glorious Hemisphere of the Heavens (4), and an ample Horizon on Earth (5) to entertain his Eye.

And

then. For an Example, (because it is a little out of the Way) I shall pitch upon his Account of the different Length of the Fingers, L. 1. c. 24. The Reason of this Mechanism, he saith, is, That the Tops of the Fingers may come to an Equality, *cum magnas aliquas moles in circuitu comprehendunt, & cum in seipsis humidum vel parvum corpus continere conantur.* — Apparent vero in unam circuli circumferentiam convenire Digiti quinque in actionibus hujusmodi, maxime quando exquisite sphericum corpus comprehendunt. And this Evenness of the Fingers Ends, in grasping Spherical, and other round Bodies, he truly enough saith, makes the Hold the firmer. And it seems a noble and pious Design he had in so strictly surveying the Parts of Man's Body, which take in his own translated Words, *Cum multa namque esset apud veteres, tam Medicos, quam Philosophos de utilitate particularum dissentio (quidam enim corpora nostra nullius gratia esse facta existimant, nullaue omnino arte; alii autem & alicujus gratia, & artificiose, —) primum quidem tanta hujus dissentionis ~~rectior~~ invenire studui: deinde vero & unam aliquam universalem methodum constituere, qua singularum partium corporis, & eorum quæ illis accidunt, utilitatem invenire possemus.* Ibid. cap. 8.

- (4) *Pronaque cum spectant animalia cætera terram
Os Homini sublime dedit, cælumque tneri
Fussit, & erectos ad sidera tollere vultus.*

Ovid. Metam. L. 1. car. 84.

(5) If any should be so curious to desire to know how far a Man's Prospect reacheth by means of the Height of his Eye, supposing the Earth was an uninterrupted Globe, the Method is a common Case of Right angled plain Triangles; where two Sides, and an opposite Angle are given. Thus in Fig. 4. *AHB* is the Surface, or a great Circle of the terraqueous Globe: *C* the Center, *HC* it's Semidiameter; *E* the Height of the Eye: and forasmuch as *HE* is a Tangent, therefore the Angle at *H* is a Right-angle. So that

that there are given HC 3967,737 Miles, or 20949655 English Feet (according to B. II. Ch. 2. Note 1.) CE the same Length with the Height of the Eye on the Mast of a Ship, or at only a Man's Height, &c. added to it : and EC the opposite Right-Angle. By which three Parts given, it is easy to find all the other Parts of the Triangle. And first the Angle at C , in order to find the Side HE , the Proportion is, As the Side CE , to the Angle at H :: So the Side HC , to the Angle at E , which being subtracted out of 90 gr. the Remainder is the Angle at C . And then, As the Angle at E is to it's opposite Side HC , or else, As the Angle at H is to it's opposite Side CE :: So the Angle at C to its opposite Side EH , the visible Horizon. Or the Labour may be shortned, by adding together the Logarithm of the Sum of the two given Sides, and the Logarithm of their Difference : the Half of which two Logarithms, is the Logarithm of the Side required, nearly. For an Example we will take the two Sides in Yards, by Reason scarce any Tables of Logarithms will serve us farther. The Semidiameter of the Earth is 6983218 : the Height of the Eye is 2 Yards more, the Sum of both 13966438.

Logar. of which sum is	7.1450856
Logar. of 2 Yards (the Differ.) is	0.3010300
Sum of both Logar.	<u>7.4461156</u>
The Half Sum	3.7230578

is the Logar. of 5285 Yards = 3 Miles, which is the Length of the Line EH , or Distance the Eye can reach at 6 Feet Height.

This would be the Distance, on a perfect Globe, did the visual Rays come to the Eye in a strait Line. But by means of the Refractions of the Atmosphere, distant Objects on the Horizon appear higher than really they are, and may be seen at a greater Distance, especially on the Sea ; which is a Matter of great Use, especially to discover at Sea the Land, Rocks, &c. and it is a great Act of the divine Providence in the Contrivance and Convenience of the Atmosphere, which by this means enlargeth the visible Horizon, and is all one as if the terraqueous Globe was much larger than really it is. As to the Height of the Apparent above the true Level, or how much, distant Objects are raised by the Refractions, the ingenious and accurate Gentlemen of the *French Academy-Royal* have given us a Table in their *Measure of the Earth* ; Art. 12.

And as this Erection of Man's Body is the most compleat Posture ; so if we survey the Provision made for it, we find all done with manifest Design, the utmost Art and Skill being employed therein. To pass by the particular Conformation of many of the Parts, the Ligaments and Fastnings to answer this Posture, as the Fastning, for instance, of the *Pericardium* to the *Diaphragm* (which is peculiar to Man (6) I say passing by a deal of this Nature, manifesting this Posture to be an Act of Design) let us stop a little at the curious Fabrick of the Bones, those Pillars of the Body. And how artificially do we find them made, how curiously placed from the Head to Foot ! The *Vertebræ* of the Neck and Back Bone (7) made short and complanated, and firmly braced with Muscles and Tendons, for easy Incurvations of the Body, but withal for greater Strength, to support the Body's own Weight, together with other additional Weights it may have Occasion to bear. The *Thigh-Bones* and Legs long, and strong, and every way well fitted for the Motion of the Body. The *Feet* accomodated with a great Number of Bones, curiously and firmly tacked together (to which must be added the ministry of the Muscles (8) to answer all the Motions

(6) See Book 6. Ch. 5. Note 7.

(7) See Book 4. Ch. 8. Note 2.

(8) The Mechanism of the Foot would appear to be wonderful, if I should descend to a Description of all parts : but that would be too long for these Notes : therefore a brief Account (most of which I owe to the before commended Mr. *Chefelden*) may serve for a Sample. In the first Place, it is necessary the Foot should be concave, to enable us to stand firm, and that the Nerves and Blood-Vessels may be free from Compression when we stand or walk. In order hereunto the long *Flexors* of the Toes cross one another at the

tions of the Legs and Thighs, and at the same time to keep the Body upright, and prevent it's falling, by readily assisting against every Vacillation thereof, and with easy and ready Touches keeping the *Line of Innixion*, and *Center of Gravity* in due Place and Posture (9).

And as the Bones are admirably adapted to prop, so all the Parts of the Body are as incomparably placed to poise it. Not one Side too heavy for the other, but all in nice *Æquipoise*: the Shoulders, Arms, and Sides *æquilibrated* on one Part; on the other Part the *Viscera* of the Belly counterpoised with the Weight of the Scapular part, and that useful Cushion of Flesh behind.

And lastly, to all this we may add the wonderful Concurrence, and ministry of the prodigious Number and Variety of Muscles, placed throughout the Body for this Service: that they should so readily answer every Posture, and comply with every Motion thereof, without any previous Thought

the Bottom of the Foot, in the Form of a *St. Andrew's Cross*, to incline the lesser Toes towards the great One, and the great One towards the lesser. The *short Flexors* are chiefly concerned in drawing the Toes towards the Heel. The *Transversalis Pedis* draws the Outsides of the Foot towards each other; and by being inserted into one of the *Sesamoid Bones* of the great Toe, diverts the Power of the *Abductor Muscle* (falsely so called) and makes it become a *Flexor*. And lastly the *Peroneus longus* runs round the outer Ankle, and obliquely forwards cross the Bottom of the Foot, and at once helps to extend the *Tarsus*, to constrict the Foot, and to direct the Power of the other *Extensors* towards the Ball of the great Toe. Hence the Loss of the *Great Toe* is more than of all the other Toes. See also *Mr. Cowper's Anat. Tab. 28. &c.*

(9) It is very well worth while to compare here what *Borelli* saith *de motu Animal. Par. 1. cap. 18. de statione Animal. Prop. 132. &c.* to which I refer the Reader, it being too long to recite here,

Thought or Reflex act, so that (as the excellent *Borelli* (10) saith) “ It is worthy of Admiration, “ that in so great a Variety of Motions, as running, leaping, and dancing, Nature’s Laws “ of *Æquilibration* should always be observed; “ and when neglected, or wilfully transgressed, “ that the Body must necessarily and immediately tumble down.

C H A P. III.

Of the FIGURE and SHAPE of Man's BODY.

THE Figure and Shape of Man's Body is the most commodious that could possibly be invented for such an Animal; the most agreeable to his Motion, to his Labours, and all his Occasions. For had he been a Rational Reptile, he could not have moved from Place to Place fast enough for his Business, nor indeed have done any almost. Had he been a Rational Quadrupede, among other things, he had lost the Benefit of his Hands, those noble Instruments of the most useful Performances of the Body. Had he been made a Bird, besides many other great Inconveniences, those before mentioned of his Flying, would have been some. In a Word, any other Shape of Body, but that which the Allwise Creator hath given Man, would have been as incommodious, as any Posture but that of Erect: it would have rendered him more helpless, or have put it in his Power to have been more pernicious, or deprived him of ten thousand Benefits, or

Plea-

(10) *Borel. ibid. Prop. 142.*

Pleasures, or Conveniences, which his present Figure capacitates him for.

C H A P. IV.

Of the STATURE and SIZE of Man's BODY.

AS in the Figure, so in the Stature and Size of Man's Body, we have another manifest Indication of excellent Design. Not too Pygmean (1), nor too Gigantick (2), either of which Sizes would in some particular or other, have been incommodious to Himself, or to his Business, or to the rest of his fellow Creatures. Too Pygmean would have rendered him too puny a Lord of the Creation, too impotent and unfit to manage the inferiour Creatures, would have exposed him to the Assaults of the weakest Animals, to the ravening Appetite of voracious Birds, and have put him in the Way, and endangered his being trodden in the Dirt by the larger Animals. He would have been also too weak for his Business, unable to carry Burdens, and in a Word to transact the greater Part of his Labours and Concerns.

And on the other Hand, had Man's Body been made too monstrously strong, too enormously
Gigan-

(1) What is here urged about the Size of Man's Body, may answer one of *Lucretius's* Reasons why *Nil ex nihilo gignitur*. His Argument is

*Denique cur Homines tantos natura parare
Non potuit, pedibus qui pontum per vada possent
Transire, & magnos manibus divellere montes?*

Lucret. L. 1. Car. 200.

(2) *Haud facile fit ut quisquam & ingentes corporis vires,
& ingenium subtile habeat.* *Diodor. Sic. L. 17.*

(3)

Gigantick (3), it would have rendered him a dan-

(3) Although we read of *Giants* before *Noah's Flood*, *Gen.* 6. 4. and more plainly afterwards in *Num.* 13. 33. Yet there is great reason to think the size of Man was always the same from the Creation. For as for the *Nephilim* or *Giants*, in *Gen.* 6, the Ancients vary about them: some taking them for great Atheists, and Monsters of Impiety, Rapine, Tyranny, and all Wickedness, as well as of monstrous Stature, according as indeed the Hebrew signification allows.

And as for the *Nephilim* in *Num.* 13. which were evidently Men of a Gigantick Size, it must be considered, that it is very probable, the Fears and Discontent of the Spies, might add somewhat thereunto.

But be the Matter as it will, it is very manifest, that in both these Places, *Giants* are spoken of as Rarities, and Wonders of the Age, not of the common Stature. And such Instances we have had in all Ages; excepting some fabulous Relations: such as I take to be that of *Theutobocchus*, who is said to have been dug up, *Anno* 1613, and to have been higher than the Trophies, and 26 feet long; and no better I suppose the *Giants* to have been, that *Ol. Magnus* gives an account of in his 5th Book, such as *Hartben*, and *Starchaten*, among the Men; and among the Women, *reperta est* (saith he) *puella* — *in capite vulnerata, ac mortua, induta chlamyde purpurea, longitudinis cubitorum 50, latitudinis inter humeros quatuor.* *Ol. Mag. Hist. L. 5. c. 2.*

But as for the more credible Relations of *Goliath* (whose Height was 6 Cubits and a Span, *1 Sam.* 17. 4. which according to the present Curious and Learned Lord Bishop of *Peterborough*, is somewhat above 11 feet English. *vid. Bishop Cumberland of Jewish Weights and Measures.*) of *Maximinus* the Emperor, who was 9 feet high, and others in *Augustus*, and other Reigns, of about the same height; to which we may add the Dimensions of a *Skeleton*, dug up lately in the place of a *Roman Camp* near *St. Albans*, by an Urn inscribed, *Marcus Antoninus*; of which an account is given by Mr. *Cbeselden*, who judgeth by the Dimensions of the Bones, that the Person was 8 foot high. *vid. Philos. Transact. No. 333.* these antique Examples and Relations, I say, we can match, yea out-do, with modern Examples; of which we have divers in *J. Ludolph. Comment. in Hist. Æthiop. L. 1. c. 2. §. 22.* *Magus, Conringius, Dr. Hakerwill*, and others. Which latter relates, from *Nannez*, of Porters and Archers belonging to the Emperor of *China*, of 15 feet high; and others from

Purchas

Purchas of 10 and 12 feet high, and more ; see in the learned Authors Apolog. p. 208.

These indeed exceed what I have seen in *England* ; but in 1684, I measur'd an *Irish* Youth, said to be not 19 Years old, who was 7 feet near 8 Inches ; and in 1697, a Woman who was 7 feet 3 Inches in height.

But for the ordinary Size of Mankind, in all probability, it was always (as I said) the same, as may appear from the Monuments, Mummies, and other ancient Evidences to be seen at this day. The most ancient Monument at this day I presume is that of *Cheops*, in the first and fairest Pyramid of *Egypt* ; which was, no doubt, made of capacity every way sufficient to hold the Body intended to be laid up in it. But this we find, by the nice Measures of our curious Mr. *Greaves*, hardly to exceed our common Coffins. *The hollow part within* (saith he) *is in length only 6,488 feet, and in breadth, but 2,218 feet : The depth, 2,860 feet. A narrow space, yet large enough to contain a most potent and dreadful Monarch, being dead ; to whom living, all Ægypt was too streight and narrow a Circuit. By these Dimensions, and by such other Observations, as have been taken by me from several embalmed Bodies in Ægypt, we may conclude there is no decay in Nature (though the Question is as old as Homer) but that the Men of this Age are of the same Stature they were near 3000 Years ago.* vid. *Greaves* of the Pyr. in 1638. in *Rays Collect. of Trav.* Tom. 2. pag. 118.

To this more Ancient, we may add others of a later date. Of which take these, among others, from the Curious and Learned *Hakewill*. The Tombs at *Pisa*, that are some thousand Years old, are not longer than ours : so is *Athelstanes* in *Malmesbury* Church ; so *Sehba's* in *St. Paul's* of the Year, 693 ; so King *Ethelred's*, &c. Apol. p. 219, &c.

The same evidence we have also from the Armour, Shields, Vessels, and other Utensils dug up at this day. The brass Helmet dug up at *Metaurum*, which was not doubted to have been left there at the overthrow of *Asdrubal*, will fit one of our Men at this day.

Nay besides all this probable, we have some more certain Evidence, *Augustus* was 5 Foot 9 Inches high, which was the just Measure of our famous Queen *Elizabeth*, who exceeded his Height 2 Inches, if proper Allowance be made for the Difference between the Roman and our Foot. Vid. *Hake. ib.* p. 215.

dangerous Tyrant in the World, too strong (4) in some Respects, even for his own kind, as well as the other Creatures. Locks and Doors might per-

(4) To the Stature of Men in the foregoing Note, we may add some Remarks about their unusual *Strength*. That of *Sampson* (who is not said to have exceeded other Men in Stature as he did in Strength) is well known. So of old, *Hector*, *Diomedes*, *Hercules*, and *Ajax* are famed: and since them many others: for which I shall seek no farther than the before commended *Hakewill*, who by his great and curious Learning, hath often most of the Examples that are to be met with on all his Subjects he undertakes. Of the after-Ages he names *C. Marius*, *Maximinus*, *Aurelian*, *Scanderberge*, *Bardefin*, *Tamerlane*, *Ziska*, & *Hunniades*. Anno 1529. *Klunber* Provost of the great Church at *Misnia*, carried a Pipe of Wine out of the Cellar, and laid it in the Cart. *Mayolus* saw one hold a Marble Pillar in his Hand 3 Foot long, and one Foot diameter, which he tost up in the Air, and caught again, as if 'twas a Ball. Another of *Mantua*, and a little Man, named *Rodamas*, could break a Cable, &c. *Ernaudo Burg* fetched up Stairs an Ass laden with Wood, and threw both on the Fire. At *Constantinople* Anno 1582 one lifted a Piece of Wood, that twelve Men could scarce raise: then lying along, he bare a Stone that ten Men could but just roll to him. *G. of Fronsberge Baron Mindleheim* could raise a Man off his Seat, with only his middle Finger; stop an Horse in his full Career; and shove a Cannon out of it's Place. *Cardan* saw a Man dance with two Men in his Arms, two on his Shoulders, and one on his Neck. *Potacoua* Captain of the *Cossacks* could tear an Horse-shoe (and if I mistake not, the same is reported of the present King *Augustus* of Poland.) A Gigantick Woman of the *Netherlands* could lift a Barrel of *Hamburg* Beer. Mr. *Carew* had a Tenant that could carry a But's length, 6 Bushel of wheaten Meal (of 15 Gallon Measure) with the Lubber, the Miller, of 24 Years of Age, on the Top of it. And *J. Roman* of the same County could carry the Carcass of an Ox. Vid. *Hakewill* ib. p. 238.

Viros aliquot moderna memoria tam a mineralibus, quam aliis Sueviae, & Gothiae provinciis adducere congruit, tanta fortitudine praeditos, ut quisque eorum in humeros sublevatum Equum, vel Bovem maximum, imo vas ferri 600, 800, aut 1000 librarum (quale & aliqua Puella levare possunt) ad plura Radia portaret. Ol. Mag. ubi supr.

perhaps have been made of sufficient Strength to have barricaded our Houses ; and Walls, and Ramparts might perhaps have been made strong to have fenced our Cities. But these things could not have been without a great and inconvenient Expence of Room, Materials, and such Necessaries, that such vast Structures and Uses would have occasioned, more perhaps than the World could have afforded to all Ages and Places. But let us take the Descant of a good Naturalist and Physician on the Case (5), “ Had Man been
“ a Dwarf (saith he) he had scarce been a Reasonable Creature. For he must then have had
“ a Jolt Head ; so there would not have been
“ Body and Blood enough to supply his Brain
“ with Spirits ; or he must have had a small
“ Head, answerable to his Body, and so there
“ would not have been Brain enough for his Business — Or had the Species of Mankind been
“ Gigantick, he could not have been so commodiously supplied with Food. For there would
“ not have been Flesh enough of the best edible
“ Beasts, to serve his Turn. And if Beasts had
“ been made answerably bigger, there would
“ not have been Grass enough. And so he goeth on. And a little after, “ There would not have
“ been the same Use and Discovery of his Reason ; in that he would have done many things
“ by meer Strength, for which he is now put to
“ invent innumerable Engines. — Neither
“ could he have used an Horse, nor divers other
“ Creatures. But being of a middle Bulk, he
“ is fitted to manage and use them all. For (saith
“ he) no other Cause can be assigned why a Man
“ was

(5) *Greaves Cosmol. Sacr.* B. 1. ch. 5. §. 25.

“ was not made five or ten times bigger, but his
 “ Relation to the rest of the Universe. Thus far
 our curious Author.

C H A P. V.

Of the STRUCTURE of the PARTS of Man's Body.

HAVING thus taken a View of the Posture, Shape, and Size of Man's Body, let us in this Chapter survey the Structure of it's Parts. But here we have so large a Prospect, that it would be endless to proceed upon Particulars. It must suffice therefore to take Notice, in general only, how artificially every Part of our Body is made. No Botch, no Blunder, no unnecessary *Apparatus* (or in other Words) no Signs of Chance (1); but every thing curious, orderly, and performed in the shortest and best Method, and adapted to the most compendious Use. What one Part is there throughout the whole Body, but what is composed of the fittest Matter for that Part;

(1) It is manifestly an argument of Design, that in the Bodies of different Animals, there is an agreement of the Parts, so far as the Occasions and Offices agree, but a difference of those where there is a difference of these. In an humane Body are many Parts agreeing with those of a Dog for instance, but in his Forehead, Fingers, Hand, Instruments of Speech, and many other Parts, there are Muscles and other Members which are not in a Dog. And so contrariwise in a Dog, what is not in Man. If the Reader is minded to see what particular Muscles are in a Man, that are not in a Dog; or in a Dog that are not in an humane Body, let him consult the curious and accurate Anatomist, Dr. Douglass's *Myogr. compar.*

Part ; made of the most proper Strength and Texture ; shaped in the compleatest Form ; and in a Word, accourer'd with every thing necessary for it's Motion, Office, Nourishment, Guard, and what not ! What so commodious a Structure and Texture could have been given to the Bones, for Instance, to make them firm and strong, and withal light, as that which every Bone in the Body hath ? Who could have shaped them so nicely to every Use, and adapted them to every Part, made them of such just Lengths, given them such due Sizes and Shapes, channelled, hollowed, headed, lubricated, and every other thing ministering in the best and most compendious manner to their several Places and Uses ? What a glorious Collection and Combination have we also of the most exquisite Workmanship and Contrivance in the Eye, in the Ear, in the Hand (2), in the Foot (3), in the Lungs, and other Parts already mentioned ? What an Abridgment of Art, what

a

(2) *Galen* having described the Muscles, Tendons, and other parts of the Fingers, and their Motion, crys out, *Considera igitur etiam hic mirabilem CREATORIS sapientiam. De Us. Part. L. I. c. 18.*

(3) And not only in the Hand, but in his account of the Foot (L. 3.) he frequently takes notice of what he calls *Artem, Providentiam & Sapientiam Conditoris*. As Ch. 13. *An igitur non æquum est hic quoque admirari Providentiam Conditoris, qui ad utrumque usum, etsi certe contrarium, exacte convenientes & consentientes invicem fabricatus est totius membri [tibiæ] particulas ?* And at the end of the Chap. *Quod si omnia quæ ipsarum sunt partium mente immutaverimus, neque invenerimus positionem aliam meliorem ea, quam nunc sortita sunt, neque figuram, neque magnitudinem, neque connexionem, neque (ut paucis omnia complectar) aliud quidquam eorum, quæ corporibus necessario insunt, perfectissimam pronunciare oportet, & undique recte constitutam præsentem ejus constructionem.* The like also concludes. Ch. 15.

a Variety of Uses (4) hath Nature laid upon that one Member the Tongue, the grand Instrument of Taste, the faithful Judge, the Centinel, the Watchman of all our Nourishment, the artful Modulator of our Voice, the necessary Servant of Mastication, Swallowing, Sucking, and a great deal besides? But I must desist from proceeding upon Particulars, finding I am fallen upon what I proposed to avoid.

CHAP. VI.

Of the PLACING the PARTS of Man's Body.

IN this Chapter, I propose to consider the Lodgment of the curious Parts of Man's Body, which is no less admirable than the Parts themselves, all placed in the most convenient Parts of the Body, to minister to their own several Uses and Purposes, and to assist, and mutually to help one another. Where could those faithful Watchmen the Eye, the Ear, the Tongue be so commodiously placed, as in the upper Part of the Building? where could we throughout the Body find so proper a Part to lodge four of the five Senses, as in the Head (1), near the Brain

(4) *At enim Opificis industrii maximum est indicium (quemadmodum ante saepenumero jam diximus) iis quæ ad alium usum fuerunt comparata, ad alias quoque utilitates abuti, neque laborare ut singulis utilitatibus singulas faciat ac proprias particulas.* Galen. ub. supr. L. 9. c. 5.

(1) *Sensus, interpretes ac nuntii rerum, in capite, tanquam in arce, mirifice ad usus necessarios & facti, & collocati sunt. Nam oculi tanquam speculatores, altissimum locum obtinent: ex quo plurima conspicientes, fungantur suo munere. Et Aures cum sonum recipere debeant, qui natura in sublime fertur; recte in illis corporum partibus collocata sunt.* Cicer. de Nat. Deor. L. 2. ubi plura de cæteris Sensibus.

Brain (2), the common Sensory, a Place well guarded, and of little other Use than to be a Seat to those Senses? And how could we lodge the Fifth Sense, that of *Touching* otherwise (3), than to disperse it to all Parts of the Body? Where could we plant the Hand (4), but just where it is, to be ready at every Turn, on all Occasions of Help and Defence, of Motion, Action, and every of it's useful Services? Where could we set the Legs and Feet, but where they are, to bear up, and handsomely to carry about the Body? Where could we lodge the Heart, to labour about the whole Mass of Blood, but in, or near the Center of the Body (5)? Where could we find Room for that noble Engine to play freely in, where could we so well guard it against external Harms, as it is in that very Place in which it is lodged and secured? Where could we more commodiously place, than in the Thorax and Belly, the useful *Viscera* of those Parts, so as not to swagg, and jogg, and overset the Body, and yet to minister so harmoniously, as they do, to all the several Uses of Concoction, Sanguification, the Separation of various Ferments from the Blood, for the great Uses of Nature, and to make Dis-

charges

(2) *Galen* well observes, that the Nerves ministering to Motion, are hard and firm, to be less subject to Injury: but those ministering to Sense, are soft and tender: and that for this Reason it is, that Four of the Five Senses are lodged so near the Brain, *viz.* partly to partake of the Brains softness and tenderness, and partly for the sake of the strong guard of the Skull. *vid. Gal. de Us. Part. L. 8. c. 5, 6.*

(3) See Book 4. Ch. 6. Note 3.

(4) *Quam vero aptas, quamque multarum artium ministras Manus natura homini dedit?* The particulars of which, enumerated by him, see in *Cic. ub. supr.*

(5) See Book 6. Ch. 5.

charges of what is useless, or would be burdensome or pernicious to the Body (6)? How could we plant the curious and great Variety of Bones and of Muscles of all Sorts and Sizes, necessary as I have said to the Support, and every Motion of the Body? where could we lodge all the Arteries and Veins to convey Nourishment; and the Nerves Sensation throughout the Body? where, I say, could we lodge all these Implements of the Body, to perform their several Offices? how could we secure and guard them so well, as in the very Places, and in the self same manner in which they are already placed in the Body? And lastly, to name no more, what Covering, what Fence could we find out for the whole Body, better than that of Nature's own providing, the Skin (7)? how could we shape it to, or brace it about every part better, either for Convenience or Ornament? What better Texture could we give it, which altho' less obdurate and firm, than that of some other Animals, yet is so much the more sensible of every Touch, and more compliant with every Motion? and being easily defendible by the Power of Man's Reason, and Art, is therefore much the properest Tegument for a Reasonable Creature.

C H A P.

(6) *Ut in edificiis Architecti avertunt ab oculis & naribus dominorum ea, qua profluentia necessario tetri essent aliquid habitura; sic natura res similes (scil. excrementa) procul amandavit a sensibus.* Cicer. de Nat. Deor. L. 2.

(7) Compare here Galen's Observations de Uf. Part. L. II. c. 15. Also L. 2. c. 6. See also Cowpers Anat. where in Tab. 4. are very elegant Cuts of the Skin in divers parts of the Body, drawn from Microscopical Views, as also of the *Papille pyramidales*, the *Sudoriferous Glands* and Vessels, the *Hairs*, &c.

C H A P. VII.

Of the PROVISION in Man's Body against EVILS.

HAVING taken a transient View of the Structure and Lodgment of the Parts of human Bodies, let us next consider the admirable Provision that is made throughout Man's Body to stave off Evils, and to discharge (1) them when befallen. For the Prevention of Evils, we may take the Instances already given, of the Situation of those faithful Sentinels, the Eye, the Ear, and Tongue in the superiour Part of the Body, the better to descry Dangers at a Distance, and to call out presently for Help. And how well situated is the Hand, to be a sure and ready Guard to the Body, as well as the faithful Performer of most of it's Services? The Brain, the Nerves, the Arteries, the Heart (2), the Lungs, and in a Word, all the

(1) One of Nature's most constant Methods here is by the *Glands*, and the Secretions made by them: the particulars of which being too long for these Notes, I shall refer to the modern Anatomists who have written on these Subjects, and indeed, who are the only Men that have done it tolerably: particularly, our learned Drs. *Cockburn*, *Keil*, *Morland*, and others at home and abroad: an Abridgment of whose Opinions and Observations, may be met with in Dr. *Harris's Lex. Tech.* Vol. 2. under the words *Glands*, and *Animal Secretion*.

(2) In Man, and most other Animals, the Heart hath the guard of Bones. But in the *Lamprey* which hath no Bones, (no not so much as a Back-bone) the Heart is very strangely secured, and lies immured or capsulated in a Cartilage, or gristly Substance, which includes the Heart, and its Auricle, as the Skull——doth the Brain in other Animals. Powers Microf. Obser. 22.

the principal Parts, how well are they barricaded either with strong Bones, or deep Lodgments in the Flesh, or some such the wisest, and fittest Method, most agreeable to the Office and Action of the Part? Besides which, for greater Precaution, and a farther Security, what an incomparable Provision hath the infinite Contriver of Man's Body made for the Loss of, or any Defect in some of the Parts we can least spare, by doubling them? by giving us two Eyes, two Ears, two Hands, two Kidneys, two Lobes of the Lungs, Pairs of the Nerves, and many Ramifications of the Arteries and Veins in the fleshly Parts, that there may not be a Defect of Nourishment of the Parts, in Cases of Amputation, or Wounds, or Ruptures of any of the Vessels.

And as Man's Body is admirably contrived and made to prevent Evils: so no less Art and Caution hath been used to get rid of them, when they do happen. When by any Misfortune, Wounds or Hurts do befall, or when by our own wicked Fooleries and Vices, we pull down Diseases and Mischiefs upon ourselves, what Emunctories (3), what admirable Passages (4), are dispersed throughout

(3) Here [from the Pustules he observed in Monomotapa] were grounds to admire the contrivance of our Blood, which on some Occasions, so soon as any thing destructive to the constitution of it, comes into it, immediately by an intestine Commotion endeavoureth to thrust it forth, and is not only freed from the new Guest, but sometimes what likewise may have lain lurking therein——— for a great while. And from hence it comes to pass, that most part of Medicines, when duly administred, are not only sent out of the Body themselves, but likewise great quantities of morbid Matter; as in Salivation, &c. Dr. Sloanes Voy. to *Jamaica*. p. 25.

(4) Valsalva discovered some Passages into the Region of the Ear-drum, of mighty use (among others) to make Discharges

out the Body, what incomparable Methods doth Nature take (5), what vigorous Efforts is she enabled

charges of Bruises, Impostumes, or any purulent, or morbid Matter from the Brain, and parts of the Head. Of which he gives two Examples: one, a Person, who from a Blow on his Head, had dismal Pains therein, grew Speechless, and lay under an absolute Suppression and Decay of his Strength: but found certain Relief, whenever he had a Flux of Blood, or purulent Matter out of his Ear: which after his Death, *Valsalva* discovered, was through those Passages.

The other was an *Apoplethical Case*, wherein he found a large quantity of extravasated Blood, making way from the Ventricles of the Brain, through those same Passages. *Valsal. de Aure hum. c. 2. §. 14. and c. 5. §. 8.*

(5) *Hippocrates Lib. de Alimentis*, takes notice of the sagacity of Nature, in finding out Methods and Passages for the discharging Things offensive to the Body, of which the present Learned and Ingenious Bishop of Clogher in Ireland (*Boyle*) gave this remarkable Instance to my very Curious and Ingenious Neighbour and Friend, *D^r Acre Barret, Esq;* viz. That in the Plague-Year, a Gentleman at the University, had a large Plague-Sore gathered under his Arm, which when they expected it would have broken, discharged it self by a more than ordinary large and foetid Stool; the Sore having no other Vent for it, and immediately becoming sound and well thereupon.

Like to which, is the Story of *Jos. Lanzonius* of a Soldier of 35 Years of Age, who had a Swelling in his right Hip, accompanied with great Pain, &c. By the use of emollient Medicines having ripened the Sore, the Surgeon intended the next Day to have opened it; but about Midnight, the Patient having great provocations to Stool, disburthened himself three times; immediately upon which, both the Tumour and Pain ceased, and thereby disappointed the Surgeons Intention. *Ephem. Germ. Anno 1690. Obs. 49.* More such Instances we find of Mr. *Yonges* in *Philos. Transact.* No. 323. But indeed there are so many Examples in our *Philos. Transact.* in the *Ephem. German. Tho. Bartholine, Rhodius, Sennertus, Hildanus, &c.* that it would be endless to recount them. Some have swallowed Knives, Bodkins, Needles and Pins, Bullets, Pebbles, and 20 other such things as could not find a Passage the ordinary Way, but have met with an Exit through the Bladder, or some other way of Nature's own

bled to make, to discharge the peccant Humours, to correct the morbidick Matter, and in a Word, to set all things right again? But here we had best take the Advice of a learned Physician in the Case: "The Body (saith he) is so contrived, as
 "to be well enough secured against the Mutations in the Air, and the lesser Errors we daily
 "run upon; did we not in our Excesses of Eating,
 "Drinking, Thinking, Loving, Hating, or some
 "other Folly, let in the Enemy, or lay violent
 "Hands upon our selves. Nor is the Body fitted
 "only to prevent, but also to cure, or mitigate
 "Diseases, when by these Follies brought upon
 "us. In most Wounds, if kept clean, and from
 "the Air, — the Flesh will glew together,
 "with its own native Balm. Broken Bones are
 "cemented with the *Callus*, which themselves
 "help to make. And so he goes on with ample
 Instances in this Matter, too many to be here specified (6). Among which he instanceth in the Distempers of our Bodies, shewing that even many of them are highly serviceable to the Discharge of malignant Humours, and preventing greater Evils.

And no less kind than admirable is this Contrivance of Man's Body, that even it's Distempers should many times be it's Cure (7), that when
 the

own providing. But passing over many Particulars, I shall only give one Instance more, because it may be a good Caution to some Persons, that these Papers may probably fall into the hands of, and that is the danger of swallowing *Plumb*, *Prune-stones*, &c. Sir Francis Butlers Lady had many *Prune-stones* that made way through an Abscess near her Navel. *Philos. Trans.* No. 265. where are other such like Examples. More also may be found in No. 282, 304, &c.

(6) *Grew's Cosmol.* §. 28, 29.

(7) *Nor are Diseases themselves useless. For the Blood in a Fever, if well governed, like Wine upon the fret, dischargeth*

the Enemy lies lurking within to destroy us, there should be such a reluctancy, and all Nature excited with it's utmost Vigour to expell him thence. To which Purpose even Pain it self is of great and excellent Use, not only in giving us Notice of the Presence of the Enemy, but by exciting us to use our utmost Diligence and Skill to root out so troublesome and destructive a Companion.

C H A P. VIII.

Of the HARMONY between the PARTS of Man's Body.

IT is an admirable Provision the merciful Creator hath made for the good of Man's Body, by

it self of all heterogeneous Mixtures : and Nature, the Disease, and Remedies clean all the rooms of the House ; whereby that which threatens Death, tends, in conclusion, to the prolonging of Life. Grew ubi supr. §. 52.

And as Diseases minister sometimes to Health, so to other good Uses in the Body, such as quickning the Senses : of which take these Instances relating to the Hearing and Sight. *A very ingenious Physician falling into an odd kind of Fever, had his sense of Hearing thereby made so very nice and tender, that he very plainly heard soft Whispers, that were made at a considerable distance off, and which were not in the least perceived by the By-standers, nor would have been by him before his Sickness.*

A Gentleman of eminent Parts and Note, during a Distemper he had in his Eyes, had his Organs of Sight brought to be so tender, that both his Friends and Himself have assured me, that when he waked in the Night, he could for a while plainly see and distinguish Colours, as well as other Objects, discernable by the Eye, as was more than once tryed. Boyl deter nat. of Effluv. ch. 4.

Daniel Frazer ——— continued Deaf and Dumb from his Birth, till the 17th Year of his Age. ——— After his recovery from a Fever, he perceived a Motion in his Brain, which was very uneasy to him ; and afterwards he began to hear, and in process of time, to understand Speech, &c. Vid. Philos. Trans. No. 312.

by the Harmony between the Parts thereof. Of which let us take St. Paul's description in 1 Cor. 12. 8. *But now hath God set the members every one of them in the body, as it hath pleased him. And (v. 21.) the Eye cannot say unto the Hand, I have no need of thee: nor again, the Head to the Feet, I have no need of you. But such is the consent of all the Parts, or as the Apostle wordeth it, God hath so tempered the Body together, that the Members should have the same Care one for another, v. 25. So that whether one Member suffer, all the Members suffer with it: or one Member be honoured, (or affected with any Good) all the Members rejoyce [and sympathize] with it; v. 26.*

This mutual Accord, Harmony and Sympathy of the Members, there is no Reason to doubt (1), is made by the Commerce of the Nerves (2), and their artificial Positions, and curious Ramifications throughout the whole Body, which is admirable and incomparable, and might deserve a place in this Survey, as greatly and manifestly setting forth the Wisdom and Benignity of the great Creator: but that to give a Description thereof from the Origin of the Nerves in the Brain, the Cerebellum and Spine, and so through every Part of the Body, would be tedious, and in-

(1) See Book 4. Ch. 8.

(2) *Tria proposita ipsi Nature in Nervorum distributione fuerunt: 1. Ut Sensoriis instrumentis Sensum impertiret. 2. Ut motoriis Motum: 3. Ut omnibus aliis [partibus] daret, ut quæ si dolorem adferrent, dignoscerent.* And afterwards, *Si quis in dissectionibus spectavit, consideravitque justene, an secus Natura Nervos non eadem mensura omnibus partibus distribuerit, sed aliis quidem liberalius, aliis vero parcius, eadem cum Hippocrate, velit nolit, de Natura omnino pronunciabit, quod ea scilicet sagax, justa, artificiosa, animaliumque provida est.* Galen, de us. part. L. 5. c. 9.

intrench too much upon the Anatomist's Province : and therefore one Example shall suffice for a Sample of the whole ; and that shall be (what was promised before (3)) the great Sympathy occasioned by the *Fifth Pair* of Nerves, which I chuse to instance in, rather than the *Par vagum*, or any other of the Nerves ; because although we may have less Variety of noble Contrivance and Art, than in that Pair, yet we shall find enough for our Purpose, and which may be dispatched in fewer Words. Now this *Fifth Conjugation* of Nerves is branched to the Ball, the Muscles and Glands of the Eye ; to the Ear ; to the Jaws, the Gums, and Teeth ; to the Muscles of the Lips (4) ; to the Tonsils, the Palate, the Tongue, and the parts of the Mouth ; to the *Præcordia* also, in some Measure, by inosculating with one of its Nerves ; and lastly, to the Muscles of the Face, particularly the Cheeks, whose sanguiferous Vessels it twists about.

From hence it comes to pass that there is a great Consent and Sympathy (5) between these Parts ; so that a Gustable thing seen or smelt, excites the Appetite, and affects the Glands and Parts of the Mouth ; that a thing seen or heard,
that

(3) Book 4. Ch. 5.

(4) Dr. Willis gives the reason *cur mutua Amasiorum oscula labiis impressa, tum præcordia, tum genitalia afficiendo, amorem ac libidinem tam facile irritant*, to be from the consent of those Parts, by the Branches of this 5th Pair. *Nerv. Descrip. c. 22.*

And Dr. Sachs judges it to be from the consent of the *Labia Oris cum Labiis Uteri*, that in April, 1669, a certain breeding Lady, being affrighted with seeing one that had scabby Lips, which they told her were occasioned by a Pestilential Fever, had such like Pustules brake out in the *Labia Uteri*. *Ephem. Germ. T. 1. Obs. 20.*

(5) Consult Willis *ubi supra*.

that is shameful, affects the Cheeks with modest Blushes ; but on the contrary, if it pleases and tickles the Phancy, that it affects the *Præcordia* and Muscles of the Mouth and Face with Laughter ; but a thing causing Sadness and Melancholy, doth accordingly exert itself upon the *Præcordia*, and demonstrate it self by causing the Glands of the Eyes to emit Tears (6), and the Muscles of the Face to put on the sorrowful Aspect of Crying. Hence also that torvous sour Look produced by Anger and Hatred : and that gay and pleasing Countenance accompanying Love and Hope. And in short, it is by means of this Communication of the Nerves, that whatever affects the Soul, is demonstrated (whether we will or no) by a Consentaneous Disposition of the *Præcordia* within, and suitable Configuration of the Muscles and Parts of the Face without. By which means (as *Pliny* saith) (7) “ the Face in Man alone is the
 “ Index of Sorrow or Joy, of Pity or Severity.
 “ In it's ascending Part, the Brow, is a part of
 “ the Mind seated. Therewith we deny, there-
 “ with we assent, therewith we shew Disdain
 “ and Pride. Pride hath (saith he) “ its Con-
 “ ception, it's Rise in another place ; but here
 “ its Seat. In the Heart it is born and begun,
 “ but here it abides and dwells ; and that because
 “ (saith he) it could find no other part of the
 “ Body higher or more craggy (8) where it
 “ might reside alone. Thus

(6) Tears serve not only to moisten the Eye, to clean and brighten the *Cornea*, and to express our Grief ; but also to alleviate it, according to that of *Ulysses* to *Andromache*, in *Seneca's Troas*, v. 762.

*Tempus moramque dabimus ; arbitrio tuo
 Implere lachrymis : Fletus arumnas levat.*

(7) *Plin. Nat. Hist. L. 11. c. 37.*

(8) *Nilil altius simul abruptiusque invenit.*

Thus I have dispatched what I shall remark concerning the Soul and Body of Man. There are divers other things which well deserve a place in this Survey; and these that I have taken notice of deserved to have been enlarged upon: But what hath been said, may suffice for a taste and sample of this admirable piece of God's Handy-work; at least serve as a Supplement to what others have said before me. For which reason I have endeavoured to say as little wittingly as I could of what they have taken notice of, except where the Thread of my Discourse laid a necessity upon me.

C H A P. IX.

Of the Variety of Men's FACES, VOICES, and HAND-WRITING.

HERE I would have put an End to my Observations relating to Man; but that there are three things so expressly declaring the divine Management and Concurrence, that I shall just mention them, although taken notice of more amply by others; and that is, the great Variety throughout the World of Men's Faces (1), Voices (2), and Hand writing. Had Man's Body been

(1) If the Reader hath a mind to see Examples of Men's likenesses, he may consult *Valer. Maximus*, (L. 9. c. 14.) concerning the Likeness of *Pompey* the Great, and *Vibius* and *Publicius Libertinus*; as also of *Pompey* the Father, who got the Name of *Coquus*, he being like *Menogenes* the Cook; with divers others.

(2) As the difference of Tone makes a difference between every Man's Voice, of the same Country, yea Family: So

been made according to any of the Atheistical Schemes, or any other Method than that of the infinite Lord of the World, this wise Variety would never have been : but Men's Faces would have been cast in the same, or not a very different Mould, their Organs of Speech would have sounded the same or not so great a Variety of Notes ; and the same Structure of Muscles and Nerves would have given the Hand the same Direction in Writing. And in this Case, what Confusion, what Disturbance, what Mischiefs would the World eternally have lain under ? No Security could have been to our Persons ; no Certainty, no Enjoyment of our Possessions (3) ; no Justice between Man and Man ; no Distinction between Good and Bad, between Friends and Foes, between Father and Child, Husband and Wife,
Male

a different Dialect and Pronunciation, differs Persons of divers Countries ; yea Persons of one and the same Country, speaking the same Language. Thus in Greece, there were the *Ionick*, *Dorick*, *Attick*, and *Æolick* Dialects : So in Great-Britain, besides the grand diversity of *English* and *Scotch*, the different Counties vary much in their Pronunciation, Accent and Tone, although all one and the same Language. And the way of the *Gileadites* proving the *Ephraimites*, Judg. 12. 6. by the pronunciation of *Shibboleth*, with a *Schin*, or *Sibboleth* with a *Samech*, is well known. So a *Lapide* saith the *Flemings*, prove whether a Man be a *Frenchman* or not, by bidding him pronounce, *Acht en tachtentich* ; which they pronounce, *Aët en taëtentic*, by reason they can't pronounce the Aspirate *ch*.

(3) *Regi Antiocho unus ex equalibus, ---- nomine Artemon, perquam similis fuisse traditur. Quem Laodice, uxor Antiochi, interfecto viro, dissimulandi sceleris gratia, in le-
Aulo perinde quasi ipsum Regem agrum collocavit. Admissumq;
universum populum, & sermone ejus & vultu consimili fefellit : credideruntque homines ab Antiocho moriente Laodicem &
natos ejus sibi commendari. Valer. Max. ib.*

Male or Female; but all would have been turned topsy-turvey, by being exposed to the Malice of the Envious and ill Natured, to the Fraud and Violence of Knaves and Robbers, to the Forgeries of the crafty Cheat, to the Lusts of the Effeminate and Debauched, and what not! Our Courts of Justice (4) can abundantly testify the dire Effects of mistaking Men's Faces, of counterfeiting their Hands, and forging Writings. But now as the infinitely wise Creator and Ruler hath ordered the Matter, every Man's Face can distinguish him in the Light, and his Voice in the Dark; his Hand-writing can speak for him though absent, and be his Witness, and secure his Contracts in future Generations. A manifest as well as admirable Indication of the divine Super-intendence and Management (5).

CHAP:

(4) *Quid Trebellius Calca! quam asseveranter sese Clodium tulit! & quidem dum de bonis ejus contendit, in centumvirale judicium adeo favorabilis descendit, ut vix justis & equis sententiis consternatio populi ullum relinqueret locum. In illa tamen questione neque calumnie petitoris, neque violentie plebis judicantium religio cessit.* Val. Max. ib. c. 15.

(5) To the foregoing Instances of Divine Management, with relation to the Political State of Man, I shall add another thing that I confess hath always seemed to me somewhat odd, but very providential, and that is, the value that Mankind, at least the civilized part of them, have in all Ages put upon Gems, and the purer, finer Metals, Gold and Silver; so as to think them equivalent unto, and exchange them for things of the greatest use for Food, Cloathing, and all other Necessaries and Conveniences of Life. Whereas those things themselves are of very little, if any use in Physick, Food, Building, or Cloathing, otherwise than for Ornament, or to minister to Luxury; as *Suetonius* tells us of *Nero*, who fished with a Net gilt with Gold, and shod his Mules with Silver; but his Wife *Poppaia*, shod her Horses with Gold. *Vit. Ner. c. 30. Plin. N. H. L. 33. c. 11.* So the same *Suetonius* tells us, *Jul. Cesar* lay in a Bed of
D d Gold,

Gold, and rode in a Silver Chariot. But *Heliogabalus* rode in one of Gold, and had his Close-stool Pans of the same Metal. And *Pliny* saith, *Vasa Coquinaria ex argento Calvus Orator fieri queritur*. Ibid. Neither are those pretious Things of greater use to the making of Vessels, and Utensils, unless some little Niceties and Curiosities, by means of their Beauty, Imperdibility, and Ductility. Of which last, the great Mr. *Boyl* hath among others, these two Instances in his *Essay about the Subtilty of Effluvioms*, ch. 2. *Silver, whose Ductility and Tractility are very much inferiour to those of Gold, was, by my procuring, drawn out to so slender a Wire, that — a single grain of it amouned to 27 feet*. As to Gold, he demonstrates it possible to extend an Ounce thereof, to reach to 777600 Feet, or 155½ Miles, yea to an incredibly greater length.

And as to Gems, the very Stories that are told of their prodigious Vertues, are an Argument, that they have very little, or none more than other hard Stones. That a *Diamond* should discover whether a Woman be true or false to her Husband's Bed; cause Love between Man and Wife: secure against Witchcraft, Plague, and Poysons; that the *Ruby* should dispose to Cheerfulness, cause pleasant Dreams, change its Colour against a Misfortune befalling, &c. that the *Sapphire* should grow foul, and lose its Beauty when worn by one that is Leacherous; that the *Emerald* should fly to pieces, if it touch the Skin of any unchaste Person in the Act of Uncleanness: that the *Chrysolite* should lose its Colour if Poyson be on the Table, and recover it again when the Poyson is off: and to name no more, that the *Turcoise* (and the same is said of a Gold Ring) should strike the Hour when hung over a drinking Glass, and much more to the same purpose: all these, and many other such fabulous Stories, I say, of Gems, are no great Arguments, that their Vertue is equivalent to their Value. Of these and other Vertues, consult *Worm* in his *Musaeum*. L. 1. §. 2. c. 17, &c.

But as to *Gems* changing their Colour, there may be somewhat of Truth in that, particularly in the *Turcoise* last mentioned. Mr. *Boyl* observed the Spots in a *Turcoise*, to shift their Place from one part to another, by gentle degrees. So did the Cloud in an *Agate*-handle of a Knife. A *Diamond* he wore on his Finger, he observed to be more illustrious at some times than others: which a curious Lady told him she had also observed in hers. So likewise a rich *Ruby* did the same. *Boyl* of *Absol. Rest. in Bodies*.

C H A P. X.

The CONCLUSION of the SURVEY of Man.

AND now having taken a View of *Man*, and finding every Part of him, every thing relating to him contrived and made in the very best manner ; his Body fitted up with utmost Foresight, Art, and Care ; and this Body (to the great Honour, Privilege, and Benefit of Man) possessed by a divine Part, the *Soul*, a Substance made as 'twere on purpose to contemplate the Works of God, and glorify the great Creator ; and since this Soul can discern, think, reason, and speak ; what can we conclude upon the whole matter, but that we lie under all the Obligations of Duty and Gratitude to be thankful and obedient to, and to set forth the Glories of our great Creator, and noble Benefactor ? And what ungrateful Wretches are we, how much worse than the poor Irrationals, if we do not employ the utmost Power of our Tongue, and all our Members, and all the Faculties of our Souls in the Praises of God ! But above all, should we who have the Benefit of those glorious Acts and Contrivances of the Creator, be such wicked, such base, such worse than brutal Fools to deny the Creator (1) in some of his noblest Works ? should we

(1) It was a pious as well as just Conclusion, the ingenious *Laurence Bellini* makes of his *Opusculum de Motu Cordis*, in these words. *De Motu Cordis isthæc. Quæ equidem omnia, si a rudi intelligentia Hominis tantum consilii, tantum ratiocinii, tantum peritæ mille rerum, tantum scientiarum exigunt, ad hoc, ut inveniantur, seu ad hoc, ut percipiantur*

we so abuse our Reason, yea our very Senses; should we be so besotted by the Devil, and blinded by our Lusts, as to attribute one of the best contrived Pieces of Workmanship to blind Chance, or unguided Matter and Motion, or any other such sottish, wretched, atheistical Stuff; which we never saw, nor ever heard made any one Being (2) in any Age since the Creation? No, No!

postquam facta sunt; illum, cujus opera fabrefacta sunt hæc singula, tam vani erimus atque inanes, ut existimemus esse consilii impotem, rationis expertem, imperitum, aut ignarum omnium rerum? Quantum ad me attinet, nolim esse Rationis compos, si tantum insudandum mihi esset ad consequendam intelligentiam earum rerum, quas fabrefaceret, nescio quæ Vis, quæ nihil intelligeret eorum quæ fabrefaceret; mihi etenim viderer esse vile quiddam, atque ridiculum, qui vellem totam ætatem meam, sanitatem, & quicquid humanum est deterere, nihil curare quicquid est jucunditatum, quicquid letitiarum, quicquid commodorum; non divitiis, non dignitates; non pœnas etiam, & vitam ipsam, ut gloriari possem postremo invenisse unum, aut alterum, & fortasse ne invenisse quidem ex iis innumeris, quæ produxisset, nescio quis ille, qui sine labore, sine cura, nihil cogitans, nihil cognoscens, non unam aut alteram rem, neque dubie, sed certo produxisset innumeras innumerabiles rerum in hoc tam immenso spatio corporum, ex quibus totus Mundus compingitur. Ah Deum immortalem! video præsens numen tuum in hisce tam prodigiosis Generationis initiis, & in altissima eorum contemplatione defixus, nescio quo æstro admirationis concitor, & quasi divine furens cohibere me minime me possum quin exclamem.

Magnus Dominus! Magnus Fabricator Hominum Deus! Magnus atque Admirabilis! Conditor rerum Deus quam Magnus es! Bellin de Mot. Cord. fin.

(2) *Hoc [i. e. mundum effici ornatissimum, & pulcherrimum ex concursione fortuitâ] qui existimat fieri potuisse, non intelligo cur non idem putet, si innumerabiles unius, & viginti forme literarum, vel aureæ, vel qualeslibet, aliquo conjiciantur, posse ex his in terram excussis annales Ennii, ut deinceps legi possint, effici, &c.——— Quod si Mundum efficere potest concursus Atomorum, cur porticum, cur templum, cur domum, cur urbem non potest? quæ sunt minus operosa, & multo quidem faciliora. Cicero de Nat. Deor. L. 2. c. 37.*

No ! But like wise and unprejudiced Men, let us with *David* say, *Pfal.* 139. 14. (with which I conclude) *I will praise thee, for I am fearfully and wonderfully made, marvellous are thy Works : and that my Soul knoweth Right well.* Having thus made what (considering the copiousness and excellence of the Subject) may be called a very brief Survey of *Man*, and seen such admirable Marks of the divine Design and Art ; let us next take a transient View of the other, inferiour Creatures ; and next of **Q U A D R U P E D S.**



BOOK VI.

A SURVEY of QUADRUPEDS.

CHAP. I.

Of their Prone POSTURE.



N taking a View of this Part of the Animal World, so far as the Structure of their Bodies is conformable to that of Man, I shall pass them by, and only take Notice of some Peculiarities in them, which are plain Indications of Design, and the divine Superintendence and Management. And 1. The most visible apparent Variation is the *Prone Posture of their Body*. Concerning which I shall take Notice only of two things, the Parts ministring thereto; and the Use and Benefit thereof.

1. As for the Parts, 'tis observable that in all these Creatures the *Legs* are made exactly conformable to this Posture, as those in Man are to his erect Posture: and what is farther observable also is that the Legs and Feet are always admirably suited to the Motion and Exercises of each Animal: in some they are made for Strength only, to support a vast unweildy Body (1); in others they

(1) The Elephant being a Creature of prodigious Weight, the largest of all Animals, *Pliny* saith, hath its Legs accordingly made of an immense Strength, like Pillars, rather than Legs,

they are made for Agility and Swiftneſs (2), in ſome they are made for only Walking and Running, in others for that, and Swimming too (3); in others for Walking and Digging (4); and in others for Walking and Flying (5): in ſome they are made more lax and weak, for the plainer Lands; in others rigid, ſtiff, and leſs flexible (6) for

(2) Deer, Hares, and other Creatures, remarkable for Swiftneſs, have their Legs accordingly ſlender, but withal ſtrong, and every way adapted to their Swiftneſs.

(3) Thus the Feet of the Otter are made, the Toes being all conjoyned with Membranes, as the Feet of Geese and Ducks are. And in Swimming, it is obſervable, that when the Foot goes forward in the Water, the Toes are cloſe; but when backward, they are ſpread out, whereby they more forcibly ſtrike the Water, and drive themſelves forward. The ſame may be obſerved alſo in Ducks and Geese, &c.

Of the Caſtor or Beaver, the French Academiſts ſay, *The Structure of the Feet was very extraordinary, and ſufficiently demonſtrated, that Nature hath deſigned this Animal to live in the Water, as well as upon Land.* For although it had four Feet, like terreſtrial Animals, yet the hindmoſt ſeemed more proper to Swim than Walk with; the five Toes of which they were compos'd, being joyned together like thoſe of a Goose, by a Membrane, which ſerves this Animal to Swim with. But the fore-ones were made otherwiſe; for there was no Membrane which held theſe Toes joyned together: and this was requiſite for the conveniency of this Animal, which uſeth them as Hands (like a Squirrel, when he Eats. *Memoirs for a Nat. Hiſt. of Animals.* pag. 84.

(4) The Moles Feet are a remarkable Inſtance.

(5) The Wings of the Bat are a prodigious deviation from Nature's ordinary Way. So 'tis in the Virginian Squirrel, whoſe Skin is extended between the Fore-Legs and its Body.

(6) Of the Legs of the Elk, the French Academiſts ſay, *Although ſome Authors report, that there are Elks in Moſcovia, whoſe Legs are jointleſs; there is great probability, that this Opinion is founded on what is reported of theſe Elks of Moſcovia, as well as of Cæſar's Alce, and Pliny's Machlis, that they have Legs ſo ſtiff and inflexible, that they do run on*

for traversing the Ice, and dangerous Precipices of the high Mountains (7) in some they are shod with tough and hard Hoofs, some whole, some cleft; in others with only a callous Skin. In which latter, 'tis observable that the Feet are composed of Toes, some short for bare going; some long to supply the Place of an Hand (8); some armed with long and strong Talons, to catch hold, and tear the Prey; some fenced only with short Nails, to confirm the Steps in running and Walking.

2. As the Posture of Man's Body is the fittest for a Rational Animal, so is the Prone Posture of Quadrupeds the most useful and beneficial to themselves, as also most serviceable to Man. For they are hereby better made for their gathering their Food, to pursue their Prey, to leap, to climb, to swim, to guard themselves against their Enemies, and in a Word, to do whatever may be of principal use to themselves; as also they are hereby rendered more useful and serviceable to Man, for carrying his Burdens, for tilling his Ground, yea even for his Sports and Diversions.

And

Ice without slipping; which is a way that is reported that they have to save themselves from the Wolves, &c. ibid. p. 108.

(7) The common tame Goat, whose Habitation is generally Mountains and Rocks, and who delighteth to walk on the tops of Pales, Houses, &c. and to take great and seemingly dangerous Leaps; I have observ'd, hath the Joynts of the Legs very stiff and strong, the Hoof hollow underneath, and its Edges sharp. The like I doubt not is to be found in the *Wild Goat*, considering what Dr. *Scheuchzer* hath said of its climbing the most dangerous Craggs of the *Alps*, and the manner of their hunting it. *vid. Iter. Alpin.* 3. p. 9.

(8) Thus in *Apes* and *Monkeys*, in the *Beaver* before, and divers others,

And now I might here add a Survey of the excellent Contrivances of the Parts ministering to this Posture of the Four-footed Animals, the admirable Structure of the Bones (9), the Joynts and Muscles ; their various Sizes and Strength ; their commodious Lodgment and Situation, the nice Æquipose of the Body, with a great deal more to the same Purpose. But I should be tedious to insist minutely upon such Particulars, and besides I have given a Touch upon these kinds of things, when I spake of Man.

Passing by therefore many things of this Kind, that might deserve Remark, I shall only consider some of the Parts of Quadrupeds, differing from what is found in Man (10), and which are manifest Works of Design.

C H A P. II.

Of the HEADS of Quadrupeds.

IT is remarkable that in Man the Head is of one singular Form : in the Four-footed Race,

(9) It is a singular Provision Nature hath made for the strength of the Lion, if that be true which *Galen* saith is reported of its Bones being not hollow, as in other Animals, but solid. Which report he thus far confirms, that most of the Bones are so ; and that those in the Legs, and some other parts, have only a small and obscure Cavity in them. Vid. *Galen de Us. Part. L. 11, c. 18.*

(10) *These sorts of Differences in the Mechanism of Animals, upon the score of the Position of their Bodies, occur so often, that it would be no mean Service to Anatomy ; — if any one would give us a History of those Variations of the parts of Animals, which spring from the different Postures of their Bodies.* Drake Anat. V. 1. B. 1. c. 17.

Race, as various as their Species. In some square and large, suitable to their slow Motion, Food, and Abode; in others less, slender, and sharp, agreeable to their swifter Motion, or to make their Way to their Food (1), or Habitation under Ground (2). But passing by a great many Observations that might be made of this Kind, I shall stop a little at the Brain, as the most considerable Part of this Part of the Body, being the great Instrument of Life and Motion in Quadrupeds as 'tis in Man of that, as also in all probability the chief Seat of his immortal Soul. And accordingly it is a remarkable Difference, that in Man, the Brain is large, affording Substance and Room for so noble a Guest; whereas in Quadrupeds, it is but small. And another thing no less remarkable is the Situation of the *Cerebrum* and *Cerebellum*, or the greater or lesser Brain, which I shall give in the Words of one of the most exact Anatomists we have of that Part (3): “ Since, saith he, God hath given to Man
 “ a lofty Countenance, to behold the Heavens,
 “ and hath also seated an immortal Soul in the
 “ Brain, capable of the Contemplation of heavenly
 “ things;

(1) Thus *Swine*, for Instance, who dig in the Earth for Roots and other Food, have their Neck, and all parts of their Head very well adapted to that Service. Their Neck short, brawny, and strong; their Eyes set pretty high out of the way; their Snout long; their Nose callous and strong; and their Sense of Smelling very accurate, to hunt out and distinguish their Food in Mud, under ground, and other the like Places where it lies concealed.

(2) What hath been said of *Swine* is no less, rather more remarkable in the *Mole*, whose Neck, Nose, Eyes, and Ears, are all fitted in the nicest manner to its subterraneous way of Life.

(3) *Willis Cerebr. Anat. cap. 6. Cumque huic Deus os sublime dederit, &c.*

(4)

“ things ; therefore as his Face is erect, so the
 “ Brain is set in an higher Place, namely above
 “ the *Cerebellum* and all the Sensories. But in
 “ Brutes, whose Face is prone towards the Earth,
 “ and whose Brain is incapable of Speculation,
 “ the *Cerebellum*, (whose Business it is to mi-
 “ nister to the Actions and Functions of the
 “ *Præcordia*, the principal Office in those Crea-
 “ tures) in them it is situated in the higher Place,
 “ and the *Cerebrum* lower. Also some of the Or-
 “ gans of Sense, as the Ears and Eyes, are pla-
 “ ced, if not above the *Cerebrum*, yet at least
 “ equal thereto.

Another Convenience in this Position of the
Cerebrum and *Cerebellum*, the last ingenious Anato-
 mist (4) tells us is this, “ In the Head of Man,
 “ saith he, the Base of the *Brain* and *Cerebell*, yea
 “ of the whole Skull, is set parallel to the Horizon,
 “ by which means there is the less Danger of the
 “ two Brains joggling, or slipping out of their
 “ place. But in Quadrupeds, whose Head hangs
 “ down, the Base of the Skull makes a right An-
 “ gle with the Horizon, by which means the
 “ Brain is undermost, and the *Cerebell* upper-
 “ most ; so that one would be apt to imagine the
 “ *Cerebell* should not be steady, but joggle out
 “ of it's Place. To remedy which Inconveni-
 “ ence (he tells us) “ and least the frequent Con-
 “ cussions of the *Cerebell* should cause a fainting,
 “ or disorderly Motion of the Spirits about the
 “ *Præcordia*, therefore by the Artifice of Nature,
 “ sufficient Provision is made in all, by the
 “ *dura Meninx* closely encompassing the *Cerebel-*
 “ *lum* ; besides which, it is (in some) guarded
 with

(4) Id. Paulo post. *In capite humano Cerebri & Cerebelli, &c.*
 (5)

“ with a strong bony Fence ; and in others, as
 “ the Hare, the Coney, and such lesser Quadru-
 “ peds, a Part of the Cerebell is on each side
 “ fenced with the *Os petrosum* : So that by this
 “ double Stay, it's whole Mass is firmly contain-
 “ ed within the Skull.

Besides these Peculiarities, I might take Notice
 of divers other things no less remarkable, as the
Nictitating Membrane of the Eye (5) the different
 Passages of the *Carotid Arteries* (6) through the
 Skull, their Branching into the *Rete Mirabile* (7),
 the

(5) See Book 4. Ch. 2. Note 33.

(6) *Arteria Carotis aliquanto pisterius in homine quam in alio quovis animali Calvariam ingreditur, si juxta illud foramen, per quod sinus lateralis in Venam jugularem desiturus cranio elabatur ; nam in ceteris hæc arteria sub extremitate, seu processu acuto ossis petrosi, intra cranium emergit : verum in capite humano, eadem, ambage longiori circumducta (ut sanguinis torrens, priusquam ad cerebri oram appellit, fracto impetu, lenius & placidius fluat) prope specum ab ingressu sinus lateralis factum, Calvaria basin attingit ; ——— & in majorem cautelam, tunica insuper ascititia crassiore investitur.* And so he goes on to shew the Conveniency of this Guard the Artery hath, and it's passage to the Brain, and then saith, *Si hujusmodi confirmationis ratio inquiritur, facile occurrit, in capite humano, ubi generosi affectus, & magni animorum impetus ac ardores excitantur, sanguinis in Cerebri oras appulsum debere esse liberum & expeditum, &c. Atque hoc quidem respectu differt Homo a plerisque Brutis, quibus Arteria in mille surculos divisa, ne sanguinem pleniore alveo, aut citatiore, quam par est, cursu, ad cerebrum evehat, Plexus Retiformes constituit, quibus nempe efficitur, ut sanguis tardi admodum, lenique & equabili fere stillicidio, in cerebrum illabatur.* And then he goes on to give a farther Account of this Artery, and the *Rete mirabile* in divers Creatures. *Willis ibid. cap. 8.*

(7) *Galen* thinks the *Rete mirabile* is for concocting and elaborating the Animal Spirits, as the *Epididymides*, [the Convolutions *μυροειδὲς ἔλκω*] are for elaborating the Seed. *De Us. Part. L. 9. c. 4.* This *Rete* is much more conspicuous in Beasts, than Man ; and as Dr. *Willis* well judges, serves : 1. To bridle the too rapid incursion of the Blood
 into

the different magnitude of the *Nates*, and some other Parts of the Brain, in Beasts, quite different from what it is in Man : but the Touches already given, may be Instances sufficient to prevent my being tedious in enlarging upon these admirable Works of God.

C H A P. III.

Of the NECKS of Quadrupeds.

FROM the Head pass we to the Neck, no principal Part of the Body, but yet a good Instance of the Creator's Wisdom and Design, inasmuch as in Man it is short, agreeable to the Erection of his Body ; but in the Four-footed Tribe it is long, answerable to the Length of the Legs (1) ; and in some of these long, and less strong,

into the Brain of those Creatures whose Heads hang down much. 2. To separate some of the superfluous serous parts of the Blood, and send them to the Salival Glands, before the Blood enters the Brain of those Animals, whose Blood is naturally of a watery Constitution. 3. To obviate any Obstructions that may happen in the Arteries, by giving a free Passage through other Vessels when some are stopped.

In Quadrupeds, as the *Carotid Arteries* are branched into the *Rete mirabile*, for the bridling the too rapid Current of the Blood into the Brain ; so the *Vertebral Arteries* are, near their entrance into the Skull, bent into an acuter Angle than in Man, which is a wise Provision for the same Purpose.

(1) It is very remarkable, that in all the Species of Quadrupeds, this Equality holds, except only the Elephant ; and that there should be a sufficient special Provision made for that Creature by its *Proboscis* or *Trunk*. A Member so admirably contrived, so curiously wrought, and with so great Agility and Readiness, applied by that unweildy Crea-

strong, serving to carry the Mouth to the ground; in others shorter, brawny and strong, serving to dig, and heave up great Burdens (2).

But that which deserves especial Remark, is that peculiar Provision made in the Necks of all, or most granivorous Quadrupeds, for the perpetual holding down their Head in gathering their Food, by that strong tendinous and insensible *Aponeurosis*, or Ligament (3) braced from the Head to the middle of the Back. By which means the Head, although heavy, may be long held down without any Labour, Pain, or Uneasiness to the Muscles of the Neck, that would otherwise be wearied by being so long put upon the Stretch.

C H A P.

ture to all its several Occasions, that I take it to be a manifest Instance of the Creator's Workmanship; see its Anatomy in Dr. A. Moulens's *Anat. of the Elephant*. p. 33. As also in Mr. Blairs Account in *Phil. Trans.* No. 326.

Aliorum ea est humilitas ut cibum terrestrem rostris facile contingant. Quæ autem altiora sunt, ut Anseres, ut Cygni, ut Grues, ut Cameli, adjuvantur proceritate collorum. Manus etiam data Elephantis, quia propter magnitudinem corporis difficiles aditus habebant ad pastum. Cic. de N. D. L. 2.

Quod iis animalibus quæ pedes habent fissos in digitos, Collum brevius sit factum, quam ut per ipsum Cibum ori admove-re queant: iis vero quæ ungulas habent solidas, aut bifidas, longius, ut prona atque inclinantia pasci queant. Qui id etiam opus non sit Artificis utilitatis memoris? Ad hæc quod Grues ac Ciconiæ, cum crura haberent longiora, ob eam causam Rostrum etiam magnum, & Collum longius habuerint. Pisces autem neque Collum penitus habere, utpote qui neque Crura habent. Quo pacto non id etiam est admirandum? Galen. de Us. part. L. 11. c. 8.

(2) As in Moles and Swine, in Ch. 2. Note 1.

(3) Called the *Whitethroat*, *Packwax*, *Taxwax*, and *Fixfax*.

C H A P. IV.

Of the STOMACHS of Quadrupeds.

FROM the Neck, let us descend to the *Stomach*; a part, as of absolute Necessity to the Being, and Well-being of Animals, so is in the several Species of Quadrupeds sized, contrived, and made with the utmost Variety, and Art (1). What Artist, what Being, but the infinite Conservator of the World, could so well adapt every Food to all the several Kinds of those grand Devourers of it! Who could so well suit their Stomachs to the Reception and Digestion thereof; one kind of Stomach to the Carnivorous, another to the Herbaceous Animals; one fitted to digest by bare Mastication; and a whole set of Stomachs in others to digest with the Help of *Rumination*! Which last Act, together with the Apparatus for that Service, is so peculiar, and withal so curious an Artifice of Nature, that it might justly deserve a more particular Enquiry: but having formerly mentioned it (2), and lest I should be too tedious, I shall pass it by. CHAP.

(1) The peculiar contrivance and make of the *Dromedaries* or *Camels* Stomach, is very remarkable, which I will give from the *Parisian Anatomists*: *At the top of the second* [of the 4 Ventracles] *there were several square holes, which were the Orifices of about 20 Cavities, made like Sacks placed between the two Membranes, which do compose the substance of this Ventricle. The view of these Sacks made us to think, that they might well be the Reservoirs where Pliny saith that Camels do a long time keep the Water, which they drink in great abundance—to supply the wants thereof in the dry Desarts, &c. vid. Memoirs, &c. Anat. of Dromedary. p. 39. See also Peyer Merycol. L. 2. c. 3.*

(2) Book 4. ch. 11.

C H A P. V.

Of the HEART of Quadrupeds.

IN this Part there is a notable Difference found between the Heart of Man and that of Beasts. Concerning the later of which I might take notice of the remarkable Conformation of the of the Hearts of Amphibious Quadrupeds, and their difference from those of Land-Animals, some having but one Ventricle (1), some three (2), and some but two (like Land-Animals) but then the *Foramen ovale* therewith (3). All which may be justly esteemed as wonderful, as they are excellent Provisions for the manner of those Animals living. But I shall content my self with bare Hints

(1) *Frogs* are generally thought to have but one Ventricle in their Hearts.

(2) The *Tortoise* hath 3 Ventricles, as the *Parisian Academists* in their *Memoirs* affirm. Besides these 2 Ventricles [before spoken of] which were in the hinder part of the Heart which faceth the Spine, there was, say they, a third in the fore-part, enclining a little towards the right side, &c. *Memoirs*, &c. p. 259. But Mr. *Buffiere* charges this as a Mistake in those ingenious Gentlemen, and asserts there is but one Ventricle in the *Tortoise's* Heart. See his Description of the Heart of the *Land-Tortoise*, in *Philos. Transact.* No. 328.

(3) The *Sea-Calf* is said by the *French Academists*, to have this Provision, and their Account of it is this: Its Heart was round and flat. Its Ventricles appeared very large, and its Auricles small. ————— Underneath the great Aperture, through which the Trunk of the *Vena Cava*, conveyed the Blood into the right Ventricle of the Heart, there was another which penetrated into the *Arteria Venosa*, and from thence into the left Ventricle, and afterwards into the *Aorta*. This Hole, called the *Foramen Ovale* in the *Fœtus*, makes the *Anastomosis*, by the means of which, the Blood goes from the *Cava* into the *Aorta*, without passing through the Lungs. *French Anatomists*. p. 124.

Hints of these things, and speak only of two particulars more, and that but briefly.

One is the Situation of the Heart. Which in Beasts is near the middle of the whole Body ; in Man nearer the Head (4). The Reason of which I shall give from one of the most curious Anatomists of that Part (5), “ Seeing, saith he, the
“ Trajection and Distribution of the Blood depends wholly on the Systole of the Heart, and
“ that it’s Liquor is not driven of it’s own Nature
“ so readily into the upper Parts as into Vessels
“ even with it, or downwards into those under it :
“ if the Situation of the Heart had been further
“ from the Head, it must needs either have been
“ made stronger to cast out it’s Liquor with greater Force ; or else the Head would want it’s
“ due Proportion of Blood. But in Animals
“ that have a longer Neck, and which is extended towards their Food as it were, the Heart is
“ seated as far from the other Parts ; and they
“ find no Inconvenience from it, because they
“ feed with their Head for the most part hanging
“ down ; and so the Blood, as it hath farther to
“ go to their Head than in others, so it goes a
“ plainer and often a steeper Way (6).

The

(4) Τὴν τε Καρδίαν πρὸς τὸ μέσον, πλεὺς ἐν Ἀνθρώπῳ. Arist. Hist. An. L. 2. c. 17.

(5) Dr. Lower de Corde. c. 1.

(6) I might have mentioned another wise Provision from the same Author, which take in his own words ; *In Vitulis & Equis, imo plerisque aliis animalibus majoribus, non solas propagines a Nervo sexti paris ut in Homine, sed etiam plurimas a Nervo intercostali, ubi recta cor transit, cor accedere, imò in parenchyma ejus dimitti : & hoc ideo a Natura quasi subsidium Brutis comparatum, ne capita quæ terram prona spectant, non satis facile aut copiose Spiritus Animales impertirent* Blasii Anat. Animal. Par. 1. c. 4. ex Lowero de Corde.

The other peculiar Matter is the fastning I (formerly mentioned) which the Cone of the *Pericardium* hath in Man to the *Diaphragm* (7), whereas in all Quadrupeds it is loose. By which means the Motion of the *Midriff*, in that necessary Act of Respiration, is assisted both in the upright Posture of Man, as also in the prone Posture of Quadrupeds (8), which would be hindered, or rendered more difficult, if the Case was otherwise
 “ which must needs be the Effect of Wisdom and
 “ Design, and that Man was intended by Nature
 “ to walk erect, and not upon all four, as Quadrupeds do : to express it in the Words of a great Judge in such matters (9).

C H A P.

(7) *Diaphragmatis circulo nerveo firmiter adheret [Pericardium] quod Homini singulare : nam ab eo in Canibus & Simiis distat, item in aliis animalibus omnibus.* Bartholin. Anat. L. 2. c. 5.

(8) *Finalem causam quod attinet, — cum erectus sit Hominis incessus atque figura, eoque facilius abdominis viscera suo pondere descendant, minore Diaphragmatis nixu atque Systole ad Inspirationem opus est : porro, cum in Expiratione pariter necessarium sit Diaphragma relaxari, — cum capsula cordis omnino connectendum fuit in Homine, ne forte, quamdiu erectus incedit, ab Hepatis aliorumque viscerum appensorum pondere deorsum adeo deprimeretur, ut neque Pulmo satis concidere, neque Exspiratio debito modo peragi potuerit. Quocirca in Quadrupedibus, ubi abdominis viscera in ipsum Diaphragma incumbunt, ipsumque in pectoris cavitatem suo pondere impellunt, ista partium accretio Expirationi quidem inutilis, Inspirationi autem debitam Diaphragmatis tensionem impediendo, prorsus incommoda fuisset.* Lower ib. p. 8.

(9) Dr. Tyson's Anat. of the Orang-Outang in Rays Wisd. of God. p. 262.

C H A P. VI.

*Of the Difference between Man and Quadrupeds
in the NERVOUS Kind.*

There is only one Difference more between Man and Quadrupeds that I shall take Notice of, and that is the Nervous Kind: and because it would be tedious to insist upon many Particulars (1), I shall, for a Sample, insist chiefly upon one, and that is of Nature's prodigious Care for a due Communication and Correspondence between the Head and Heart of Man, more than what is in the four-footed Tribe. For this Purpose besides the Correspondence those Parts have by Means of the Nerves of the *Par vagum* (common both to Man and Beast) there is a farther and more special Communication and Correspondence occasioned by the Branches (2) of the *Intercoastal Pair* sent from the *Cervical Plexus* to the Heart, and the *Præcordia*. By which means the Heart and Brain of Man have a mutual and very
inti-

(1) Amongst these I might name the site of the Nerves proceeding from the *Medulla Spinalis*, which Dr. Lower takes notice of; in Beasts, whose Spine is above the rest of the Body, the Nerves tend directly downwards; but in Man, it being erect, the Nerves spring out of the Spine, not at Right, but in Oblique Angles downwards, and pass also in the Body the same way. *ibid.* p. 16.

(2) *In plerisq; Brutis tantum hac via (i. e. by the Par vagum) & vix omnino per ullos Paris Intercoastalis nervos, aditus ad cor aut Appendicem ejus patescit. Verum in Homine, Nervus Intercoastalis, præter officia ejus in imo ventre huic cum cæteris animalibus communia, etiam ante pectoris claustra internuncii specialis loco est, qui Cerebri & Cordis sensa mutua ultra citraque refert.* Willis Nervor. descr. & usus. Cap. 26.

intimate Correspondence, and Concern with each other, more than is in other Creatures; or as one of the most curious Anatomists and Observers of these things saith (3), “ Brutes are as ’twere
 “ Machines made with a simpler, and less operative Apparatus, and endowed therefore with
 “ only one and the same kind of Motion, or determined to do the same thing: whereas in
 “ Man, there is a great Variety of Motions and
 “ Actions. For by the Commerce of the aforesaid *Cervical Plexus* (4), he saith, “ The Conceptions of the Brain presently affect the Heart,
 “ and agitate it’s Vessels and whole Appendage,
 “ together with the *Diaphragm*. From whence
 “ the Alteration in the Motion of the Blood, the
 “ Pulse and Respiration. So also on the contrary, when any thing affects, or alters the
 “ Heart, those Impressions are not only retorted to the Brain by the same Duct of the
 “ Nerves, but also the Blood itself (it’s Course being once changed) flies to the Brain with a
 “ different and unusual Course, and there agitating the animal Spirits with divers impulses,
 “ produceth various Conceptions and Thoughts in the Mind. And he tells us, “ that hence it
 “ was that the ancient Divines and Philosophers
 “ too, made the Heart the Seat of Wisdom; and
 “ cer-

(3) Id ib. *Dum hanc utriusque speciei differentiam perpendo, succurrit animo, Bruta esse velut machinas, &c.*

(4) That our great Man was not mistaken, there is great Reason to imagine, from what he observed in dissecting a Fool. Besides the Brain being but small, he saith, *Præcipua autem discriminis nota quam inter illius & viri cordati partes advertimus hæcce erat; nempe quod prædictus Nervi Intercoastalis Plexus, quem Cerebri & Cordis internuncium & Hominis proprium diximus, in Stulto hoc valde exilis, & minori Nervorum satellitio stipatus fuerit. Ibid.*

“ certainly (saith he) the Works of Wisdom and
“ Virtue do very much depend upon this Com-
“ merce which is between the Heart and Brain:
and so he goeth on with more to the same Pur-
pose. Upon the Account of this *Intercoastal Com-*
merce with the Heart being wanting in Brutes,
there is another singularly careful and wise Pro-
vision the infinite Creator hath made in them,
and that is, That by reason both the *Par vagum*
and the *Intercoastal* too, do not send their Branches
to the Heart, and it's Appendage in Brutes,
therefore, lest their Heart should want a due Pro-
portion of Nervous Vessels, the *Par vagum* sends
more Branches to Their Heart than to that of
Man. This as it is a remarkable Difference be-
tween Rational and Irrational Creatures; so it is
as remarkable an Argument of the Creator's Art
and Care; who altho' he hath denied Brute-Ani-
mals Reason and the Nerves ministering thereto,
yet hath another way supplied what is necessary
to their Life and State. But let us hear the same
great Author's Descant upon the Point (5); “ In-
“ asmuch, saith he, as Beasts are void of Dis-
“ cretion, and but little subject to various and
“ different Passions, therefore there was no need
“ that the Spirits that were to be conveyed from
“ the Brain to the *Præcordia*, should pass two diffe-
“ rent Ways, namely one for the Service of the
“ vital Functions, and another for the recipro-
“ cal Impressions of the Affections; but it was
“ sufficient that all their Spirits, whatever use
“ they were designed for, should be conveyed
“ one and the same Way.

Here

(5) Id. ib. cap. 29. *In quantum Bestia prudentia carent,
& variis diversisque passionibus, &c.*

Here now in the *Nervous Kind* we have manifest Acts of the Creator's Design and Wisdom, in this so manifest and distinct a Provision for Rational and Irrational Creatures ; and that *Man* was evidently intended to be the one, as the *Genus* of *Quadrupeds* was the other.

CH A P. VII.

The CONCLUSION.

AN D now 'tis time to pause a while, and reflect upon the whole. And as from the Considerations in the preceding Book, we have especial Reason to be thankful to our infinitely merciful Maker for his no less kind than wonderful Contrivances of our Body ; so we have Reason from this brief View I have taken of this last Tribe of the Creation, to acknowledge and admire the same Creator's Work and Contrivances in them. For we have here a large Family of Animals, in every particular Respect, curiously contrived and made for that especial Posture, Place, Food, and Office or Business which they obtain in the World. So that if we consider their own particular Happiness and Good, or Man's Use and Service ; or if we view them throughout, and consider the Parts wherein they agree with Man, or those especially wherein they differ, we shall find all to be so far from being things fortuitous, undesigned, or any way accidental, that every thing is done for the best ; all wisely contrived, and incomparably fitted up, and every Way worthy of the great Creator. And he
that

that will shut his Eyes, and not see God (||) in these his Works even of the poor Beasts of the Earth, that will not say (as *Elibu* hath it *Job.* 35. 10, 11.) *Where is God my Maker, who teacheth us more than the Beasts of the Earth, and maketh us wiser than the Fowls of the Heaven :* of such an one we may use the Psalmist's Expression *Psal.* 49. 12. *That he is like the Beasts (†) that perish.*

(||) ———— *Deum namque ire per omnes
Terrasque tractusque Maris, Cælumque profundum.
Hinc Pecudes, Armenta, Viros, genus omne Ferarum.
Virgil Georg. L. 4.*

(†) *Illos qui nullum omnino Deum esse dixerunt, non modo non Philosophos, sed ne homines quidem fuisse dixerim ; qui, mutis simillimi, ex solo corpore constiterunt, nihil videntes animo. Lactant, L. 7, c. 9.*



BOOK VII.

A SURVEY of BIRDS.

HAVING as briefly as well I could dispatched the Tribe of *Quadrupeds*, I shall next take as brief and transient a View of the *Feathered Tribe*.

And here we have another large Province to expatiate in, if we should descend to every thing wherein the Workmanship of the Almighty appears. But I must contract my Survey as much as may be, and shall therefore give only such Hints and Touches upon this curious Family of Animals, as may serve for Samples of the rest of what might be observed.

CHAP. I.

Of the MOTION of Birds, and the PARTS ministering thereto.

AS this Tribe hath a different Motion from that of other Animals, and an Amphibious way of Life, partly in the Air, and partly on the Land and Waters, so is their Body accordingly shaped, and all their Parts incomparably fitted for that way of Life and Motion; as will be found by a cursory View of some of the Particulars. And the

1. And most visible thing, is the Shape and Make of their Body, not thick, and clumisie, but incom-

incomparably adapted to their Flight: sharp before, to pierce, and make Way through the Air, and then by gentle Degrees rising to it's full Bulk. To which we may add

2. The neat Position of the *Feathers* throughout the Body; not ruffled, or discomposed, or placed some this, some a contrary Way, according to the Method of Chance; but all artificially placed (1) for facilitating the Motion of the Body, and it's Security at the same time by Way of Cloathing: and for that End, most of the *Feathers* tend backward, and are laid over one another in exact regular Method, armed with warm and soft Down next the Body, and more strongly made, and curiously closed next the Air, and Weather, to fence off the Injuries thereof. To which purpose, as also for the more easy and nimble gliding of the Body through the Air, the Provision Nature hath made, and the Instinct of these Animals to *preen* and *dress* their *Feathers*, is admirable; both in respect of their Art and Curiosity in doing it, and the *Oyl-bag* (2), Glands, and whole Apparatus for that Service.

And now having said thus much relating to the Body's Motion, let us 3. Survey the grand Instrument

(1) See before, Book 4. Ch. 12. Note 11.

(2) Mr. *Willughby* saith there are two Glands for the Secretion of the unctuous Matter in the *Oyl-bag*. And so they appear to be in Geese. But upon Examination, I find, that in most other Birds (such at least as I have enquired into) there is only one Gland: in which are divers little Cells, ending in two or three larger Cells, lying under the Nipple of the *Oyl-bag*. This *Nipple* is perforated, and being pressed, or drawn by the Bird's Bill, or Head, emits the liquid *Oyl*, as it is in some Birds, or thicker unctuous Grease, as it is in others. The whole *Oyl-bag* is in its structure somewhat conformable to the Breasts of such Animals as afford Milk.

ment thereof the *Wings*. Which as they are principal Parts, so are made with great Skill, and placed in the most commodious Point of the Body (3), to give it an exact *Æquipoise* in that subtile Medium, the Air.

And here it is observable, with what incomparable Curiosity every Feather is made; the *Shaft* exceeding strong, but hollow below for Strength and Lightness sake; and above, not much less strong, and filled with a *Parenchyma* or *Pith*, both strong and light too. The *Vanes* as nicely gauged on each side as made; broad on one side, and narrower on the other; both which incomparably minister to the progressive Motion of the Bird, as also to the Union and Closeness of the Wing (4).

And

(3) In all Birds that fly much, or that have the most occasion for their Wings, it is manifest that their Wings are placed in the very best part, to ballance their Body in the Air, and to give as swift a Progression, as their Wings and Body are capable of: for otherwise, we should perceive them to reel, and fly unsteadily; as we see them to do, if we alter their *Æquipoise*, by cutting the end of one of the Wings, or hanging a weight at any of the extreme parts of the Body. But as for such Birds as have as much occasion for Swimming as Flying, and whose Wings are therefore set a little out of the Center of the Bodies gravity see Ch. 3. Note 9. And for such as have more occasion for Diving than Flying, and whose Legs are for that Reason set more backward, and their Wings more forward see Ch. 4. Note 9.

(4) The wise Author of Nature hath afforded an Example of the great Nicety in the Formation of Birds, by the Nicety observed in a part no more considerable than the Vanes of the Flag-feathers of the Wing. Among others, these two Things are observable. 1. The Edges of the exterior, or narrow Vanes bend downwards, but of the interior, wider Vanes upwards; by which means they catch hold, and lye close to one another, when the Wing is spread, so that not one Feather may miss its full Force and Impulse upon

And no less exquisite is the Textrine Art of the Plumage (5) also ; which is so curiously wrought, and

upon the Air. 2. A yet lesser Nicety is observed, and that is in the very sloping the tips of the Flag-feathers: the interiour Vanes being neatly sloped away to a Point, towards the outward part of the Wing; and the exterior Vanes, towards the Body, at least in many Birds; and in the middle of the Wing, the Vanes being equal, and but little sloped. So that the Wing, whether extended or shut, is as neatly sloped and formed, as if constantly trimmed with a pair of Scissors.

(5) Since no exact account that I know of, hath been given of the Mechanism of the *Vanes* or *Webs* of Feathers, my Observations may not be unacceptable. The *Vane* consists not of one continued Membrane, because, if once broken, it would hardly be repairable: but of many *Laminae*, which are thin, stiff, and somewhat of the nature of a thin Quill. Towards the Shaft of the Feather (especially in the Flag-feathers of the Wing) those *Laminae* are broad, &c. of a semicircular Form; which serves for strength, and for the closer shutting of the *Laminae* to one another, when impulses are made upon the Air. Towards the outer part of the Vane, these *Laminae* grow slender and taper: on their under side they are thin and smooth, but their upper outer Edge is parted into two hairy Edges, each side having a different sort of Hairs, laminated or broad at bottom, and slender and bearded above the other half. I have, as well as I could, represented the uppermost Edge of one of these *Laminae* in Fig. 18. with some of the Hairs on each side, magnified with a Microscope. These bearded Bristles or Hairs on one side the *Laminae*, have strait Beards, as in Fig. 19. those on the other side, have hooked Beards on one side the slender part of the Bristle, and strait ones on the other, as in Fig. 20. Both these sorts of Bristles magnified (only scattering and not close) are represented as they grow upon the upper Edge of the *Lamina* *f. t.* in Fig. 18. And in the Vane, the hooked Beards of one *Lamina*, always lye next the strait Beards of the next *Lamina*, and by that means lock and hold each other, and by a pretty Mechanism brace the *Laminae* close to one another. And if at any time the Vane happens to be ruffled and discomposed, it can by this pretty easy Mechanism, be reduced and repaired. V. Book 4. Ch. 12. at Note 12.

and so artificially interwoven, that it cannot be viewed without Admiration, especially when the Eye is assisted with Glasses.

And as curiously made, so no less curiously are the Feathers placed in the Wing, exactly according to their several Lengths and Strength: the *Principals* set for Stay and Strength, and these again well lined, faced and guarded with the *Covert* and *Secondary Feathers*, to keep the Air from passing through, whereby the stronger Impulses are made thereupon.

And lastly, to say no more of this Part, that deserves more to be said of it, what an admirable *Apparatus* is there of *Bones*, very strong, but withal light, and incomparably wrought? of *Joints*, which open, shut, and every way move, according to the Occasions either of extending it in Flight, or withdrawing the Wing again to the Body? and of various *Muscles*; among which the peculiar Strength of the *Pectoral Muscles* deserves especial Remark, by reason they are much stronger (6) in Birds, than in Man, or any other Animal, not made for Flying.

4. Next the Wings, the Tail is in Flight considerable; greatly assisting in all Ascents and Descent

(6) *Pectorales Musculi Hominis flectentes humeros, parvi, & parum carnosum sunt; non equant 50am aut 70am partem omnium Musculorum Hominis. E contra in Avibus, Pectorales Musculi vastissimi sunt, & equant, imo excedunt, & magis pendent, quam reliqui omnes Musculi ejusdem Avis simul sumpti.* Borell. de Mot. Animal. Vol. I. Prop. 184.

Mr. Willughby having made the like Observation, hath this Reflection on it, whence, if it be possible for Man to fly, it is thought by them who have curiously weighed and considered the matter, that he that would attempt such a thing with hopes of success, must so contrive and adapt his Wings, that he may make use of his Legs, and not his Arms in managing them: [because the Muscles of the Legs are stronger, as he observes.] Willugh. Ornith. L. I, c. 1. §. 19.

cents in the Air ; as also serving to steady (7) Flight, by keeping the Body upright in that subtile and yielding Medium, by it's readily turning and answering every Vacillation of the Body.

And now to the Parts serving to Flight, let us add the nice and compleat Manner of it's Performance ; all done according to the strictest Rules of Mechanism (8). What Rower on the Waters, what Artist on the Land, what acutest Mathematician could give a more agreeable and exact Motion to the Wings, than these untaught flying Artists do theirs ! serving not only to bear their Bodies up in the Air, but also to waft them along therein with a speedy progressive Motion, as also to steer and turn them this Way and that Way, up and down, faster or slower, as their Occasions require, or their Pleasure leads them.

5. Next to the Parts for Flight, let us view the *Feet* and *Legs* ministering to their other Motion ; Both made light for easier Transportation through the Air ; and the former spread, some with Membranes for Swimming (9), some without,
for

(7) Mr. *Willughby*, *Ray*, and many others, imagine the principal use of the Tail to be to steer, and turn the Body in the Air, as a Rudder. But *Borelli* hath put it beyond all doubt, that this is the least use of it, and that it is chiefly to assist the Bird in its Ascents and Descents in the Air, and to obviate the Vacillations of the Body and Wings. For as for turning to this or that side, it is performed by the Wings, and Inclination of the Body, and but very little by the help of the Tail.

(8) See *Borelli ubi supr.* Prop. 182. &c.

(9) It is considerable in all Water-Fowl, how exactly their Legs and Feet correspond to that way of Life. For either their Legs are long, to enable them to wade in the Waters : in which case, their Legs are bare of Feathers a good way above the Knees, the more conveniently for this
pur-

for steady Going, for Perching, for Catching and Holding of Prey (10), or for Hanging by the Heels to gather their Food (11), or to fix themselves in their Places of Retreat and Safety. And the latter, namely the *Legs*, all curved for their easy Perching, Roosting, and Rest, as also to help them up upon their Wings in taking their Flight, and to be therein commodiously tucked up to the Body, so as not to obstruct their Flight. In some long, for Wading and Searching the Waters; in some of a moderate Length, answerable to their vulgar Occasions; and in others as remarkably short, to answer their especial Occasions and Manner of Life (12). To all which let us add the pla-

purpose. Their Toes also are all broad; and in such as bear the name of *Mudsuckers*, two of the Toes are somewhat joyned, that they may not easily sink in walking upon boggy Places. And as for such as are whole-footed, or whose Toes are webbed together (excepting some few) their Legs are generally short, which is the most convenient size for Swimming. And 'tis pretty enough to see how artificially they gather up their Toes and Feet when they withdraw their Legs, or go to take their Stroke; and as artificially again extend or open their whole Foot when they press upon, or drive themselves forward in the Waters.

(10) Some of the Characteristics of Rapacious Birds are to have hooked, strong, and sharp-pointed Beaks and Talons, fitted for Rapine, and tearing of Flesh: and strong and brawny Thighs, for striking down their Prey. Willughby Ornith. L. 2. c. 1. Raii Synopf. Av. Method. p. 1.

(11) Such Birds as climb, particularly those of the *Woodpecker* kind, have for this purpose (as Mr. Willughby observes L. 2. c. 4.) 1. Strong and musculous Thighs. 2. Short Legs and very strong. 3. Toes standing two forwards, and two backwards. Their Toes also are close joyned together, that they may more strongly and firmly lay hold on the Tree they climb upon. 4. All of them—have a hard stiff Tail, bending also downwards, on which they lean, and so bear up themselves in Climbing.

(12) *Swifts* and *Swallows* have remarkably short Legs, especially the former, and their Toes grasp any thing very strong-

placing these last mentioned Parts in the Body. In all somewhat out of the Center of the Body's Gravity (13), but in such as swim, more than in others, for the better rowing their Bodies through the Waters, or to help them in that and Diving (14) too.

C H A P. II.

Of the HEAD, STOMACH, and other Parts of Birds.

THUS having dispatched the Parts principally concerned in the Motion of the *Feathered Tribe*, let us proceed to some other Parts not yet ani-

strongly. All which is useful to them in building their Nests, and other such Occasions as necessitate them to hang frequently by their Heels. But there is far greater use of this Structure of their Legs and Feet, if the reports be true of their hanging by the Heels in great Clusters (after the manner of Bees) in Mines and Grottos, and on the Rocks by the Sea, all the Winter. Of which latter, I remember the late learned Dr. Fry told this Story at the University, and confirmed it to me since, viz. That an ancient Fisherman, accounted an honest Man, being near some Rocks on the Coast of *Cornwal*, saw at a very low Ebb, a black List of something adhering to the Rock, which when he came to examine, he found it was a great number of *Swallows*, and, if I misremember not, of *Swifts* also, hanging by the Feet to one another, as Bees do; which were covered commonly by the Sea-Waters, but revived in his warm Hand, and by the Fire. All this the Fisherman himself assured the Doctor of. Of this, see more Ch. 3. Note 4.

(13) In Birds that frequent not the Waters, the Wings are in the Center of Gravity, when the Bird lies along, as in Flying; but when it stands or walks, the erection of the Body throws the Center of Gravity upon the Thighs and Feet.

(14) See Ch. 4. Note 9.

animadverted upon. And we will begin with the *Head*. Concerning which I have already taken Notice of it's Shape for making way through the Air ; of the make of the *Bill*, for gathering Food, and other Uses ; the commodious Situation of the *Eye* ; and I might add that of the *Ear* too, which would be in the way, and obstruct Flight, if 'twas like that of most other Animals : also I might say a great deal of the Conformation of the *Brain*, and of the Parts therein wanting, and of others added, like to what is observeable in Fishes ; whose Posture in the Waters resembles that of Birds in the Air (1), and both very different from Man and Beasts : and lastly, to hint at no more, I might survey the peculiar Structure of the *Larynx* (2), the *Tongue* (3), the inner *Ear* (4), and many

(1) *Cerebra Hominum & Quadrupedum in plerisque similia existunt.*——*Capitibus Volucrum & Piscium contenta, ab utrisque prioribus longe diversa, tamen inter se, quoad precipuas ἐγκράδαι partes, Symbola reperiuntur.* The particulars wherein the Brains of Birds and Fishes agree with one another, and wherein they differ from the Brain of Man and Beasts see in the same justly famous Author, *Willis Cereb. Anat. c. 5.*

(2) *Circa bifurcationem Asperæ Arteriæ, elegans Artificis libere agentis indicium detegitur ex Avium comparatione cum Quadrupedibus ; cum Vocis gratia in diversis Avibus diversam musculorum fabricam bifurcationi Asperæ Arteriæ dederit, quorum nullum vestigium extat in Homine & Quadrupedibus mihi visis, ubi omnes vocis musculos capiti Arteriæ junxit. In Aquila, &c. supra bifurcationem, &c. Steno in Blas. Anat. Animal. P. 2. c. 4.*

The *Aspera Arteria* is very remarkable in the Swan, which is thus described by T. Bartholin, viz. *Aspera Arteria admiranda satis structura. Nam pro Colli longitudine deorsum Oesophagi comes protenditur donec ad sternum perveniat, in cujus capsulam se incurvo flexu insinuat & recondit, velut in tuto loco & theca, moxque ad fundum ejusdem cavitatis delata, sursum reflectitur, egrediturque angustias Sterni, & Claviculis*

lis mediis consensu, quibus ut fulcro nititur, ad Thoracem se flectit——*Miranda hercle modis omnibus constitutio, & Respirationi inservit & Voci. Nam cum in stagnorum fundo edulia pro victu quærat, longissimo indiguit collo, ne longa mora suffocationis incurreret periculum. Et certe dum dimidiam fere horam toto Capite & Collo pronis vado immergitur, pedibus in altum elatis cæloque obversis, ex ea Arteria quæ pectoris diætæ vaginæ reclusa est portione, tanquam ex cõdo promo spiritum haurit. Blas. ib. c. 10.*

(3) The structure of the Tongue of the Wood-pecker is very singular, and remarkable, whether we look at its great length, its Bones and Muscles, its encompassing part of the Neck and Head, the better to exert it self in length, and again, to retract it into its Cell ; and lastly, whether we look at its sharp horny bearded Point, and the glewy Matter at the end of it, the better to stab, to stick unto, and draw out little Maggots out of Wood. *Utilis enim Picis (saith Coiter) ad Vermiculos, Formicas, aliaque Insecta venanda talis Lingua foret. Siquidem Picus, innata sua sagacitate cum deprehendit alibi in arboribus, vel carie, vel alia de causa cavatis, Vermes insectaque delitescere, ad illas volitat, seseque digitis, ungulisque posterioribus robustissimis, & Caudæ pennis rigidissimis sustentat, donec valido ac peracuto Rostrum arborem pertundat, arbore pertusâ, foramini rostrum immittit, ac quo animalcula stridore excitet percellatque, magnam in arboris cavo emittit vocem, insecta vociferatione hac concitata huc illucque repunt ; Picus v. linguam suam exerit, atque aculeis, hamisque animalia infigit, infixâ attrahit & devorat. vid. Blasii ubi supra. P. 2. c. 24.*

(4) I have before in Book 4. Ch. 3. Note 19. taken notice of what others have observed concerning the inner Ear of Birds, reserving my own Observations for this place : which I hope may be acceptable, not only for being some of them new, but also as shewing the Mechanism of Hearing.

In this Organ of Birds, I shall take notice only of three Parts, the Membranes and Cartilages ; the Columella ; and the Conclave : The Drum, as some call it, or *Membrana Tympani*, as others, consists of two Membranes, the Outer, which covers the whole *Meatus*, Bason, or Drum (as some call it) and the inner Membrane. To support, distend and relax the outermost, there is one single Cartilage, reaching from the side of the *Meatus*, to near the middle of the Membrane. On the top of the *Columella* is another Cartilage, consisting of 3 Branches, *a. b. c.* in Fig. 23. The longest middle Branch (*a*) is joyned to the top of the single upper Cartilage before spoken of, and assists it to bear up the upper outer Membrane : the two Branches, *b, c.*

are joyned to the *Os Petrosum*, at some distance from the outer Membrane: upon this inner Cartilage, is the inner Membrane fixed, the two outer sides of which, *a, b,* and *a, c,* are joyned to the outer Membrane, and makes a kind of three-square Bag. The design of the two Branches, or Legs of the Cartilage, *b, c,* are I conceive to keep the *Cartilage,* and *Columella* from wavering sideways: and to hinder them from flying too much back, there is a very fine slender Ligament, extended from the oppetite-side, quite cross the *Meatus* or *Bafon*, to the bottom of the Cartilage, near its joyning to the *Columella*. Thus much for the *Membrana Tympani*, and their *Cartilages*.

The next Part is the *Columella* (as *Schelhammer* calls it.) This is a very fine, thin, light Tube; the bottom of which spreads about, and gives it the resemblance of a wooden Potlid, such as I have seen in Countrey Houses. It exactly shuts into, and covers a *Foramen* of the *Conclave*, to which it is braced all round with a fine subtile Membrane, composed of the tender Auditory Nerve. This Bottom, or Base of the *Columella*, I call the *Operculum*.

The last part which some call the *Labyrinth* and *Cochlea* consisting of Branches more like the *Canales Semicirculares* in Man, than the *Cochlea*, I call the *Conclave Auditus*. It is (as in most other Animals) made of hard, context Bone. In most of the Birds I have opened, there are circular Canals some larger, some lesser, crossing one another at right Angles, which open into the *Conclave*. But in the Goose it is otherwise, there being cochleous Canals, but not like those of other Birds. In the *Conclave*, at the side opposite to the *Operculum*, the tender part of the Auditory Nerve enters and lineth all those inner retired parts, viz. the *Conclave* and *Canals*.

As to the *Passages, Columnæ*, and other parts observable in the Ear of Birds, I shall pass them by, it being sufficient to my purpose, to have described the Parts principally concerned in the act of Hearing. And as the Ear is in Bird the most simple and incomplex of any Animals Ear; so we may from it make an easy and rational judgment, how Hearing is performed: viz. Sound being a Tremor, or Undulation in the Air, caused by the collision of Bodies, doth, as it moves along, strike upon the Drum, or *Membrana Tympani* of the Ear. Which Motion, whether strong or languid shrill or soft, tuneful or not, is at the same instant impressed upon the *Cartilages, Columella*, and *Operculum*, and so communicated to the Auditory Nerve in the *Conclave*.

And now if we compare the Organ and Act of Hearing with those of Sight, we shall find, that the *Conclave* is the

Hear

ny matters besides ; but for a Sample I shall only insist upon the wonderful Provision in the Bill for the judging of the Food, and that is by peculiar Nerves lodged therein for that purpose ; small and less numerous in such as have the Assistance of another Sense, the Eye ; but large, more numerous, and thickly branched about, to the very End of the Beak, in such as hunt for their Food out of Sight in the Waters, in Mud, or under Ground (5).

And

Hearing, as the *Retina* is to Sight ; that sonorous Bodies make their impressions thereby on the Brain, as visible Objects do by the *Retina*. Also, that as there is an Apparatus in the Eye, by the opening and shutting of the Pupil, to make it correspond to all the degrees of Light ; so there is in the Ear to make it conformable to all the degrees of Sound ; a noble train of little Bones, and Muscles in Man, &c. to strain and relax the Membrane, and at the same time to open and shut the *Basis* of the *Stapes* (the same as what I call the *Operculum* in Birds :) but in Birds, there is a more simple, but sufficient Apparatus for this purpose, tender Cartilages, instead of Bones and Joynts, to correspond to the various impressions of Sounds, and to open and shut the *Operculum*. Besides which, I suspect the Ligament I mentioned is only the Tendon of a Muscle, reaching to the inner *Membrana Tympani*, and joyned thereto (as I find by a stricter Scrutiny) and not to the Cartilage, as I imagined. By this Muscle, the inner Membrane, and by means of that, the Outer also can be distended or relaxed, as it is in Man, by the *Malleus* and its Muscle, &c.

(5) Flat-billed Birds, that grope for their Meat, have three pair of Nerves, that come into their Bills ; whereby they have that accuracy to distinguish what is proper for Food, and what to be rejected, by their Taste, when they did not see it. This was most evident in a Ducks Bill and Head ; a Duck having larger Nerves that come into their Bills than Geese, or any other Bird that I have seen ; and therefore quaffer and grope out their Meat the most. But then I discovered none of these Nerves in Round-billed Birds. But since, in my Anatomies in the Country, in a Rook I first observed two Nerves that came down between the Eyes into the upper Bill, but considerably smaller

And now from the Head and Mouth, pass we to it's near Allie the Stomach, another no less notable than useful Part; whether we consider the Elegancy of it's Fibres and Muscles; or it's Multiplicity, one to soften and macerate, another to digest; or it's Variety, suited to various Foods, some Membranaceous, agreeable to the frugivorous or carnivorous kind; some Musculous and strong (6), suited to the Comminution and grinding of Corn and Grain, and so to supply the Defect of Teeth.

And now to this Specimen of the Parts, I might add many others no less curiously contrived, made and suited to the Occasions of these Volatiles; as particularly the Structure and Lodgment of the
Lung

than any of the three pair of Nerves in the Bills of Ducks, but larger than the Nerves in any other round-billed Birds. And 'tis remarkable, that these Birds, more than any other round-billed Birds, seem to grope for their Meat in Cow-dung, &c. Mr. J. Clayton, in Philos. Transact. No. 206.

I observed three pair of Nerves in all the broad-billed Bird that I could meet with, and in all such as feel for their Food out of Sight, as Snites, Woodcocks, Curlews, Geese, Ducks, Teals, Widgeons, &c. These Nerves are very large, equalling almost the Optick Nerve in thickness. — Two are distributed nigh the end of the upper Bill, and are there very much expanded, passing thro' the Bone into the Membrane, lining the Roof of the Mouth. Dr. Al. Moulen, *ibid.* No. 199. or both in Mr. Lowthorp's Abridg. V. 2. p. 861, 862.

(6) The Gizzard is not only made very strong, especially in the Granivorous, but hath also a Faculty of grinding what is therein. For which purpose, the Bird swalloweth rough Stones down, which, when grown smooth, are rejected and cast out of the Stomach, as useles. This grinding may be heard in Falcons, Eagles, &c. by laying the Ear close to them when their Stomachs are empty, as the famous Dr. Harvey saith, *De Generat. Exer.* 7.

As to the strength of the Gizzard, and the use of Stone to the Digestion of Fowls, divers curious Experiments may be met with, tryed by *Seigneur Redi*, with glass Bubbles, solid Glass, Diamonds, and other hard Bodies. See his *Exp. Nat.*

Lungs (7); the Configuration of the *Breast*, and its Bone, made like a Keel for commodious Passage through the Air, to bear the large and strong Muscles which move the Wings, and to counterpoise the Body, and support and rest it upon at Roost; the *Neck* also might deserve our notice, always either exactly proportioned to the Length of the Legs, or else longer, to hunt out Food, to search in the Waters (8), as also to counterpoise the Body in Flight (9). And lastly,

I

(7) It is no less remarkable in Birds, that their *Lungs* adhere to the *Thorax*, and have but little play, than that in other Animals they are loose and play much: which is a good provision for their steady flight. Also they want the *Diaphragm*; and instead thereof, have divers large Bladders made of thin transparent Membranes, with pretty large Holes out of one into the other. These Membranes seem to me to serve for *Ligaments* or *Braces* to the *Viscera*, as well as to contain Air. Towards the upper part, each Lobe of the *Lungs* is perforated in two Places with large Perforations, whereof one is towards the outer, the other towards the inner part of the Lobe. Through these Perforations, the Air hath a Passage into the Belly (as in B. I. Ch. I. Note 8.) that is, into the forementioned Bladders: so that by blowing into the *Aspera Arteria*, the *Lungs* will be a little raised, and the whole Belly blown up, so as to be very turgid. Which doubtless is a Means to make their Bodies more or less buoyant, according as they take in more or less Air, to facilitate thereby, their Ascents and Descents: like as it is in the *Air-bladders* of Fishes, in the last cited place, Note 9.

(8) Such Birds as have long Legs, have also a long Neck; for that otherwise they could not commodiously gather up their Food, either on Land, or in the Water. But on the other side, those which have long Necks, have not always long Legs, as in Swans — whose Necks serve them to reach to the bottoms of Rivers, &c. Willughby's Ornithol. L. I. c. I. §. 7.

(9) We have sufficient Instances of this in Geese, Ducks, &c. whose Wings (their Bodies being made for the convenience of Swimming) are placed out of the center of Gravity, nearer the Head. But the extending the Neck and

I might here take Notice of the Defect of the Diaphragm, so necessary in other Animals to Respiration, and also of divers other Parts redundant, defective, or varying from other Animals. But it would be tedious to insist upon all, and therefore to the Examples already given I would rather recommend a nice Inspection (10) of those curious Works of God, which would be manifest Demonstrations of the admirable Contrivance and Oeconomy of the Bodies of those Creatures.

From the Fabrick therefore of their Bodies, I shall pass to take a Glance of one or two things relating to their *State*, and so conclude this Genus of the Animal World.

CHAP. III.

Of the MIGRATION of Birds.

Concerning the *State* of this Tribe of *Animals*, the first thing I shall speak of (by reason
God

Head in Flight, causeth a due *Æquipoise* and Libration of the Body upon the Wings. Which is another excellent use of the long Necks of these Birds, besides that of reaching and searching in the Waters for their Food.

But in the *Heron*, whose Head and long Neck (although tucked up in Flight) over-balance the hinder part of the Body, the long Legs are extended in Flight, to counterpoise the Body, as well as to supply what is wanting in the Tail, from the shortness of it.

(10) *Steno* thus concludes his Myology of the Eagle, *Imperfecta hac Musculorum descriptio non minus arida est legentibus, quam Inspectantibus fuerit jucunda eorumdem præparatio. Elegantissima enim Mechanices artificia, creberrime in illis obvia, verbis non nisi obscure exprimuntur, carniū autem ductu, tendinū colore, insertionū proportionē, & trochlearum distributione oculis exposita omnem superant admirationem. Steno in Blas. Anat. Animal. P. 2. c. 4.*

God himself instanceth in it) shall be their Migration, mentioned Jer. 8. 7. *Yea, the Stork in the Heaven knoweth her appointed Times, and the Turtle, and the Crane, and the Swallow observe the Time of their Coming; but my People, &c.*

In which Act of *Migration* there are two things to me exceedingly notable. One is what the Text speaks of, their knowing their proper Times for their *Passage*, when to come (1), when to go; as also that some should come, when others go; and some others go, when these come. There is no doubt but the Temperature of the Air, as to Heat and Cold, and their natural Propensity to breed their Young may be great Incentives to those Creatures to change their Habitation: but yet it is a very odd Instinct that they should at all shift their Habitation, that some certain Place is not to be found in all the terraqueous Globe affording them convenient Food and Habitation all the Year, either in the colder Climes, for such as delight in the colder Regions, or the hotter, for such *Birds of Passage* as fly to us in Summer.

Also it is somewhat strange, that those untaught, unthinking Creatures should so exactly know the best and only proper Seasons to go and come. This gives us good Reason to interpret the *מִיָּמֵינוּ* Appointed Times, (2), in the Text, to be such

(1) Curiosa res est, scire, quam exacte hoc genus avium [Gruum] quotannis observet tempora sui reditus ad nos. Anno 1667, primæ Grues comparuerunt in campestribus Pise 20 Feb. &c. F. Redi Exp. Nat. p. 100. ubi plura.

(2) From *מִיָּמֵינוּ* indixit, constituit, scil. locum, vel tempus, ubi vel quando aliquid fieri debet. Buxt. in verb.

De voluntate sua certiore reddidit. Con. Kircher concordant. Pars 1. Col. 1846. *מִיָּמֵינוּ* Generaliter pro re aliqua certa, attestata, & definita accipitur. 1. Pro tempore certo & constituto. 2. Deinde pro festo seu Solennitate, qua certo & stato tempore celebratur. 3. Pro loco certo & constituto. Id, ibid. Col. 1847, F f 4 (1)

such Times as the Creator hath appointed those Animals, and hath accordingly, for this end, imprinted upon their Natures such an Instinct as exciteth and moveth them thus, at proper Times, to fly from a Place that would obstruct their Generation, or not afford convenient Food for them, and their Young, and betake themselves to another Place, affording all that is wanting for Food or Incubation.

And this leads me to another thing remarkable in this Act of Migration, and that is, That those unthinking Creatures should know what Way to steer their Course (3), and whither to go. What but the great Creator's Instinct, should ever move a poor foolish Bird to venture over vast Tracts of Land, but especially over large Seas? If it should be said, That by their high Ascents up into the Air, they can see cross the Seas, yet what should teach or perswade them, that that Land is more proper for their Purpose, than this? that *Britain* (for instance) should afford them better Accommodations than *Egypt* (4), than the *Canaries*, than *Spain*,
or

(3) *Quis non cum admiratione videat ordinem & politiam peregrinantium Avium, in itinere turmatim volantium, per longos terrarum & maris tractus absque Acu marina? — Quis eas certum iter in aeris mutabili regione docuit? quis præterita signa, & futura via indicia; quis eas ducit, nutrit, & vitæ necessaria ministrat? Quis insulas & hospitia illa, in quibus victum reperiant, indicavit; modumque ejusmodi loca in peregrinationibus suis inveniendi? Hæc sane superant hominum captum & industriam, qui non nisi longis experientiis, multis itinerariis, chartis geographiis, — & acus magnetice beneficio, — ejusmodi marium & terrarum tractus conficere tentant & audent. Lud. de Beaufort. Cosmop. divina Sect. 5. c. 1.*

(4) I instance particularly in *Egypt*, because Mr. Willughby thinks *Swallows* fly thither, and into *Æthiopia*, &c. and that they do not lurk in Holes, or under Water, as *Olaus Mag-*

or any of those many intermediate Places over which some of them probably fly?

And lastly, to all this let us briefly add the Accommodations these *Birds of Passage* have to enable them to take such long Flights, viz. the Length of their Wings, or their more than ordinary Strength (5) for Flight.

C H A P.

nus reports. vid. *Ornith.* L. 2. c. 3. But *Etmuller* puts the Matter out of doubt; who saith, *Memini me plures, quam quas Medimnus caperet, Hirundines arcte coacervatas intra Piscinæ cannas, sub glacie prorsus ad sensum exanimas, pulsantes tamen, reperiisse.* *Etmuller Dissert.* 2. c. 10. §. 5. This as it is like what *Ol. Magnus* saith, so is a Confirmation of it. The A. Bp's Account is, *In Septentrionalibus aquis sapius casu Piscatoris extrahuntur Hirundines, in modum conglomeratæ massæ, quæ ore ad os, & ala ad alam, & pede ad pedem post principium autumnî sese inter cannas descensuræ colligarunt.* — *Massa autem illa per imperitos adolescentes — extracta, atque in æstuarîa portata, caloris accessu Hirundines resolutæ, volare quidem incipiunt, sed exiguo tempore durant.* *Ol. Mag. Hist.* L. 19. c. 29.

Since my penning this Note, we had at a meeting of the Royal-Society, Feb. 12, 1713², a farther confirmation of *Swallows* retiring under Water in Winter, from Dr. *Colas*, a Person very curious in these Matters; who, speaking of their way of Fishing in the Northern Parts by breaking Holes, and drawing their Nets under the Ice, saith, that he saw 16 *Swallows* so drawn out of the *Lake of Samrodt*; and about 30 out of the Kings great Pond in *Rosineilen*: and that at *Schlebitten*, near an House of the *E. of Lobna*, he saw two *Swallows* just come out of the Waters, that could scarce stand, being very wet and weak, with their Wings hanging on the ground: and that he hath observed the *Swallows* to be often weak for some Days after their appearance.

(5) As *Swallows* are well accommodated for long Flights by their long Wings, so are *Quails* by the strength of their *Pectoral Muscles*, by the breadth of their Wings, &c. For *Quails* have but short Wings for the weight of their Body; and yet they fly from us into warmer Parts, against Winter, and to us in Spring, crossing our Seas. So divers Travellers tell us, they cross the Mediterranean twice a Year, flying from *Europe* to *Africa*, and back again. Thus *Beltonius*

C H A P. IV.

Of the INCUBATION of Birds.

ANother thing relating to the State of this Tribe of Animals, is their *Incubation*.

And first, the Egg it self deserves our Notice. It's Parts within, and it's crusty Coat without are admirably well fitted for the Business of Incubation. That there should be one part provided for the Formation of the Body (1) before it's Exit into the World, and another for it's Nourishment after it is come into the World, till the Bird is able

nus in Mr. Willughby, saith ; When we sailed from *Rhodes* to *Alexandria* of *Egypt*, many Quails flying from the N. towards the S. were taken in our Ship : whence I am verily perswaded, that they shift places. For formerly also, when I sailed out of the Isle of *Zant* to *Morea* or *Negropont*, in the Spring-time I had observed Quails flying the contrary way from S. to N. that they might abide there all Summer. At which time also, there were a great many taken in our Ship. Ornith. pag. 170.

(1) The Chicken is formed out of, and nourished by the White alone, till it be grown great. The Yolk serves for the Chickens nourishment after it is well grown, and partly also after it is hatched. For a good part of the Yolk remains after exclusion, being received into the Chickens Belly ; and being there reserved as in a Store-house, is by the [Appendicula, or Ductus intestinalis] as by a Funnel, conveyed into the Guts, and serves instead of Milk, &c. Willugh. Ornith. L. 1. c. 3. *Ipsum animal ex albo liquore Ovi corporatur. Cibus ejus in luteo est.* Plin. L. 10. c. 53.

Aristotle saith, The long sharp Eggs bring Females ; the round ones, with a larger compass at the sharper end, Males. Hist. An. L. 6. c. 2. After which, he tells of a Sot at *Syracuse*, that fate drinking so long, till Eggs were hatched : as also of the custom of *Egypt*, of hatching Eggs in Dunghills.

able to shift for, and help it self ; and that these Parts should be so accurately braced, and kept in due Place (||), is certainly a designed, as well as curious Piece of Workmanship.

And then as to the Act itself of *Incubation*, what a prodigious Instinct is it in all, or almost all the several Species of Birds, that they, and only they of all Creatures, should betake themselves to this very Way of Generation! How should they be aware that their Eggs contain their Young, and that their Production is in their Power (2)? What should

(||) As the Shell and Skin keep the Yolk and two Whites together, so each of the Parts (the Yolk and inner White at least) are separated by Membranes, involving them. At each end of the Egg is a Treddle, so called, because it was formerly thought to be the Sperm of the Cock. *But the use of these* (saith Dr. Harvey in *Willugh. Ornith. c. 3.*) *is to be as 'twere, the Poles of this Microcosm, and the Connexions of all the Membranes twisted and knit together, by which the Liquors are not only conserved each in its place, but do also retain their due position one to another.* This although in a great Measure true, yet doth not come up to what I have myself observed. For I find, that these *Chalazæ* or *Treddles*, serve not barely to keep the Liquors in their Place and Position to one another ; but also to keep one and the same part of the Yolk uppermost, let the Egg be turned nearly which way it will. Which is done by this Mechanism : The *Chalazæ* are specifically lighter than the Whites, in which they Swim, and being braced to the Membrane of the Yolk, not exactly in the Axis of the Yolk, but somewhat out of it, causeth one side of the Yolk to be heavier than the other : so that the Yolk being by the *Chalazæ* made buoyant, and kept swimming in the midst of the two Whites, is by its own heavy side, kept with the same side always uppermost. Which uppermost side, I have some Reason to think, is that on which the *Cicatricula* lies, that being commonly uppermost in the Shell, especially in some Species of Eggs more I think than others.

(2) All Birds lay a certain number of Eggs, or nearly that number, and then betake themselves to their Incubation : but if their Eggs be withdrawn, they will lay more. Of which, see Mr. Ray's *Wisd. of God.* p. 137.

should move them to betake themselves to their Nests, and there with Delight and Patience to abide the due Number of Days? And when their Young are gotten into the World, I have already shewn how admirable their Art, their Care, and *Στοργή* is in bringing them up until, and only until, they are able to shift for themselves.

And lastly, when almost the whole Tribe of Birds do thus by Incubation produce their Young, it is a wonderful Deviation, that some few Families only should do it in a more novercal Way (3), without any Care or Trouble at all, only by laying their Eggs in the Sand, exposed to the Heat and Incubation of the Sun. Of this the Holy Scripture itself gives us an Instance in the Ostrich. Of which we have an Hint, Lam. 4. 3. *The Daughter of my People is become cruel, like the Ostriches in the Wilderness.* This is more plainly expressed in Job. 39. 14, 15, 16, 17. [The Ostrich] *leaveth her Eggs in the Earth, and warmeth them in the Dust, and forgetteth that the Foot may crush them,*
or

(3) The *Talon* is a Bird no bigger than a Chicken, but lays an Egg larger than a Goose's Egg, and bigger than the Bird it self. These they lay a Yard deep in the Sand, where they are hatched by the warmth of the Sun; after which they creep out, and get to Sea for Provisions. *Navarette's Account of China in Collect. of Voyages. Vol. 1.* This account is in all probability borrowed from *Nieremberg*, or *Hernandez* (that copied from him) who call this Bird by the name of *Daie*, and its Eggs *Tapun*, not the Bird it self, as *Navarette* doth. But my Friend Mr. Ray saith of it, *Historia isthac proculdubio fabulosa & falsa est. Quamvis enim Aves nonnulla maxima ova pariunt, ut v. g. Alcx, Lomwix, Anates Arcticæ, &c. hujusmodi tamen unum duntaxat, non plura ova ponunt antequam incubent: nec ullam in rerum natura avem dari existimo cujus ova albumine careant. Cum Albumen precipua ovi pars sit, quodque primum fœtui alimentum subministrat.* *Raii Synop. Av. Method. p. 155.*

or that the Wild-Beast may break them. She is hardened against her Young ones, as though they were not hers: her Labour is in vain without Fear. Because God hath deprived her of Wisdom, neither hath he imparted unto her Understanding. In which Words I shall take Notice of three things, 1. Of this anomalous Way of Generation. It is not very strange, that no other Incubation but that of the Sun, should produce the Young; but 'tis very odd and wonderful that any one Species should vary from all the rest of the Tribe. But above all, 2. The singular Care of the Creator in this Case is very remarkable, in supplying some other Way the Want of the Parent-Animals Care, and *ἐπεγὴν* (4), so that the Young should be notwithstanding bred up in those large and barren Desarts of *Arabia* and *Africa*, and such like Places where those Birds dwell, the most unlikely and unfitting (in all human Opinion) to afford Sustenance to young helpless Creatures, but the fittest therefore to give Demonstrations of the Wisdom, Care, and especial Providence of the infinite Creator and Conservator of the World. 3. The last thing I shall remark is, That the Instincts of Irrational Animals, at least of this specified in the Text, is attributed to G O D. For the Reason the Text gives

(4) *The Eggs of the Ostrich being buried in the Sand, are cherished only by the heat of the Sun, till the Young be excluded. For the Writers of Natural History do generally agree, that the old Birds, after they have laid, and covered their Eggs in the Sand, forsake them, and take no more care of them.* Willugh. Ornith. L. 2. c. 8. §. 1.

But there is another *Ostrich* [of *America*] which *Acaret* tells us of, that takes more care of her Young, by carrying four of her Eggs, a little before she hatcheth, to four parts of her Nest, there to breed Worms for Food for her Young. *Acaret's Disc. in Philos. Transact. No. 89.*

gives why the *Ostrich* is hardened against her Young ones, as though they were not her's, is Because G O D hath deprived her of Wisdom, and not imparted Understanding to her: i. e. he hath denied her that Wisdom, he hath not imparted that Understanding, that *Στοιχὴ*, that natural Instinct to provide for, and nurse up her Young, that most other Creatures of the same, and other Tribes are endowed with.

Thus I have dispatched what I intend to insist upon concerning the State of this Set of Animals; of which, as also of their admirable Instincts, a great deal more might deserve our especial Observation; particularly the admirable Curiosity, Art and Variety of Nidification (5) used among the various Species of Birds; the great Sagacity, and many Artifices used by them in the Investigation and Capture of their Prey (6), the due Proportion of the more and less useful, the Scarcity of the Voracious and Pernicious, and the Plenty of the Manfuate and Useful (7). Also the Variety of their Motion and Flight might deserve consideration, the Swiftness of such whose Food is to be sought in far distant Places, and different Seasons (8); the slower Motion, and short Flights of others more domestick; and even the Awkwardness of some others to Flight, whose Food is near at Hand, and to be gotten without any great occasion of Flight (9). These and divers other

(5) See Book 4. ch. 13.

(6) See Book 4. ch. 11, and 14.

(7) See Book 4. ch. 10. begin.

(8) See Book 4. ch. 8.

(9) The *Colymbi*, or *Douckers*, having their Food near at hand in the Waters, are remarkably made for diving therein. Their Heads are small, Bills sharp-pointed, Wings small,

other such like things as these, I say, I might have spoken more largely unto ; but I shall pass them by with only a bare Mention, having already taken Notice of them in the Company of other Matters of the like Nature, and manifested them to be Acts of excellent Design, Wisdom, and Providence, in the Great Creator.

C H A P. V.

The CONCLUSION.

AND now, if we reflect upon the whole Matter, we shall here find another large Tribe of the Creation abundantly setting forth the Wisdom and Glory of their great Creator. We praise the Ingenuity and Invention of Man, for the Contrivance of various pneumatick Engines ; we think them witty even for their unsuccessful Attempts to swim in, and sail through that subtile Element the Air ; and the curious Mechanism of that Artist is had in remembrance, and praised to this day, who made a Dove, or an Eagle (†) to fly but a short space. And is not therefore all imaginable Honour and Praise due to that infinite Artist that hath so admirably contrived, and made, all the noble Variety of Birds ; that hath with such incomparable Curiosity, and Art, formed their Bodies from Head to Tail, without and within, that not so much as
any

small, Legs flat and broad, and placed backward, and nearer the Tail than in other Birds ; and lastly, their Feet, some whole-footed, some cloven-footed, but fin-toed. *vid. Willughb. Ornith. L. 3. §. 5.*

(†) *Vid. Book 5. ch. 1. Note 25.*

any Muscle or Bone, no not even a Feather (||) is unartificially made, misplaced, redundant, or defective, in all the several Families of this large Tribe! but every thing is so incomparably performed, so nicely fitted up for Flight, as to surpass even the Imitation of the most ingenious Artificer among mortal rational Beings?

CHAP:

(||) *Deus non solum Angelum, & Hominem, sed nec exigui & contemptibilis animantis viscera, nec Avis pennulam, nec Herba flosculum, nec Arboris folium sine suarum partium convenientia dereliquit.* Augustin. de Civ. Dei L. 5. c. 11.



BOOK

BOOK VIII.

Of INSECTS and REPTILES.

CHAP. I.

Of INSECTS in general.



HAVING dispatched that part of the animal World, which used to be accounted the more perfect, those Animals styled less perfect, or imperfect will next deserve a Place in our Survey, because when strictly enquired into, we shall find them to be so far from deserving to be accounted mean and despicable Parts of the Creation, owing their Original and Production to Putrefactions, &c. as some have thought, that we shall find them, I say, noble, and most admirable Works of GOD. For, as the famous Natural Historian, *Pliny* (1), prefaceth his Treatise of *Insects* to prevent the Reproach of condescending (as might be thought) to so mean a Subject; *In great Bodies*, saith he, *Nature had a large and easy Shop to work upon obsequious Matter. Whereas*, saith he, *in these so small, and as it were no Bodies, what Footsteps of Reason, what Power, what great Perfection* is

(1) *In magnis siquidem Corporibus, &c. Plin. Nat. Hist. L. 11. c. 2.*

is there! Of this having given an Instance of two of the exquisite Senses, and curious Make of some Insects (2), he then goes on, *We admire* saith he, *the turrigerous Shoulders of Elephants, the lofty Necks and Crests of others; but saith he, the Nature of things is never more compleat than in the least things.* For which Reasons he intreats his Readers (as I do mine) *that because they slighted many of the things themselves which he took Notice of, they would not therefore disdainfully condemn his Accounts of them, since, saith he, in the Contemplation of Nature nothing ought to seem superfluous.*

Thus that eminent Naturalist hath made his own, and my Excuse too; the Force and Verity whereof will farther appear by what I shall say of these Animals; which (as despicable as they have been, or may perhaps be thought) we shall find as exquisitely contrived, and curiously made for that Place and Station they bear in the World as any other Part of the Animal World. For if we consider the innumerable Variety of their Species, the prodigious Numbers of Individuals the Shape and Make of their little Bodies, and every

(2) *Ubi tot sensus collocavit in Culice? & sunt alia dicta minora. Sed ubi Visum in eo prætendit? Ubi Gustatum applicavit? Ubi Odoratum inseruit? Ubi vero truculentam illam & portione maximam vocem ingeneravit? qua subtilitate Pennas adnexuit? praelongavit Pedum crura? Disposuit jejuna Caveam, uti Alvim? Avidam Sanguinis, & potissimum humani sitim accendit? Telum vero perfodiendo tergori, quo spiculavit ingenio? Atque ut in capaci, cum cerni non possit exilitas, ita reciproca geminavit arte, ut fodiendo acuminatum pariter sorbendoque fistulosum esset. Quos Tereдини ad perforanda Robora cum sono teste dentes affixit! Potissimumque ligno cibatum fecit? Sed turrigeros Elephantorum miramur humeros, Taurorumque colla, & truces in sublime jactus, Tigrium rapinas, Leonum jubas, cum rerum natura nusquam magis quam in minimis, tota sit. Plin. ibid.*

every Part thereof, their Motion, their Instincts, their regular Generation and Production, and to name no more, the incomparable Beauty and Lustre of the Colours of many of them, what more admirable and more manifest Demonstration of the infinite Creator, than even this little contemned Branch of the Animal World. But let us take a short View of Particulars.

C H A P. II.

Of the SHAPE and STRUCTURE of Insects.

LET us begin with the Shape and Fabrick of their Bodies. Which although it be somewhat different from that of Birds, being particularly for the most part not so sharp before, to cut and make way through the Air, yet is better adapted to their manner of Life. For considering that there is little Necessity of long Flights, and that the Strength and Activity of their Wings doth much surpass the Resistance their Bodies meet with from the Air, there was no great Occasion their Bodies should be so sharpened before. But the Condition of their Food, and manner of gathering it, together with the great Necessity of accurate Vision by that admirable Provision made for them by the reticulated *Cornea* of their Eyes; these things, I say, as they required a larger Room, so were a good Occasion for the largeness of the Head, and it's Amplitude before. But for the rest of their Body, all is well made, and nicely poised for their Flight, and every other of their Occasions.

And as their *Shape*, so the *Fabrick* and *Make* of their Bodies, is no less accurate, admirable, and

singular ; not built throughout with Bones, and covered with Flesh and Skin, as in most other Animals ; but covered with a curious Mail of a middle Nature (||), serving both as Skin and Bone too, for the Shape, as well as Strength and Guard of the Body, and as it were on purpose to shew that the great Contriver of Nature is not bound up to one way only.

C H A P. III.

Of the EYES and ANTENNÆ of Insects.

TO this last mentioned Guard we may add that farther Guard provided in the *Eyes* and *Antennæ*. The Structure of the Eye is in all Creatures an admirable Piece of Mechanism ; but that observable in the Eyes of Insects so peculiar that it must needs excite our Admiration: fenced with it's own Hardness, yea even it's own accurate Vision is a good Guard against external Injuries ; and it's *Cornea*, or outward Coat all over beset with curious, transparent, lenticular (1) Inlets

(||) *Insecta non videntur Nervos habere, nec Offa, nec Spinas, nec Cartilaginem, nec Pinguia, nec Carnes, ne Crustacea quidem fragilem, ut quadam marina, nec quæ jure dicatur Cutis : sed mediæ cujusdam inter omnia hæc naturæ corporis.* &c. Plin. N. H. L. 11. c. 4.

(1) The *Cornea* of Flies, Wasps, &c. are so common an entertainment with the Microscope, that every body knows it is a curious piece of Lattice-work. In which this is remarkable, that every *Foramen* is of a lenticular Nature ; so that we see Objects through them topsy-turvey, as through so many convex Glasses : yea, they become a small Telescope, when there is a due focal distance between them and the Lens of the Microscope.

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of such as walk, or hang upon smooth Surfaces (2): the great Strength and Spring in the Legs of such as Leap (3): the strong and well made Feet and Talons of such as Dig (4): and to name no more, the admirable Faculty of such as cannot fly, to convey themselves with Speed and Safety, by the help of their Webs (5), or some other

dious Joynts flat, and Bristles on each side towards the end, serving for Oars to Swim: and then nearer the Body, are two stiff Spikes, to enable them to walk when Occasion is.

(2) I might here name divers Flies and other Insects, who besides their sharp, hooked Nails, have also skinny Palms to their Feet, to enable them to stick on Glass, and other smooth Bodies, by means of the pressure of the Atmosphere. But because the Example will illustrate another work of Nature as well as this, I shall chuse a singular piece of Mechanism in one of the largest sorts of *Hydrocantbari*. Of these there are two sorts, one largest, all black, with *Antenne* handsomly embossed at the ends. The other somewhat lesser, hardly so black, with capillary *Antenne*; the Forehead, Edges of the *Vagina*, and two Rings on the *Thorax*, of a tawny Colour. The Female hath *Vagina* prettily furrowed; the Male smooth. But that which is most to our purpose in this Male, is a Flap, or hollowish Cap near the middle joynt of the Fore-Legs: which when clap'd on the Shoulders of the Female in *Coitu*, sticks firmly thereon; after the manner as I have seen Boys carry heavy Stones with only a wet piece of Leather clap'd on the top of the Stone.

(3) Thus *Grass-hoppers* and *Crickets* have brawny strong Thighs, with long slender, but strong Legs, which enable them to leap with great Agility and Strength.

(4) I have wondered to see with what great Quickness, Art, and Strength, many *Vespe-ichneumons*, *Wild Bees*, and *Beetles*, perforate the Earth, yea even Wood it self: but the most remarkable Animal in this way, is the *Mole-Cricket* in Book 4. Ch. 13. Note 17.

(5) I have with pleasure often seen Spiders dart out their Webs, and sail away by the help thereof. For the manner of which, see Mr. *Lowth.* Abridg. Vol. 2. p. 794. from Dr. *Lister* and Dr. *Hulse*, who both claimed the Discovery thereof;

other Artifice to make their Bodies lighter than the Air (6): these and a Multitude of other such like

of: and do both seem to have hit thereupon, without any foreknowledge of what each other had discovered, as is said in the last cited place, and as I more plainly find by some original Letters of Mr. Ray's, Dr. Lister's, and Dr. Hulses, in my Hands: by which I also find the two ingenious Doctors were very modest in their Claims, and very amicable in the Matter. In one of Dr. Lister's to Mr. Ray he thinks there is a fair hint of the Darting of Spiders in *Arist. Hist. An. L. 9. c. 39*: and in *Pliny, L. 11. c. 24*: but for their Sailing, that the Ancients are silent, and he thinks it was seen first by him. And in another Letter, Jan. 20 1670, speaking of the height Spiders are able to fly, he saith, *the last October, &c. I took notice, that the Air was very full of Webs, I forthwith mounted to the top of the highest Steeple on the Minster [in York] and could thence discern them yet exceeding high above me. Some that fell, and were intangled upon the Pinnacles, I took and found them to be Lupi which Kind, seldom or never enter Houses, and cannot be supposed to have taken their Flight from the Steeples.*

(6) There are (I imagine) divers Animals, as well as Spiders, that have some way of conveyance, as little known to us, as that of Spiders formerly was. Thus the *Squillulae Pulices arborescentes*, and *Microscopical Animalcules* of the stagnating Waters, so numerous in them as to discolour sometimes the Water, and make them look as if they were tinged Red, Yellow, or Green, or covered with a thick green Scum; all which is nothing but Animalcules of that Colour. That these Creatures have some way of Conveyance I conclude, because most stagnating Waters are stock'd with them; new Pits and Ponds, yea Holes and Gutters on the tops of Houses and Steeples. That they are not bred there by Æquivocal Generation, every ingenious considering Philosopher will grant; that they have not Legs for travelling so far, is manifest from Inspection: and therefore I am apt to think, that they have some faculty of inflating their Bodies, or darting out Webs, and making their Bodies buoyant, and lighter than Air; or their Bodies, when dry, may be lighter than Air, and so they can swim from place to place; or the Eggs of such as are oviparous, may be light enough to float in the Air. But then the Viviparous (as my late ingenious Friend, Mr. Charles King, shewed me the *Pulices aquat. arbores.* are; these I say) can't be this way

account-

like things as these I might, I say, take Notice of, as great Evidences of the Infinite Creator's Wisdom: but lest I should be too tedious, I will confine my Observations to the Legs and Wings only. And these at first View we find to be incomparably fitted up for their intended Service, not to overload the Body, not in the least to retard it, but to give it the most proper and convenient Motion. What for Example can be better contrived and made for this Service than the Wings? distended and strengthened by the finest Bones, and these covered with the finest and lightest Membranes, some of them adorn'd with neat and beautiful Feathers (7), and many of them provided with the finest Articulations, and Foldings, for the Wings to be withdrawn, and neatly laid up in their *Vaginae* and Cases, and again readily extended for Flight (8).

And

accounted for. The cause of these latter Suspicions was, that in the Summer Months, I have seen the *Pulices arbores* and the green Scum on the Waters (nothing but Animalcules, as I said) lye in a manner dry on the surface of the Waters: at which time (as I have shewn in B. 4. ch. 11. Note 13.) those Animalcules copulate: And perhaps, they may at the same time change their Quarters, and seek out new Habitations for their numerous Offspring, as well as themselves.

(7) It is well known to all Persons any way conversant in Microscopical Observations, that these elegant Colours of *Moths*, and *Butter-Flies*, are owing to neat and well made Feathers, set with great Curiosity and Exactness in rows, and good order.

(8) All that have *Elytra*, *Scarabs*, (who have whole *Elytra*, or reaching to the *Podex*) or the *Ἡμικηλόπτεροι*, such as *Earwigs*, and *Staphylini* of all sorts, do by a very curious Mechanism extend and withdraw their Membranaceous Wings (wherewith chiefly they fly) and it is very pretty to see them prepare themselves for Flight, by thrusting out, and unfolding their Wings; and again, withdraw those

Joynts,

And then for the poising of the Body, and keeping it upright, and steady in Flight, it is an admirable Artifice and Provision for this Purpose; in some, by four Wings (9); and in such as have but two, by Pointils and Poises placed under the Wings, on each side the Body.

And lastly, It is an amazing thing to reflect upon the surprising Minuteness, Art, and Curiosity of the (10) Joynts, the Muscles, the Tendons, the Nerves necessary to perform all the Motions of the Legs, the Wings, and every other Part. I have already mentioned this in the larger Animals: but to consider that all these things

Joynts, and neatly fold in the Membranes, to be laid up safely in their *Elytra* or Cases. For which Service the Bones are well placed, and the Joynts ministering thereunto, are accurately contrived for the most compendious and commodious folding up the Wings.

(9) For the keeping the Body steady and upright in Flight, it generally holds true (if I mistake not) that all bipennated Insects have *Poises* under the hinder part of their Wings, but such as have four Wings, or Wings with *Elytra*, none. If one of the Poises be cut off, or one of the lesser Auxiliary Wings, the Insect will fly as if one side overballanced the other, until it falleth on the Ground. So if both be cut off, they will fly awkwardly and unsteadily, manifesting the Defect of some very necessary part. These *Poises* or *Pointills* are, for the most part, little Balls set at the top of a slender Stalk, which they can move every way at pleasure. In some they stand alone, in others, (as in the whole *Flesh-Fly* Tribe) they have little Covers or Shields under which they lye and move. The Use, no doubt, of these *Poises*, and *Secondary* lesser Wings, is to poise the Body, and to obviate all the Vacillations thereof in Flight, serving to the Insect, as the long Pole loaden at the ends with Lead doth the *Rope-dancer*.

(10) As all the parts of Animals are moved by the help of these; so there is no doubt but the minutest Animals have such like Parts. But the Muscles and Tendons of some of the larger Insects, and some of the lesser too, may be seen with a Microscope.

things concur in minute Animals, even in the smallest Mite, yea the Animalcules, that (without good Microscopes) escape our Sight ; to consider, I say, that those minute Animals have all the Joynts, Bones, Muscles, Tendons and Nerves necessary to that brisk and swift Motion that many of them have, is so stupendous a Piece of curious Art (11), as plainly manifesteth the Power and Wisdom of the infinite Contriver of those inimitable Fineries. But having named those minute Animals, why should I mention only any one Part of their Bodies, when we have in that little Compass a whole and compleat Body, as exquisitely formed, and (as far as our Scrutiny can possibly reach) as neatly adorned as the largest Ani-

(11) The minute Curiosities and inimitable Fineries, observable in those lesser Animals, in which our best Microscopes discover no Botch, no rude ill made Work, (contrary to what is in all artificial Works of Man) do they not far more deserve our Admiration, than those celebrated pieces of humane Art : such as the Cup made of a Pepper-Corn, by *Oswald Nerlinger*, that held 1200 little Ivory Cups, all guilt on the Edges, and having each of them a Foot, and yet afforded room for 400 more, in the *Ephem. Germ.* T. 1. Addend. ad Obs. 13. Such also was *Phaethon* in a Ring, which *Galen* thus reflects upon, when he speaks of the Art and Wisdom of the Maker of Animals, particularly such as are small, *Quanto*, saith he, *ipsum minus fuerit, tanto majorem admirationem tibi excitabit ; quod declarant Opifices cum in corporibus parvis aliquid insculpant : cujus generis est quod nuper quidam in Annulo Phaetonta quatuor equis inventum sculpsit. Omnes enim equi frenum, os, & dentes anteriores habebant, &c.* And then having taken notice, that the Legs were no bigger than those of a Gnat, he shews that their Make did not come up to those of the Gnat, as also, saith he, *Major adhuc alia quaedam esse videtur artis ejus, qui Pulicem condidit, Vis atque Sapientia, quod, &c. Cum igitur Ars tanta in tam abjectis animalibus appareat, — quantam ejus Vim ac Sapientiam in praestantioribus inesse putamus ?* *Galen* d: *Us. Part. L. 17. c. 1. fin.*

Animal. Let us consider that there we have Eyes, a Brain, a Mouth, a Stomach, Entrails, und every other part of an Animal-Body, as well as Legs and Feet ; and that all those Parts have each of of them their necessary *Apparatus* of Nerves, of various Muscles, and every other Part that other Insects have ; and that all is covered and guarded with a well-made Tegument, beset with Bristles, adorned with neat Imbrications, and many other Fineries. And lastly, let us consider in how little Compass all this Art and Curiosity may lie, even in a Body many times less than a small Grain of Sand (12), so that the least Drop of Water can contain many of them, and afford them also sufficient Room to dance and frisk about (13).

Having surveyed as many of the Parts of Insects as I care to take notice of, I shall in the next place say somewhat of their State, and Circumstances of Life. And here I shall take Notice only of two things, which have been only hinted at before, but will deserve more particular Consideration here, as being Acts of a wonderful Instinct, namely, Their Security of themselves against Winter ; and their special Care of preserving their Species.

CHAP.

(12) It will in some Measure appear, how wonderfully minute some Microscopical Animalcules are, by what follows in the next Note. But because more particular Examples would be endless, I shall refer to the Observations of Mr. *Leeuwenhoek*, and others, in the *Philos. Transf.* and elsewhere.

(13) It is almost impossible, by reason of their perpetual Motion, and changing Places, to count the number of the Animalcules, in only a drop of the green Scum upon Water ; but I guess I have sometimes seen not fewer than 100 frisking about in a Drop no bigger than a Pin's head. But in such a Drop of Pepper-Water, a far greater Number ; these being much less than those.

C H A P. V.

The SAGACITY of Insects to secure themselves against Winter.

IT is an extraordinary Act of Instinct and Sagacity observable in the Generality of the Insect-Tribe, that they all take care to secure themselves, and provide against the Necessities of Winter. That when the Distresses of Cold and Wet force them, they should retire to warm and dry Places of Safety, is not strange: but it is a prodigious Act of the infinite Conservator's Care to enable some to live in a different Kind of Insect-state; others to live, as without Action, so without Food; and others that act and eat, to lay up in Summer sufficient Provisions against the approaching Winter. Some, I say, live in a different State. For having sufficiently fed, nourished, and bred up themselves to the Perfection of their *Vermicular*, *Nympha-state*, in the Summer Months, they then retire to Places of Safety, and there throw off their *Nympha*, and put on their *Aurelia* or *Chrysalis-state* for all the Winter, in which there are no Occasions for Food. This is the constant Method of many Families of the Insect-Tribe (1).

But

(1) It would be endless to enter into particulars here, because all the *Papilionaceons*, *Flesh*, and *Ichneumon-Fly* Tribes, and all others that undergo the *Nympha* and *Aurelia-state*, between that of the Egg and *Mature-state*, (which are very numerous) appertain to this Note. For a Sample therefore only, I shall take what some may think a mean one, but if considered, deserves our Admiration, and that is the sagacity

But there are others, and some of them in their most perfect State too, that are able to subsist in a kind of Torpitude or Sleeping-state, without any Food at all ; by Reason as there is no Action, so no Wast of Body, no Expence of Spirits, and therefore no need of Food (2).

But for others that move and act, and need Food, it is a prodigious Instinct and Foresight the Creator hath imprinted on them to lay up sufficient Food in Summer for the Winter's (3) Necessities

city of the *White-Butterfly Caterpillar*, which having fed it self its due time, then retires to places of Security. I have seen great Trains of them creeping up the Walls and Posts of the next Houses, where, with the help of some Cobweb-like Filaments, they hang themselves to the Ceilings, and other commodious Places, and then become *Aurelia* ; in which State and Places they hang secure from Wet and Cold, till the Spring and warmer Months, when they are transmitted into Butter-Flies.

(2) I shall not name any of the particular Species of Insects which live in this state, because they are very numerous, but only remark two Things observable in their Sagacity in this Matter : 1. That they are not driven by stress of Weather to their Retirement, but seem as naturally to betake themselves thereto, as other Animals do to Rest and Sleep. For before the approach of cold Weather, towards the end of Summer, we may see some kinds of them flocking together in great numbers within Doors (as *Swallows* do a little before they leave us) as if they were making ready for their Winter's rest. 2. That every Species betakes it self to a proper convenient Receptacle ; some under the Waters to the bottoms of Ponds ; some under the Earth, below the Frosts ; some under Timber, Stone, &c. lying on the ground ; some into hollow Trees, or under the Bark, or in the Wood ; some into warm and dry Places ; and some into dry alone.

(3) There are not many Kinds that thus provide their Food before-hand. The most remarkable, are the *Ant* and the *Bee* ; concerning the first of which, *Origen* hath this Remark, viz. *De solertia Formicarum, ventura hyemi mature prospicientium, sibi que invicem sub onere fessis succurrentium ; quod que fruges arrosas conduunt, ne rursus enascantur, sed per*
a u p u m

ties and Occasions. And it is very pretty to see with what unwearied Diligence all Hands are at work for that Purpose, all the warmer Months. Of this the Holy Scripture it self gives us an Instance in the *Ant*, calling that little Animal *exceeding wise*, Prov. 30. 24. And the Reason is v. 25. *The Ants are a People not strong, yet they prepare their Meat in the Summer.* And therefore Solomon sends the Sluggard to this little contemptible Creature, to learn Wisdom, Foresight, Care, and Diligence, Prov. 6, 6, 7, 8. *Go to the Ant, thou Sluggard, consider her Ways, and be wise: which having no Guide, Overseer, or Ruler, provideth her Meat in the Summer, and gathereth her Food in the Harvest.*

To this Scriptural Example, give me leave to anticipate, and subjoyn an Observation of the farther great Wisdom of this little Creature; and that is their unparalleled *Σμερνή*, their Tenderness, Sagacity, and Diligence about their Young (4). 'Tis very diverting, as well as admira-

annum alimento sint, non ratiocinationem Formicarum in causa debemus credere, sed aliam matrem Naturam bruta quoque sic ornantem, ut etiam minimis addat sua quadam ingenia. Orig. cont. Cels. L. 4.

But as for Wasps, Hornets, Humble-Bees, and other Wild-Bees, *Vespe-Ichneumones*, and divers others that carry in Materials for Nests and Food; this is only for the Service of their Generation, for hatching their Eggs, and nourishing their Young, not for Supplies in Winter. For they all forsake their Nests towards Winter, and retire to other Quarters, living (I conceive) without Food all that time.

(4) *Hos vermiculos [Formicarum Ova vulgo vocatos] incredibili Σμερνή & cura Formicæ educant, summamque dant operam, ne vel tantillum, quod spectet eorum vermiculorum educationem atque nutritionem, omittant: quem in finem fere semper eosdem ore circumportant secum, ne ulla eos ladat injuria. In museo meo nonnullas istius generis formicas vitro terra repleto conclusas cum Vermiculis istis adservabam: ibi non sine jucunditate spectabam, quo terra fieret in superficie*
siccior

mirable to see, with what Affection, and Care they carry about their Young in their Mouths, how they expose themselves to the greatest Dangers, rather than leave their Young exposed, or forsaken ; how they remove them from Place to Place in their little Hills, sometimes to this Part, sometimes to that, for the Benefit of convenient Warmth, and proper Moisture ; and then again withdraw, and guard them against Rain, and Cold. Now that this great Wisdom which the Scriptures attribute unto, and is discernible in this little Animal, is owing only to the Instinct, or Infusions of the great Conservator of the World, is evident, because either this Wisdom, Thought, and Forecast is an Act of the Animal
it

siccior, eo profundius Formicas cum fœtibus suis prorepere : cum vero aquam adfunderem, visu mirificum erat, quanto affectu, quanta solitudine, quanta cōp̄yā omnem in eo collocarent operam, ut fœtus suos sicciorē & tuto loco reponerent. Sæpius vidi, cum aliquot diebus aqua caruissent, atque cum affuso tantillo aqua terram illam humectarem, e vestigio a Formicis fœtus suos eo loci fuisse allatos, quos ibi distincte conspiciebam moveri atque sugere humorem. Multoties fui conatus, ut eos Vermiculos ipse educarem, at semper conatum fefellit eventus : neque ipsas Formicarum Nymphas alimenti jam non indigas unquam sine ipsis Formicis potui motu artificiali excludere. J. Swammerd. Epilog. ad Hist. Insect. p. 153.

Sir Edward King, who was very curious in examining the Generation of Ants, observes their great Care and Diligence. 1. About their Sperm, or true Eggs, which is a fine white Substance like Sugar, which they diligently gather together into an heap when scattered ; and on which they lye in Multitudes, (I suppose, by way of Incubation.) 2. I have observed, saith he, in Summer, that in the Morning they bring up those of their Young (call'd Ant-Eggs) towards the top of the Bank : so that you may from 10 in the Morning, until 5 or 6 Afternoon, find them near the Top ——— for the most part on the South side the Bank. But towards 7 or 8 at Night, if it be cool, or likely to rain, you may dig a Foot deep before you can find them. *Philos. Transf. No. 23. or Lowthorp's Abridg. V. 2. p. 7, and 9.*

it self, or of some other Being that hath Wisdom. But the Animal being irrational, 'tis impossible it can be it's own Act, but must be derived, or received from some wise Being. And Who! What can that be, but the infinite Lord, Conservator and Governour of all the World?

C H A P. VI.

Of the Care of INSECTS about their YOUNG.

THE other notable Instinct I am to treat of, is the peculiar Art and Care of the Insect-Tribe about the Preservation of their Species. Here I might speak of many things, but I have occasionally mentioned divers of them before, under some or other of the general Heads, and therefore shall fix only upon two things relating to their special Art and Care about the Production (1) of their Young, which have not been so particularly spoken to as they deserve.

One thing is their singular Providence for their Young, in making or finding out such proper Receptacles and Places for their Eggs and Seed, as that they may receive the advantage of a sufficient Incubation, and that the Young, when produced, may have the benefit of proper and sufficient Food for their Nurture and Education, till they

(1) The Doctrine of *Æquivocal Generation*, is at this Day sufficiently exploded by all Learned Philosophers, that I shall not enter the Dispute, but take it for granted, that all Animals spring from other Parent-Animals. If the Reader hath any doubt about it, I refer him to *Seigneur Redi de Gen. Insect.* and *Mr. Ray's Wisd. of God, &c. p. 344.* See also before Book 4. Ch. 15. Note 1.

they are able to shift for themselves. It is admirable to see with what Diligence and Care the several Species of Insects lay up their Eggs or Sperm in their several proper Places : not all in the Waters in Wood, or on Vegetables ; but those whose Substance is in the Waters, (2) in the Water ; those to whom Flesh is a proper Food, in Flesh (3) ; those

(2) It would be endless to specify the various Species of Insects, that have their Generation in the Waters. And therefore I shall only observe of them. 1. That their Eggs are always laid up with great Care, and in good order. And also 2. Where proper and sufficient Food is. 3. That in their *Nympha*-state in the Waters, they have parts proper for Food and Motion ; and in many or most of them very different from what they have in their *Mature* State. A manifest Argument of the Creator's Wisdom and Providence. For an Instance, see Note 17.

(3) As *Seigneur Redi* was one of the first that made it his Business to discard Anomalous Generation, so he tried many Experiments relating to the Vermination of Serpents, Fish, putrified Vegetables, and in short, whatever was commonly known to be the Nursery of Maggots, more I probably, than any one hath done since. And in all his Observations, he constantly found the Maggots to turn into *Aurelia*, and these into Flies. But then saith, *Dubitare cupi, utrum omne hoc vermium in carne genus, ex solo Muscarum semine, an ex ipsis putrescentis carnibus oriretur, tanto magis confirmabar in hoc meo dubio, quanto in omnibus generationibus ——— saepius videram, in carnibus, antequam verminare inciperent, resedisse ejusdem speciei Muscas, cui propago postea nascebatur.* Upon this he tells us, he put Flesh, &c. into Pots, which he covered close from the Fly with Paper, and afterwards (for the free Air sake) with a Lawn, whilst other Pots were left open, with such Flesh, &c. in them : that the Flies were very eager to enter into the covered Pots : and that they produced not a Maggot, when the open ones had many. *Fr. Redi de Ge. Insect.*

Among the Insects that come from the Maggots he mentions, he names *Culices*. Now from the most critical Observations I have made, I never observed any sort of Gnats come from putrified Flesh, Vegetables, or any other th

to whom the Fruits(4) or Leaves of Vegetables are
Food,

he taxeth with them. So that either he means by *Culex*, some Fly that we call not by the name of *Gnat*; or else their *Gnats* in *Italy*, vary in their Generation from ours in *England*. For among above 30, near 40 distinct Species of *Gnats* that I have observed about the Place where I live, I never found any to lay their Eggs in Flesh, Fish, &c. but the largest Sort called by *Aldrovand*, *Culices maximi*, by *Swammerdam*, *Tipula terrestres*, lay their Eggs in Meadows, &c. under the Grass: one of the larger middle sort, in dead Beer, Yeast, &c. lying on the tops, or in the leaks of Beer-Barrels, &c. and all the rest (as far as ever I have observed) lay and hatch in the Waters, as in Note 17.

The Generation of the second of these being akin to some of the foregoing Instances, and a little out of the way, may deserve a Place here. This *Gnat* lays its Eggs commonly in dead Beer, &c. as I said, and probably in Vinegar, and other such Liquors. Some time after which, the Maggots are so numerous, that the whole Liquor stirreth as if it was alive; being full of Maggots, some larger, some smaller. The larger are the Offspring of our *Gnat*; the smaller, of a small dark coloured Fly tending to reddish; frequent in Cellars, and such obscure Places. All these Maggots turn to *Aurelia*, the larger of which, of a Tan-Colour, turn to our *Gnat*. This *Gnat* is of the unarmed Kind, having no Spear in its Mouth. Its Head is larger than of the common *Gnats*; a longer Neck; short joyned *Antennae*; spotted Wings, reaching beyond its slender *Alvius*: it is throughout of a brown Colour, tending to Red, especially in the Female. The chief difference between the Male and Female, is (as in other *Gnats*, yea most Insects) the Male is less than the Female, and hath a slenderer Belly, and its Podex not so sharp as the Females is.

(4) The Insects that infest Fruits, are either of the *Ichneumon-Fly* kind, or *Phalena*. Plums, Pease, Nuts, &c. produce some or other *Ichneumon-Fly*. That generated in the Plum is black, of a middle-size, its Body near $\frac{1}{2}$ Inch long, its Tail not much less, consisting of 3 Bristles, wherewith it conveys its Eggs into Fruits: its *Antennae*, or Horns long, slender, recurved; its Belly longish, tapering small towards the Thorax; Legs reddish; Wings membranaceous, thin and transparent, in number 4, which is one Characteristick of the *Ichneumon-Fly*.

Food are accordingly repositied, some in this Fruit, some on this Tree (5), some on that Plant (6),
some

The *Pease Ichneumon-Fly*, is very small, Wings large, reaching beyond the *Podex*; *Antennæ* long; *Alous* short, shaped like an Heart, with the point towards the *Anus*: it walketh and flieth slowly. No Tail appears as in the former; but they have one lieth hidden under the Belly, which they can at pleasure bend back, to pierce *Pease* when young and tender, and other things also, as I have reason to suspect, having met with this (as indeed the former too) in divers Vegetables.

Pears and *Apples* I could never discover any thing to breed in but only the lesser *Phalana*, about $\frac{4}{10}$ Inch long, whitish underneath; greyish brown above (dappled with brown Spots, inclining to a dirty Red) all but about a third part at the end of the Wings, which is not grey, but brown, elegantly striped with wavy Lines of a Gold-Colour, as if Gilt. Its Head is small, with a Tuft of whitish brown Down in the Forehead; *Antennæ* smooth, moderately long. The *Aurelia* of this Moth is small, of a yellowish brown. I know not what time they require for their Generation out of Boxes: but those I laid up in *August*, did not become Moths before *June* following.

(5) There are many of the *Phalana* and *Ichneumon-Fly* Tribes, that have their Generation on the Leaves, or other Parts of Trees and Shrubs, too many to be here reckoned up. The *Oak* hath many very beautiful *Phalana*, bred in it's convolved Leaves, White, Green, Yellow, Brown, spotted prettily, and neatly dappled, and many more besides, and it's Buds afford a Place for Cases, and Balls of various sorts, as shall be shewn hereafter; it's Leaves expanded minister to the Germination of globular and other sphaeroidal Balls, and flat Thecæ, some like Hats, some like Buttons excavated in the middle, and divers other such like Repositories, all belonging to the *Ichneumon-Fly* kind. And not only the *Oak*, but the *Maple* also, the *White-thorn*, the *Briar*, *Privet*, and indeed almost what not Tree, and Shrub?

(6) And as Trees and Shrubs, so Plants have their peculiar Insects. The *White Butterfly* lays it's voracious Offspring on Cabbage-leaves: a very beautiful reddish ocellated one, it's no less voracious black Offspring of an horrid Aspect, on the Leaves of Nettles; as also doth a very beautiful

some on another, and another : but constantly the same Family on the same Tree, or Plant, the most agreeable to that Family. And as for others that require a constant and greater Degree of Warmth, they are accordingly provided by the Parent Animal with some Place in or about the Body of other Animals ; some in the Feathers of Birds (7) ; some in the Hair of Beasts (8) ; some
in

tiful small greenish *Ichneumon-Fly* in Cases on the Leaves of the same Plant ; and to name no more (because it would be endless) the beautiful *Ragwort-Moth* whose Upper-Wings are brown, elegantly spotted with red, and Under-Wings are red, edged with brown ; these, I say, provide for their beautiful golden-ring'd *Eruca* upon the *Ragwort-Plant*.

(7) Many if not most sorts of Birds are infested with a distinct Kind of *Lice* ; very different from one another in Shape, Size, &c. For Figures and Descriptions of them I shall refer to *Segnieur Redi of Insects*. See also *Mouffet L. 2. c. 23*. These Lice lay their Nits among the Feathers of the respective Birds ; where they are hatched and nourished : and as *Aristotle* saith, would destroy the Birds, particularly Pheasants, if they did not dust their Feathers. *Loco infr. citat.*

(8) And as Birds, so the several sorts of Beasts have their peculiar sorts of Lice ; all distinct from the two Sorts infesting Man. Only the *Ass*, they say, is free, because our *Saviour* rode upon one, as some think : but I presume it is rather the Passage in *Pliny L. 11. c. 33*. or rather *Arist. Hist. Animal. L. 3. c. 31*. who saith, *Quibus pilus est, non carent eodem [Pediculo] excepto Asino, qui non Pediculo tantum, verum etiam Redivio immunis est*. And a little before speaking of those in Men, he shews what Constitutions are most subject to them, and instanceth in *Alcman* the Poet, and *Pherecydes Syrius* that died of the *Pthiriasis*, or Lowly Disease. For which foul Distemper if Medicines are desired, *Mouffet de Insect. p. 262*. may be consulted. Who in the same page hath this Observation, *Animadverterunt nostrates — ubi Afores insulas a tergo reliquerint, Pediculos confestim omnes tabescere ; atque ubi eas reviserint, iterum innumeros alios subito oriri*. Which Observation is confirmed by *Dr. Stubbs. V. Louth. Abridg. V. 3. p. 558*.

in the very Scales of Fishes (9); some in the Nose (10); some in the Flesh (11); yea some in the

(9) Fishes, one would think, should be free from Lice, by reason they live in the Waters, and are perpetually moving in, and brushing through them: but yet they have their Sorts too.

Besides which I have frequently found great Numbers of long slender Worms in the Stomachs and other Parts of Fish, particularly *Cod-Fish*, especially such as are poor: which Worms have worked themselves deeply into the Coats and Flesh, so that they could not easily be gotten out. So *Aristotle* saith of some Fishes, *Ballero & Tilloni Lumbri-
eus innascitur, qui debilitat &c. Chalcis vitio infestatur divo,
ut Pediculi sub Branchiis innati quam multi interimant.* Hist. An. L. 8. c. 20.

(10) Of Insects bred in the Nose of Animals, those in the Nostrils of *Sheep* are remarkable. I have my self taken out not fewer at a time than 20 or 30 rough Maggots lying among the Laminæ of the Nostrils. But I could never hatch any of them, and so know not what Animal they proceed from: but I have no great Doubt, they are of the *Ichneumon-Fly* Kind; and not improbably of that with a long Tail, called *Trisetia*, whose three Bristles seem very commodious for conveying it's Eggs into deep Places.

I have also seen a rough whitish Maggot, above two Inches within the *Intestinum rectum* of Horses, firmly adhering thereto, that the hard Dung did not rub off. I never could bring them to Perfection, but suspect the *Side-Fly* proceeds from it.

(11) In the Backs of *Cows* in the Summer-Months, there are Maggots generated, which in *Essex* we call *Wornils*: which are first only a small Knot in the Skin, and I suppose no other than an Egg laid there by some Insect. By degrees these Knots grow bigger, and contain in them a Maggot, lying in a purulent Matter: they grow to be as large as the end of one's Finger, and may be squeezed out at a Hole they have always open: they are round and rough, and of a dirty White. With my utmost Endeavours and Vigilance, I could never discover the Animal they turn into; but as they are somewhat like, so may be the same as those in the Note before.

In *Persia* there are very long slender Worms bred in the Legs, and other Parts of Men's Bodies, 6 or 7 Yards long.

In *Philos. Transf.* Mr. Dent, and Mr. Lewis relate divers Examples of Worms taken out of the Tongue, Gums, Nose, and

the very Bowels (12); and inmost Recesses of the

and other Parts, by a Woman at *Leicester*, which they were Eye-witnesses of. These and divers others mentioned in the *Transactions*, may be seen together in Mr. *Lowthorp's Abridg.* Vol. 3. p. 132.

Narrat mihi vir fide dignus — Casp. Wendlandt — se in Polonia puero cuidam rustico duorum annorum Vermiculum album e palpebra extraxisse, — magnitudinis Erucæ. — Similem fere huic causam mihi [Schulzio] & D. Segero narravit hoc Anno 1676. chirurgus noster Ant. Statlender, qui cuidam puero ex Aure extraxit Vermiculum talem, qualis in nucibus avellanis perforatis latitare solet, sed paulo majorem, coloris albißimi; alteri minores 5 ejusdem generis similiter ex Aure: omnes aliquot horas supervixerunt — Vermiculos adhuc viventes oculis nostris vidimus. Ephem. Germ. T. 2. Obs. 24. ubi Vermiculi Icon. Many other Instances may be met with in the same Tome, Obs. 147, 148, 154

The Worms in Deer are mentioned often among ancient Writers. Aristotle saith *Σκώληκος ὁρίτοι πάντες ἔχουσιν, ἐν τῇ παραλῇ ζώντας*, &c. They [Deer] all have live Worms in their Heads; bred under the Tongue, in a Cavity near the Vertebra on which the Head is placed; their Size not less than of the largest Maggots: they are bred all together, in number about 20. Aristot. Hist. Animal. l. 2. c. 15.

To these Examples may be added the Generation of the *Ichneumon-Fly* in the Bodies of Caterpillars, and other *Nymphae* of Insects. In many of which that I have laid up to be hatched in Boxes, instead of *Papilios*, &c. as I expected, I have found a great number of small *Ichneumon-Flies*, whose Parent-Animal had wounded those *Nymphae*, and darted its Eggs into them, and so made them the Foster-Mother of its Young. More particulars of this way of Generation may be seen in the great Mr. *Er. Willughby's* Observations in *Phil. Transf.* No. 76. But concerning the farther Generation of this Insect, I have taken notice of other Particulars in other places of these Notes.

(12) The Animals ordinarily bred in the Stomach and Guts, are the three sorts of Worms called *Lati*, *Teretes*, and *Ascarides*; concerning which, it would be irksome to speak in particular, and therefore I shall refer to *Moufet*, L. 2. c. 31, 32, 33, Dr. *Tyson's* Anatomy of them in Mr. *Lowthorp's Abridg.* V. 3. p. 121, *Seignr Redi's Obs.* and others that have written of them.

And not only *Worms*, but other Creatures also are said to be found in the Stomach: Instances of which are so innumerable, that I shall only select a few related by Persons of the best Credit. And first of all, by some of our own Countrymen. Dr. *Lister* (whose Credit and Judgment will hardly be questioned) gives an account of true Caterpillars, vomited up by a Boy of nine Years Old; and another odd Animal by a poor Man. Mr. *Jessop* (another very judicious, curious, and ingenious Gentleman) saw *Hexapods* vomited up by a Girl; which *Hexapods* lived and fed for 9 Weeks. See *Lowth.* ib. p. 135.

And as to Foreigners, it is a very strange Story (but attested by Persons of great Repute) of *Catharina Geileria*, that died in Feb. 1662, in the Hospital of *Altenburg*, in *Germany*, who for 20 Years voided by Vomit and Stool, *Toads* and *Lizards*, &c. *Ephemer. Germ.* T. 1. Obs. 103. See also the 109 Observation of a Kitten bred in the Stomach, and vomited up: of Whelps also, and other Animals, bred in like manner. But I fear a Stretch of Fancy might help in some of those last Instances, in those days when spontaneous Generation was held, when the Philosophers seem to have more slightly examined such Appearances than now they do. But for the Breeding of *Frogs* or *Toads*, or *Lacerta aquatica* in the Stomach, when their Spawn happeneth to be drank, there is a Story in the 2d Tome of the *Ephem. Germ.* Obs. 56. that favours it; viz. In the Year 1667, A Butchers Man going to buy some Lambs in the Spring, being thirsty, drank greedily of some standing-water, which a while after, caused great Pains in his Stomach, which grew worse and worse, and ended in dangerous Symptoms. At last he thought somewhat was alive in his Stomach, and after that, vomited up three live *Toads*; and so recovered his former Health.

Such another Story, Dr. *Sorbait* tells, and avoucheth it seen with his own Eyes, of one that had a Toad came out of an Abscess, which came upon drinking foul Water. Obs. 103.

(13) Not only in the Guts, and in the Flesh, but in many other parts of the Body Worms have been discovered. One was voided by Urine, by Mr. *Mat. Milford*, supposed to have come from the Kidneys. *Lowth.* ib. p. 135. More such Examples *Moufet* tells of, *ibid.* So the *Vermes Cucurbitini* are very common in the Vessels in Sheep's Livers: and Dr.

Lister

And as for others to whom none of these Methods are proper, but make themselves Nests by Perforations in the Earth, in Wood, or Combs they build, or such like Ways, 'tis admirable to see with what Labour and Care they carry in, and seal up Provisions that serve both for the Producti-
on

Lifter tells of them, found in the Kidney of a Dog, and thinks that the Snakes and Toads, &c. said to be found in Animals Bodies, may be nothing else. *Lowth.* ib. p. 120. Nay, more than all this: in Dr. *Bern. Verzascha's* 6th Observation, there are divers Instances of Worms bred in the Brain of Man. One, a Patient of his, troubled with a violent Headach, and an itching about the Nostrils, and frequent Sneezing; with the use of a sneezing-Powder, voided a Worm, with a great deal of Snot from his Nose. A like Instance he gives from *Bartholine*, of a Worm voided from the Nose of O. W. which he guesseth was the famous *Olaus Wormius*: another, from a Countrey Woman of *Dietmarsh*; and others in *Tulpius*, *F. Hildanus*, *Schenckius*, &c. These Worms he thinks are undoubtedly bred in the Brain: but what way they can come from thence, I can't tell. Wherefore I rather think, they are such Worms as are mentioned in Note 10, and even that Worm that was actually found in the Brain of the *Paris Girl* (when opened) I guess might be laid in the *Lamina* of the Nostrils, by some of the *Ichneumon*, or other Insect-Kind, and might gnaw its way into the Brain through the *Os cribroforme*. Of this he tells us from *Bartholine*, *Tandem cum tabida obiisset, statim aperto cranio presentes Medici totam cerebelli substantiam qua ad dextrum vergit a reliquo corpore sejunctam, nigraque tunicam involutam deprehenderunt: hac tunica rupta latentem Vermem vivum & pilosum duobus punctis splendidis loco oculorum prodidit, ejusdem fere molis cum reliqua Cerebri portione, qui duarum horarum spacio supervixit.* B. Verzas. Obs. Medicæ. p. 16.

Hildanus tells us such another Story, viz. *Filius Theod. aust der Roulen Avunculi mei diuturno vexabatur dolore capitis.*—Deinde febricula & sternutatione exorta, ruptus est Abscessus circa os cribrosum—& Vermis prorepsit. By his Figure of it, the Maggot was an Inch long, and full of Bristles. *Fabri. Hildan. Cent. 1. Obs.*

Galenus Wierus (Physician to the Princ. *Ful. & Cleve*) he saith, told him, that he had at divers times found Worms in the Gall-Bladder in Persons he had opened at *Duseldorp*. *Id. ib. Obs. 60.*

on of their Young, as also for their Food and Nurture when produced (14).

The other Piece of remarkable Art and Care about the Production of their Young, is their Curiosity and Neatness in repositing their Eggs, and in their Nidification.

As to the first of which, we may observe that great Curiosity, and nice Order is generally observed by them in this matter. You shall always see their Eggs laid carefully and commodiously up (15); when upon the Leaves of Vegetables, or other Material on Land, always glued thereon with Care with one certain End lowermost, and with handsome juxta-Positions (16). Or if in the Waters in neat and beautiful Rows oftentimes, in that spermatick Gelatine Matter in which they are repositied, and that matter carefully tied and fastened in the Waters to prevent it's Diffipation (17), or if made to float, so carefully spread and poi-

(14) See before Book 4. Ch. 13. Note 2.

(15) Some Insects lay up their Eggs in Clusters, as in holes of Flesh, and such Places, where it is necessary they should be crowded together; which, no question, prevents their being too much dried up in dry places, and promotes their hatching. But,

(16) As for such as are not to be clustered up, great order is used. I have seen upon the Posts and Sides of Windows, little round Eggs resembling small Pearl, which produced small hairy Caterpillars, that were very neatly and orderly laid. And to name no more, the *White-Butterfly* lays its neat Eggs on the Cabbage-leaves in good order, always gluing one certain end of the Egg to the Leaf. I call them neat Eggs, because if we view them in a Microscope, we shall find them very curiously furrowed, and handsomely made and adorned.

(17) By reason it would be endless to specify the various Generations of Insects in the Waters, I shall therefore (because it is little observed) take *Pliny's* Instance of the *Gnat* a mean and contemned Animal, but a notable Instance of Nature's Work, as he saith.

The

The first thing considerable in the Generation of this Insect is (for the size of the Animal) its vast *Spawn*, being some of them above an Inch long, and half a quarter diameter; made to float in the Waters, and tied to some Stick, Stone, or other fixt thing in the Waters, by a small Stem or Stalk. In this gelatine, transparent *Spawn* the Eggs are neatly laid; in some *Spawns* in a single, in some in a double spiral Line, running round round from end to end, as in Fig. 9, and 10; and in some transversely, as Fig. 8.

When the Eggs are by the Heat of the Sun, and Warmth of the Season hatched into small Maggots, these Maggots descend to the bottom, and by means of some of the gelatine Matter of the *Spawn* (which they take along with them) they stick to Stones and other Bodies at the bottom, and there make themselves little Cases or Cells, which they creep into, and out of at pleasure, until they are arrived to a more mature *Nympha-state*, and can swim about here and there to seek for what Food they have occasion for: at which time, they are a kind of Red-worms above half an Inch long, as in Fig. 11.

Thus far this mean Insect is a good Instance of the divine Providence towards it. But if we farther consider and compare the three States it undergoes after it is hatched, we shall find yet greater Signals of the Creator's Management, even in these meanest of Creatures. The three States I mean are its *Nympha-Vermicular State*, its *Aurelia*, and *Mature-State*, all as different as to Shape and Accoutrements, as if the Insect was three different Animals. In its *Vermicular-State*, it is a Red-Maggot, as I said, and hath a Mouth and other parts accommodated to Food: in its *Aurelia-State* it hath no such parts, because it then subsists without Food: but in its *Mature, Gnat-State*, it hath a curious well made Spear, to wound and suck the Blood of other Animals. In its *Vermicular-State*, it hath a long Worm-like Body, and something analogous to Finns or Feathers, standing erect near its Tail, and running parallel with the Body, by means of which resisting the Waters, it is enabled to swim about by Curvations, or flapping its Body side-ways this way and that, as in Fig. 12.

But in its *Aurelia-State*, it hath a quite different Body, with a *Club-Head* (in which the Head, Thorax, and Wings of the Gnat are inclosed) a slender *Alous*, and a neat *finny-Tail*, standing at right angles with the Body, quite contrary to what it was before; by which means, instead of easy flapping sideways, it swims by rapid, brisk Jirks, the quite contrary way: as is in some measure represented in Fig. 13. But when it becomes a *Gnat*, no finny Tail, no club Head, but all is made in the most accurate manner for Flight and Motion in the Air, as before it was for the Waters. (18)

poised, as to Swim about with all possible Artifice.

And as to their other Faculty, that of Nidification, whether it be exerted by boring the Earth or Wood, or building themselves Cells (18), or spinning and weaving themselves Cases and Webs, it is all a wonderful Faculty of those poor little Animals, whether we consider their Parts where-with they work, or their Work it self. Thus those who perforate the Earth, Wood, or such like, they have their Legs, Feet, Mouth, yea and whole Body accommodated to that Service; their Mouth exactly formed to gnaw those handsome round Holes, their Feet as well made to scratch and bore (19), and their Body handsomely turned and fitted to follow. But for such as build or spin themselves Nests, their Art justly bids Defiance to the most ingenious Artist among Men, so much as tolerably to copy the nice Geometrical Combs of some (20), the earthen Cells of others, or the Webs, Nets and Cases (21) woven

(18) See Book 4. Ch. 13. Notes 12, 13.

(19) Thus the Mouths and other parts of the *Ichneumon-Wasps* in Book 4. Ch. 13. Note 2. So the Feet of the *Grylotalpa*, *ibid.* Note 17.

(20) See the last cited places, Note 13.

(21) Of the textrine art of the *Spider*, and its Parts serving to that purpose; see the last cited Place, Note 21.

Besides these, *Caterpillars*, and divers other Insects, can emit Threads, or Webs for their use. In this their *Nymph-state*, they secure themselves from falling, and let themselves down from the Boughs of Trees, and other high Places, with one of these Threads. And in the Cases they weave, they secure themselves in their *Aurelia-state*.

And not only the Offspring of the *Phalena-Tribe*, but there are some of the *Ichneumon-Fly* kind also, endowed with this textrine Art. Of these I have met with two sorts: one that spun a Milk white, long, round silken Web, as big as the top of ones Finger, woven round Bents, Stalks of Ribwort, &c. in Mea-

ven by others. And here that natural Glue (22) which their Bodies afford some of them to consolidate their Work, and combine it's Materials together, and which in others can be darted out at Pleasure, and spun and woven by them into silken Balls (23), or Webs, I say, this so peculiar, so serviceable a Material, together with the curious Structure of all Parts ministering to this textrine Power, as mean a Business as it may seem, is such

as

Meadows. The other is a lump of many yellow, silken Cases, sticking confusedly together on Posts, under Coleworts, &c. These Webs contain in them, small Whitish Maggots; which turn to a small black *Ichneumon-Fly*, with long Capillary *Antennæ*; Tan-coloured Legs; long Wings reaching beyond their Body, with a black Spot near the middle; the *Alvus*, like an Heart; and in some, a small fetaceous Tail. Some of these Flies were of a shining beautiful green Colour. I could not perceive any difference, at least, not specifical, between the Flies coming from these two Productions.

(22) I have often admired how *Wasps*, *Hornets*, *Ichneumon-Wasps*, and other Insects that gather dry Materials for building their Nests, have found a proper matter to cement, and glue their Combs, and line their Cells; which we find always sufficiently context and firm. But in all probability, this useful Material is in their own Bodies; as 'tis in the *Tinea vestivora*, *Cadew worm*, and divers others. Goedart observes of his *Eruca* Num. 20. 6. that fed upon *Sallow-leaves*, that *hec pulveris aut arena instar comminuit, ac pituitoso quodam sui corporis succo ita maceravit, ut inde accommodatum subeunda mutationi instanti locum sibi exstruxerit. Domuncula hac a communi Salicum ligno nihil differre videbatur, nisi quod longe esset durior, adeo ut cultro vix disrumpi posset.*

(23) An ingenious Gentlewoman of my acquaintance, Wife to a learned Physician, taking much pleasure to keep *Silk-Worms*, had once the curiosity to draw out one of the oval Cases, which the *Silk-Worm* Spins — into all the Silken Wire it was made up of, which to the great wonder as well of her Husband, as her self, — appeared to be, by measure, a great deal above 300 Yards, and yet weighed but two grains and an half. Boyl Subtil. of Effluv. ch. 2.

(24)

as may justly be accounted among the noble Designs and Works of the infinite Creator and Conservator of the World.

In the last Place there is another prodigious Faculty, Art, Cunning, or what shall I call it? that others of those little Animals have to make even Nature itself serviceable to their Purpose, and that is the making the Vegetation and Growth of Trees and Plants, the very means of the building of their little Nests and Cells (24); such
as

(24) Since my penning this, I have met with the most sagacious *Malpighi's* account of *Galls*, &c. and find his Descriptions to be exceedingly accurate and true, having traced my self many of the Productions he hath mentioned. But I find *Italy* and *Sicily* (his Book *de Gallis* being published long after he was made Professor of *Messina*) more luxuriant in such Productions than *England*, at least, than the parts about *Upminster* (where I live) are. For many, if not most of those about us, are taken notice of by him, and several others besides that I never met with; although I have as critically observed all the Excrescences, and other morbid Tumors of Vegetables, as is almost possible, and do believe that few of them have escaped me.

As to the method how those *Galls* and *Balls* are produced, the most simple, and consequently the most easy to be accounted for, is that in the Gems of Oak, which may be called *Squamous-Oak-Cones*, *Capitula squamata*, in *Malpighi*. Whose Description not exactly answering our *English-Cones* in divers respects, I shall therefore pass his by, and shew only what I have observed my self concerning them.

These *Cones* are, in outward appearance, perfectly like the Gems, only vastly bigger; and indeed they are no other than the Gems, encreased in bigness, which naturally ought to be pushed out in length. The cause of which Obstruction of the Vegetation is this; into the very heart of the young tender Gem or Bud (which begins to be turgid in *June*, and to shoot towards the latter end of that Month, or beginning of the next; into this I say) the Parent-Insect thrusts one or more Eggs, and not perhaps without some venomous Ichor therewith. This Egg soon becomes a Maggot, which eats it self a little Cell, in the very heart
or

as are the Galls and Balls found on the Leaves and Branches of divers Vegetables, such as the Oak, the Willow (25) the Briar and some others.

Now

or pith of the Gem, which is the rudiment of the Branch, together with its Leaves and Fruit, as shall be hereafter shewn. The Branch being thus wholly destroyed, or at least, its Vegetation being obstructed, the Sap that was to nourish it, is diverted to the remaining parts of the Bud, which are only the scaly Teguments; which by these means grow large and flourishing, and become a covering to the Insect-Case, as before they were to the tender Branch and its Appendage.

The Case lying within this Cone is at first but small, as the Maggot included in it is, but by degrees, as the Maggot increaseth, so it grows bigger to about the size of a large White-Pease, long and round, resembling the shape of a small Acorn.

The *Insect* it self, is (according to the modern Insectologists) of the *Ichneumon-Fly* kind: with four Membranaceous *Wings*, reaching a little beyond the Body, articulated *Horns*, a large *Thorax*, bigger than the Belly; the *Belly* short and conical; much like the heart of Animals: the *Legs* partly whitish, partly black. The *Length* of the Body from Head to Tail, about $\frac{2}{10}$ of an Inch; its *Colour*, a very beautiful shining Green, in some tending to a dark copper Colour. Figures both of the Cones, Cases, & Insects, may be seen among *Malpighi's* Cutts of Galls, Tab. 13. and Tab. 20. Fig. 72; which Fig. 72. exhibits well enough some others of the *Gall-Insects*, but its *Thorax* is somewhat too short for ours.

(25) Not only the *Willow*, and some other Trees, but Plants also, as *Nettles*, *Ground-Ivy*, &c. have Cases produced on their Leaves, by the Injection of the Eggs of an *Ichneumon-Fly*. I have observed those Cases always to grow in, or adjoyning to some Rib of the Leaf, and their Production I conceive to be thus, *viz.* The Parent-Insect, with its stiff setaceous Tail, terebrates the Rib of the Leaf, when tender, and makes way for its Egg into the very Pith or Heart thereof, and probably lays in therewith, some proper Juice of its Body, to pervert the regular vegetation of it. From this Wound, arises a small Excrecence, which (when the Egg is hatched into a Maggot) grows bigger and bigger as the Maggot increases, swelling on each side the

Leaf

Now this is so peculiar an Artifice, and so far out of the Reach of any mortal Understanding, Wit, or Power, that if we consider the Matter, with some of it's Circumstances, we must needs perceive manifest Design, and that there is the Concurrence of some great and wise Being, that hath from the Beginning taken Care of, and provided for the Animal's Good. For which Reason, as mean as the Instance may seem, I might be excused, if I should enlarge upon it's Particulars. But two or three Hints shall suffice.

In the first Place 'tis certain that the Formation of those *Cases* and *Balls* is quite beyond the cunning of the Animal itself; but it is the Act partly of the Vegetable, and partly of some Virulency, or what shall I call it, in the Juyce, or Egg or both reposit on the Vegetable by the Parent-Animal (26). And as this Virulency is various ac-

cor-

Leaf between the two Membranes, and extending it self into the Parenchymous part thereof, until it is grown as big as two Grains of Wheat. In this Case, lies a small white rough Maggot; which turns to an *Aurelia*, and afterwards to a very beautiful green small *Ichneumon*-Fly.

(26) What I suspected my self, I find confirmed by *Malpighi*, who in his exact and true Description of the Fly bred in the *Oaken-Galls*, saith, *Non sat fuit natura tam miro artificio Terebram, seu Limam condidisse; sed inflicto vulnere, vel excitato foramine infundendum exinde liquorem intra Terebram condidit: quare fracta per transversum muscarum terebra frequentissime, vivente animali, gutta aliquot diaphani humoris effluunt.* And a little after, he confirms by ocular Observation, what he imagined before, viz. *Semel prope Junii finem vidi Muscam, qualem superius delineavi, insidentem quercinae gemmae, adhuc germinanti: harebat etenim foliolo stabili ab apice hiantis gemmae erumpenti; & convulso in arcum corpore, terebram evaginabat, ipsamque tensam immittebat; & tumefacto ventre circa terebra radicem tumorem excitabat, quem interpolatis vicibus remittebat.* In folio igitur, avulsa Musca, minima & diaphana reperi ejecta ova, simillima iis, quae adhuc in tubis supererant. *Non licuit iterum idem admirari spectaculum, &c.* Some-

according to the Difference of it's Animal, so is the Form and Texture of the Cases and Balls excited thereby; some being hard Shells (27), some tender Balls (28), some Scaly (29), some Smooth (30),

Somewhat like this which *Malpighi* saw, I had the good Fortune to see my self once some Years ago: And that was, the beautiful shining *Oak-Ball Ichneumon* strike it's *Terebra* into an *Oak-Apple* divers times, no doubt to lay its Eggs therein. And hence I apprehend we see many *Vermicles* towards the Outside of many of the *Oak-Apples*, which I guess were not what the Primitive Insects laid up in the Gem, from which the *Oak-Apple* had it's Rise; but some other supervenient, additional Insects, laid in after the *Apple* was grown, and whilst it was tender and soft.

(27) The *Aleppo-Galls*, wherewith we make Ink, may be reckoned of this Number, being hard, and no other than Cases of Insects which are bred in them: who, when come to Maturity, gnaw their Way out of them; which is the Cause of those little Holes observable in them. Of the Insects bred in them, See *Phil. Transact.* No. 245. Of this Number also are those little smooth Cases, as big as large *Pepper-Corns*, growing close to the Ribs under *Oaken-Leaves*, globous, but flattish; at first touched with a blushing Red, afterwards growing brown; hollow within, and an hard thin Shell without. In this lieth commonly a rough white Maggot, which becomes a little long-winged, black *Ichneumon-Fly*, that eats a little Hole in the Side of the Gall, and so gets out.

(28) For a Sample of the tender Balls, I shall choose the globous Balls, as round and some as big as small *Musket-Bullets*, growing close to the Ribs, under *Oaken-Leaves*, of a greenish yellowish Colour, with a Blush of Red; their Skin smooth, with frequent Risings therein. Inwardly they are very soft and spongy; and in the very Center is a Case with a white Maggot therein, which becomes an *Ichneumon-Fly*, not much unlike the last. As to this Gall, there is one thing I have observed somewhat peculiar, and I may say providential, and that is, that the Fly lies all the Winter in these Balls in it's Infantile-state, and comes not to it's Maturity till the following Spring. In the Autumn and Winter these Balls fall down with their Leaves to the Ground, and the Insect inclosed in them is there fenced against the Winter-Frosts, partly by other Leaves falling

(30), some Hairy (31), some Long, some Round,
some

pretty thick upon them, and especially by the thick Parenchymous Spongy Walls, afforded by the Galls themselves.

Another Sample shall be the large Oak-Balls, called Oak-Apples, growing in the place of the Buds, whose Generation, Vegetation and Figure, may be seen in *Malpighi de Gallis*. p. 24. and Tab. 10. Fig. 33, &c. Out of these Galls, he saith, various Species of Flies come, but he names only two, and they are the only two I ever saw come out of them: *frequenter* (saith he) *subnigra sunt musca brevis munita terebra*. *Inter has aliqua observantur aurea, levi viridis tinctura suffusa, oblonga pollentes terebra*. These two differently coloured Flies, I take to be no other than Male and Female of the same Species. I have not observed Tail (which are their *Terebra*) in all, as *Malpighi* seems to intimate: perhaps they were hid in their *Theca*, and I could not discover them: but I rather think there were none and that those were the Males: but in others, I have observed long recurvous Tails, longer than their whole Body. And these I take to be the Females. And in the Oak-Apple themselves, I have seen the *Aurelia*, some with, some without Tails. And I must confess, 'twas not without Admiration as well as Pleasure, that I have seen with what exact Neatness and Artifice, the Tail hath been wrapt about the *Aurelia*, whereby it is secured from either annoying the Insect, or being hurt it self.

(29) See before Note 24.

(30) As in the preceding Note.

(31) Of the rough or hairy Excrescences, those on the Briar, or Dog-rose, are a good Instance. These *Spongios villosae* as Mr. Ray, *Galla ramosa* as Dr. *Malpighi* calls them are thus accounted for by the latter; *Ex copiosis relictis ovum ita turbatur affluens [Rubi] succus, ut strumosa fiant complura tubercula simul confuse congesta, quae utriculorum seriebus, & fibrarum implicatione contexta, ramosas propagines germinant, ita ut minima quasi sylva appareat. Qualibet propago ramos, hinc inde villosos edit. Hinc inde pili pariter erumpunt, &c.*

These Balls are a safe Repository to the Insect all the Winter in its Vermicular-State. For the Eggs laid up, and hatched the Summer before, do not come to mature Insect until the Spring following, as Mr. Ray rightly observes *Cat. Cantab.*

some Conical &c. (32). And in the last Place, let us add, That those Species of Insects are all endowed with peculiar and exactly made Parts for this Service, to bore and pierce the Vegetable, and to reach and inject their Eggs and Juyce into the tender Parts thereof.

The CONCLUSION.

AND now these things being seriously considered, what less can be concluded than that there is manifest Design and Forecast in this Case, and that

As to the *Insects* themselves, they are manifestly *Ichneumon-Flies*, having four Wings, their *Alvus* thick and large towards the Tail; and tapering up till it is small and slender at its setting on to the *Thorax*. But the *Alvi* or Bellies are not alike in all, though coloured alike. In some they are as is now described, and longer, without *Terebra*, or Tails; in some shorter with Tails: and in some yet shorter, and thick, like the Belly of the *Ant*, or the Heart of Animals, as in those before, Note 24. But for a farther Description of them, I shall refer to Mr. Ray Cat. Plant. circa Cantab. under *Rosa sylvest.*

(32) It being an Instance somewhat out of the way, I shall pitch upon it for an Example here, viz. The gouty Swellings in the Body, and the Branches of the *Blackberry-Bush*; of which *Malpighi* hath given us two good Cuts in Tab. 17. Fig. 62. The Cause of these is manifestly from the Eggs of Insects laid in, whilst the Shoot is young and tender, as far as the Pith, and in some Places not so deep: which for the Reasons before mentioned, makes the young Shoots tumify, and grow knotty and gouty.

The Insect that comes from hence is of the former Tribe, a small shining black *Ichneumon-Fly*, about a tenth of an Inch long; with joyned red capillary Horns, four long Wings, reaching beyond the Body, a large *Thorax*, red Legs, and a short, heart-like Belly. They hop like Fleas. The Males are less than the Females; are very venereous, endeavouring a Coit in the very Box in which they are hatch'd; getting up on the Females, and tickling and thumping them with their Breeches and Horns, to excite them to Venercy.

that there must needs be some wise Artist, some Careful Prudent Conservator, that from the very Beginning of the Existence of this Species of Animals hath with great Dexterity and Forecast provided for it's Preservation and Good. For what else could contrive and make such a Set of curious Parts, exactly fitted up for that special Purpose: and withal implant in the Body such peculiar Impregnations as should have such a strange uncouth Power on a quite different Rank of Creatures? And lastly, what should make the Insect aware of this it's strange Faculty and Power, and teach it so cunningly and dextrously to employ it for it's own Service and Good?



BOOK

BOOK IX.

Of REPTILES and the Inhabitants of the WATERS.

CHAP. I.

Of REPTILES.

HAVING dispatched the Insect-Tribe, there is but one *Genus* of the Land-Animals remaining to be surveyed, and that is, that of *Reptiles* (1). Which I shall dispatch in a little Compass, by Reason I have somewhat amply

(1) Notwithstanding I have before in Book 4. Ch. 12. Note 15. taken notice of the *Earth-Worm*, yet it being a good Example of the Creator's use and curious Workmanship, in even this meanest Branch of the Creation, I shall superadd a few farther Remarks from Doctors *Willis* and *Tyson*. Saith *Willis*, *Lumbricus terrestris, licet vile & contemptibile habetur, Organa vitalia, necnon & alia viscera, & membra divino artificio admirabiliter fabrefacta sortitur: totius corporis compages musculorum annularium catena est, quorum fibre orbiculares contractæ, quemque annulum, prius amplum, & dilatatum, angustiores & longiores reddunt.* [This Muscle in Earth-Worms, I find is Spiral, as in a good Measure is their Motion likewise; so that by this means they can (like the Worm of an Augre) the better bore their passage into the Earth. Their reptile Motion also, may be explained by a Wire Wound on a Cylinder, which when slipped off, and one End extended and held fast, will bring the other nearer it. So the Earth-Worm, having shot out, or extended

amply treated of others, and many of the things may be applied here. But there are some things in which this Tribe is somewhat singular, which I shall therefore take Notice of briefly in this Place. One is their Motion, which I have in another Place (2) taken Notice of to be not less curious, than it is different from that of other Animals, whether we consider the manner of it, as Vermicular, or Sinuous (3) or like that of the Snail

its body (which is with a wreathing) it takes hold by those small Feet it bath, and so contracts the hinder part of its Body. Thus the curious and learned Dr. Tyson, Phil. Transf. No. 147.] *Nam proinde cum portio corporis superior elongata, & exporrecta ad spatium ulterius extenditur, ibidemque plana affigitur, ad ipsum quasi ad centrum portio corporis inferior relaxata, & abbreviata facile pertrahitur. Pedunculi serie quadruplici, per totam longitudinem Lumbrici disponuntur: his quasi totidem uncis, partem modo hanc, modo istam, plano affigit, dum alteram exporrigit, aut post seducit. Supra oris biatum, Proboscide, qua terram perforat, & elevat, donatur.* And then he goes on with the other parts that fall under View, the Brain, the Gullet, the Heart, the Spermatick Vessels, the Stomachs and Intestines, the Foramina on the top of the back, adjoyning to each Ring, supplying the place of Lungs and other parts. *Willis de Anim. Brut. P. 1. c. 3.*

(2) In Book 4. ch. 8.

(3) There is a great deal of Geometrical Neatness and Nicety in the sinuous Motion of Snakes and other Serpents. For the assisting in which Action, the annular Scales under their Bodies, are very remarkable, lying cross the Belly, contrary to what those in the Back, and rest of the Body do: also as the Edges of the foremost Scales lye over the Edges of their following Scales, from Head to Tail, so those Edges run out a little beyond, or over their following Scales; so as that when each Scale is drawn back, or set a little upright by its Muscle, the outer Edge thereof (or Foot it may be called) is raised also a little from the Body, to lay hold on the Earth, and so promote and facilitate the Serpents Motion. This is what may be easily seen in the Slough, or Body of the Serpent-kind. But there is another admirable piece of Mechanism, that my Antipathy to those Animals hath prevented my prying into,

Snail (4), or the Caterpillar (5), or the Multipedous (6), or any other Way, or the Parts ministering

into, and that is, that every Scale hath a distinct Muscle, one end of which is tacked to the middle of its Scale; the other, to the upper Edge of its following Scale. This Dr. Tyson found in the *Rattle-Snake*, and I doubt not is in the whole Tribe.

(4) The wise Author of Nature, having denied Feet and Claws to enable Snails to creep and climb, hath made them amends in a way more commodious for their state of Life, by the broad Skin along each side of the Belly, and the undulating Motion observable there. By this latter 'tis they creep; by the former, assisted with the Glutinous Slime emitted from the Snail's Body, they adhere firmly and securely to all kinds of Superficies, partly by the tenacity of their Slime, and partly by the pressure of the Atmosphere. Concerning this part (which he calls the *Snails Feet*) and their Undulation. See Dr. *Listers Exercit. Anat.* 1. §. 1. and 37.

(5) The motive Parts and Motion of Caterpillars, are useful, not only to their Progression and Conveyance from Place to Place, but also to their more certain, easy and commodious gathering of Food. For having Feet before and behind, they are not only enabled to go by a kind of Steps of their fore and hind Parts, but also to climb up Vegetables, and to reach from their Boughs and Stalks for Food at a distance. For which Services, their Feet are very nicely made both before and behind. Behind, they have broad Palms for sticking to, and these beset almost round with small sharp Nails to hold and grasp what they are upon: before, the Feet are sharp and hooked to draw Leaves, &c. to them, and to hold the forepart of the Body, whilst the hind-parts are brought up thereto. But nothing is more remarkable in these Reptiles, than that these Parts and Motion are only temporary, and incomparably adapted only to their present *Nympha-state*; whereas in their *Adult-state*, they have neither Feet, nor Motion, only a little in their hind-parts: and in their *mature-state*, they have the Parts and Motion of a flying Insect, made for Flight.

(6) It is a wonderful pretty Mechanism observable in the going of *Multipedes*, as the *Fuli*, *Scolopendæ*, &c. that on each side the Body, every Leg hath its Motion, one very regularly following the other from one end of the Body to the other, in a way not easy to be described in Words;

ring to it; particularly the Spine (7) and the Muscles co-operating with the Spine, in such as have Bones, and the Annular and other Muscles in such as have none, all incomparably made for those curious, and I may say, Geometrical Windings and Turnings, Undulations, and all the various Motions to be met with in the Reptile Kind.

Another thing that will deserve our Notice is the Poyson (8) that many of this Tribe are stocked with

so that their Legs in going make a kind of Undulation and give the Body a swifter Progression than one would imagine it should have, where so many Feet are to take so many short Steps.

(7) *Vertebrarum Apophyses breviores sunt precipue juxta caput, cujus propterea flexus in aversum, & latera facilis Viperis est: secus Leonibus, &c. — Incumbit his Ossibus ingens Musculorum minutorum praesidium, tum spinas tendinum exitium magno apparatu diducentium, tum vertebrae notissimum in diversa flectentium, atque erigentium. Adeoque illam corporis miram acilitatem, non tantum (ut Aristot.) ὅτι ἐν ὀστέων καὶ χονδρώδεϊς οἱ σπόνδυλοι quoniam faciles ad flexum, & cartilagineas produxit vertebrae, sed quia etiam multiplicia motus localis instrumenta musculos fabrefecit provida rerum Parens Natura, consecuta fuit. Blas. Anat. Anim. P. 1. c. 39 de Vipera ē Vesslingio.*

That which is most remarkable in the Vertebra [of the Rattle-Snake, besides the other curious Articulations] is that the round Ball in the lower part of the upper Vertebra enters a Socket of the upper part of the lower Vertebra, like as the head of the Os Femoris doth the Acetabulum of the Os Ischii; by which contrivance, as also the Articulation with one another, they have that free Motion of winding their Bodies any ways. Dr. Tyson's Anat. of the Rattle-Snake in Phil. Transf. No. 144. What is here observed of the Vertebrae of this Snake, is common to this whole Genus of Reptiles.

(8) My Ingenious and Learned Friend, Dr. Mead, examined with his Microscope the texture of a Viper's Poyson, and found therein at first only a Parcel of small Salts nimbly floating in the Liquor; but in a short time the appearance was changed, and these saline Particles were shot out into Crystals, of an incredible Tenuity and Sharpness, with something

with. Which I the rather mention, because some make it an Objection against the divine Superintendence and Providence, as being a thing so far from useful (they think) that 'tis rather mischievous, and destructive of God's Creatures. But the Answer is easy, viz. That as to Man, those Creatures are not without their great Uses, particularly in the Cure of (9) some of the most stubborn

thing like Knots here and there, from which they seemed to proceed ; so that the whole Texture did in a manner represent a Spiders-Web, though infinitely finer. Mead of Poysons p. 9.

As to the Nature and Operation of this Poyson, see the same ingenious Author's Hypothesis, in his fol. Pages.

This Poyson of the Viper lieth in a Bag in the Gums, at the upper end of the Teeth. It is separated from the Blood by a Conglomerated Gland, lying in the anterior lateral part of the *Os Sincipitis*, just behind the Orbit of the Eye : from which Gland lieth a Duct, that conveys the Poyson to the Bags at the Teeth.

The Teeth are tubulated, for the conveyance or emission of the Poyson into the Wound the Teeth make : but their hollownes doth not reach to the Apex, or Top of the Tooth (that being solid and sharp, the better to pierce) but it ends in a long slit below the Point ; out of which the Poyson is emitted. These Perforations of the Teeth, *Galen* saith, the Mountebanks used to stop with some kind of Past, before they suffered the Vipers to bite them before their Spectators. Cuts of these Parts, &c. may be seen in the last cited Book of Dr. Mead. Also Dr. *Tyson's Anat. of the Rattle-Snake*, in *Phil. Transact.* No. 144.

(9) That Vipers have their great Uses in Physick, is manifest from their bearing a great share in some of our best Antidotes, such as *Theriaca Andromachi*, and others ; also in the Cure of the *Elephantiasis*, and other the like stubborn Maladies, for which I shall refer to the Medical Writers. But there is so singular a Case in the curious Collection of Dr. *Ol. Worm*, related from *Kircher*, that I shall entertain the Reader with it. Near the Village of *Sassa*, about eight Miles from the City *Bracciano* in *Italy*, saith he, *Specus seu caverna (vulgo La Grotta delli Serpi) duorum hominum capax, fistulosis quibusdam foraminibus in formam cribri perforata cernitur, ex quibus ingens quaedam principio*
Veris

born Diseases : however if they were not, there would be no Injustice for God to make a set of such noxious Creatures, as Rods and Scourges, to execute the divine Chastisements upon ungrateful and sinful Men. And I am apt to think that the Nations which know not God, are the most annoyed with those noxious Reptiles, and other pernicious Creatures. As to the Animals themselves, their Poyson is no doubt of some great and especial Use to themselves, serving to the more easy Conquest, and sure Capture of their Prey,

Vovis diversicolorum Serpentum, nulla tamen, ut dicitur, singulari veneni qualitate imbutorum progenies quotannis pullulare solet. In hac spelunca Elephantiacos, Leprosos, Paralyticos, Arthriticos, Podagricos, &c. nudos exponere solent, qui mox halituum subterraneorum calore in sudorem resoluti, Serpentum propullulantium, totum corpus infirmi implicantium, suctu linſuque ita omni vitioso virulentoque humore privare dicuntur, ut repetito hoc per aliquod tempus medicamento, tandem perfecta sanitati restituantur. This Cave Kircher visited himself, found it warm, and every way agreeable to the Description he had of it ; he saw their Holes, heard a murmuring hissing noise in them ; but although he missed seeing the Serpents (it being not the Season of their creeping out) yet he saw great numbers of their *Exuvia*, or *Sluff*, and an Elm growing hard by laden with them.

The Discovery of this Cave was by the Cure of a *Leper* going from *Rome* to some Baths near this place ; who losing his way, and being benighted, happened upon this Cave ; and finding it very warm, pull'd off his Cloaths, and being Weary and Sleepy, had the good fortune not to feel the Serpents about him, till they had wrought his Cure. *Vid. Musæum Worm. L. 3. c. 9.*

The before commended *Dr. Mead*, thinks our Physicians deal too cautiously and sparingly, in their prescribing only small Quantities of the Viper's Flesh, &c. in the *Elephantiasis*, and stubborn *Leprosies* : but he recommendeth rather the Gelly, or Broth of Vipers ; or, as the ancient Manner was, to boil Vipers, and eat them like Fish ; or at least to drink Wine, in which they have been long infused, *vid Mead ubi supr. p. 34.*

Prey, which might otherwise be too resty and strong, and if once escaped, would hardly be again recovered, by Reason of their swifter Motion, and the Help of their Legs: besides all which, this their Poyson may be probably of very great Use to the Digestion of their Food.

And as to the innocuous Part of the Reptile-Kind, they as well deserve our Notice for their Harmlessness, as the others did for their Poyson. For as those are endowed with Poyson, because they are predaceous; so these need it not, because their Food is near at hand, and may be obtained without Strife and Contest, the next Earth (10) affording Food to such as can terebrate, and make Way into it by their Vermicular Faculty; and the next Vegetable being Food to others that can climb and reach (11) or but crawl to it.

CHAP. II.

Of the Inhabitants of the WATERS.

I Have now gone through that Part of the Animal World, which I proposed to survey, the Animals inhabiting the Land. As

(10) *Earth-worms* live upon Earth, is manifest from the little curled Heaps of their Dung ejected out of their Holes. But in *Philos. Transf.* No. 291. I have said it is in all probability Earth made of rotted Roots and Plants, and such like nutritive things, not pure Earth. And there is farther reason for it, because Worms will drag the Leaves of Trees into their Holes.

(11) Snails might be in danger of wanting Food, if they were to live only upon such tender Plants as are near the Ground, within their Reach only: to impower them therefore to extend their Pursuits farther, they are enabled by the means mentioned in Note 4 to stick unto, and creep up Walls and Vegetables at their Pleasure. (1)

As to the other Part of the Terraqueous Globe, the Waters, and the Inhabitants thereof, not having time at present to finish what I have done on that large Subject, I shall quit it, unless I am encouraged to re-assume it, altho' we have there as ample and glorious a Scene of the Infinite Creator's Power and Art, as hath been already set forth on the dry Land. For the Waters themselves are an admirable Work of God (1), and of Infinite Use (2) to that Part of the Globe already surveyed: and the prodigious Variety (3), and Multitudes of curious and wonderful things observable in it's Inhabitants of all sorts, are an inexhaustible Scene of the Creator's Wisdom and Power. The vast Bulk of some (4), and pro-
di-

(1) Besides their absolute Necessity, and great Use to the World, there are several Topicks, from whence the Waters may be demonstrated to be God's Work, as the forming so vast a Part of our Globe; the placing it therein, and giving it Bounds; the Methods of keeping it sweet and clean, by it's Saltness, by the Tides, and Agitations by the Winds; the making them useful to the Vegetation of Plants, and for Food to Animals, by the noble Methods of sweetening them; and many other things besides, which are insisted on in that part of my Survey.

(2) *Pliny* having named divers *Mirabilia Aquarum*, to shew their Power; then proceeds to their Uses, viz. *Eadem cadentes omnium terra nascentium causa fiunt, prorsus mirabili natura, si quis velit reputare, ut fruges gignantur, arbores fruticesque vivant, in celum migrare aquas, animamque herbis vitalem inde deferre: justa confessione, omnes terræ quoque vires aquarum beneficii. Quapropter ante omnia ipsarum potentia exempla ponemus. Cunctas enim quis mortalium enumerare queat?* And then he goes on with an Enumeration of some Waters famed for being medicinal, or some other unusual Quality. *Plin. L. 31. c. 1. & 2.*

(3) *Pliny* reckons 176 kinds in the Waters, whose Names may be met with in his *L. 32. c. 11*, but he is short in his Account.

(4) *Pliny L. 9. c. 3.* saith that in the *Indian Sea* there are *Balena quaternum iugerum* (i. e. 960 Feet) *Pristes 200 cubitorum*

digious Minuteness of others (5) together with the incomparable Contrivance and Structure of the Bodies (6) of all ; the Provisions and Supplies of Food afforded to such an innumerable company of Eaters, and that in an Element, unlikely one would think, to afford any great store of Supplies (7) ; the business of Respiration performed in a way so different from, but equivalent to what is in Land-Animals (8) ; the Adjustment of

bitorum (i. e. 300 Feet.) And L. 32. c. 1. He mentions Whales 600 Foot long, and 360 broad, that came into a River of *Arabia*. If the Reader hath a Mind, he may see his Reason why the largest Animals are bred in the Sea. L. 9. c. 2.

(5) As the largest, so the most minute Animals are bred in the Waters, as those in Pepper-water ; and such as make the green Scum on the Waters, or make them seem as if green, and many others.

(6) It might be here shewn that the Bodies of all the several Inhabitants of the Waters are the best contrived and suited to that Place and Business in the Waters which is proper for them ; that particularly their Bodies are cloathed and guarded in the best manner with Scales, or Shells, &c. suitable to the Place they are to reside in, the Dangers they may there be exposed unto, and the Motion and Business they are there to perform : that the Center of Gravity (of great Consideration in that Fluid Element) is always placed in the fittest Part of the Body : that the Shape of their Bodies (especially the more Swift) is the most commodious for making Way through the Waters, and most agreeable to Geometrical Rules : and many other Matters besides would deserve a Place here, were they not too long for Notes, and that I shall anticipate what will be more proper for another Place, and more accurately treated of.

(7) See before Book 4. Ch. 11.

(8) *Galen* was aware of the Respiration of Fishes by their *Branchiæ*. For having said that Fishes have no Occasion of a Voice, neither respire through the Mouth as Land Animals do, he saith *Sed earum, quas Branchias nuncupamus, constructio, ipsis vice Pulmonis est. Cum enim crebris ac tenuibus foraminibus sint Branchiæ hæ interceptæ, veri quidem & vaporis perviis, subtilioribus tamen quam pro mole aquæ ; hanc quidem extra repellunt, illa autem prompte intromittunt.*

Galen.

of the Organs of Vision (9) to that Element in which the Animal liveth; the Poise (10), the Support (11), the Motion of the Body (12) forwards with great Swiftneſs, and upwards and downwards with great Readineſs and Agility, and all

Galen. de Uſ. Part. L. 6. c. 9. So alſo *Pliny* held that Fiſhes reſpired by their Gills, but he ſaith *Ariſtotle* was of a different Opinion. *Plin.* L. 9. c. 7. And ſo *Ariſtotle* ſeems to be in his *Hiſt. Animal.* L. 8. c. 2. and in other Places. And I may add our famous Dr. *Needham*. See his *De form. Factu*, Ch. 6. and *Answer to Severinus*.

(9) A protuberant Eye would have been inconvenient for Fiſhes, by hindering their Motion in ſo denſe a Medium as Water is; or elſe their bruſhing through ſo thick a Medium would have been apt to wear, and prejudice their Eyes. Therefore their *Cornea* is flat. To make amends for which, as alſo for the Refraction of Water different from that of the Air, the wiſe Contriver of the Eye hath made the *Cryſtalline* ſpherical in Fiſhes, which in Animals living in the Air is *Lenticular*, and more flat.

(10) As I have ſhewed before, that the Bodies of Birds are nicely poiſed to Swim in the Air: ſo are thoſe of Fiſhes for the Waters, every part of the Body being duly balanced, and the Center of Gravity (as I ſaid in Note 6) accurately fixed. And to prevent Vacillations, ſome of the Fins ſerve, particularly thoſe of the Belly; as *Borelli* proved by cutting off the Belly-fins, which cauſed the Fiſh to reel to the Right and left Hand, and render'd it unable to ſtand ſteadily in an upright Poſture.

(11) To enable the Fiſh to abide at the top, or bottom, or any other part of the Waters, the Air-Bladder is given to moſt Fiſhes, which as 'tis more full or empty, makes the Body more or leſs buoyant.

(12) The *Tail* is the grand Inſtrument of the Motion of the Body; not the *Fins*, as ſome imagine. For which reaſon, Fiſhes are more Muſculous and Strong in that part, than in all the reſt of their Body, according as it is in the motive Parts of all Animals, in the pectoral Muſcles of Birds, the Thighs of Man, &c.

If the Reader hath a mind to ſee the admirable Method, how Fiſhes row themſelves by their Tail, and other Curioſities relating to their Swimming, I ſhall refer him to *Borelli de mot. Anim.* Part 1. ch. 23. particularly to Prop. 213.

all without Feet and Hands, and ten thousand things besides ; all these things, I say, do lay before us so various, so glorious, and withal so inexhaustible a Scene of the divine Power, Wisdom and Goodness, that it would be in vain to engage my self in so large a Province without allotting as much time and pains to it, as the preceding Survey hath cost me. Passing by therefore that Part of our Globe, I shall only say somewhat very briefly concerning the *Insensitive* Creatures, particularly those of the *Vegetable Kingdom*, and so conclude this Survey.



BOOK

BOOK X.

Of VEGETABLES.



THE Vegetable Kingdom, although an inferiour Branch of the Creation, exhibits to us such an ample Scene of the Creator's Contrivance, Curiosity, and Art, that I must rather chuse to shew what might be said, than engage too far in particulars. I might insist upon the great Variety there is both of Trees and Plants provided for all Ages, and for every Use and Occasion of the World; (1) some for Building, for Tools and Utensils of every kind; some hard, some soft; some tough and strong, some brittle; some long and tall, some short and low; some thick and large, some small and slender; some for Physick (2) some for Food, some for Pleasure; yea the most

(1) The fifth Book of *Theophrastus's Hist. Plant.* may be here consulted: where he gives ample Instances of the various Constitutions and Uses of Trees, in various Works, &c. See also before B. 4. ch. 13. Note 1.

(2) *Invisis quoque herbis inseruit [Natura] remedia: quippe cum medicinas dederit etiam aculeatis — in quibus ipsis providentiam Naturæ satis admirari amplectique non est. — Inde excogitavit aliquas aspectu hispidas, tactu truces, ut tantum non vocem ipsius fingentis illas, rationemque reddentis exaudire videamur, ne se depascant avida Quadrupes, ne procaces manus rapiant, ne neglecta Vestigia obterant, ne insidens Ales infringat: his muniendo aculeis, telisque armando, remediis ut tuta ac salva sint. Ita hoc quoque quod in iis odimus, hominum causa excogitatum est.* Plin. N. H. L. 22. c. 6.

Are

most abject (3) Shrubs, and the very Bushes and Brambles themselves the Husbandman can testify the Use of.

I might also survey here the curious Anatomy and Structure of their Bodies (4), and shew the
admi-

Are some of the Species of Nature noxious? They are also useful.——Doth a Nettle sting? It is to secure so good a Medicine from the Rapes of Children and Cattel. Doth the Bramble cumber a Garden? It makes the better Hedge: where if it chanceth to prick the Owner, it will tear the Thief. Grew Cosmolog. L. 3. c. 2. §. 47.

(3) That the most abject Vegetables, &c. have their use, and are beneficial to the World, may in some Measure appear from the use the Northern People put rotten Wood, &c. unto. *Satis ingeniosum modum habent populi septentrionales in nemoribus nocturno tempore pertranseuntes, imo & diurno, quando in remotioribus Aquilonis partibus ante, & post Solstitium hyemale continuæ noctes habentur. Quique his remediis indigent, Cortices quercinos inquirunt putres, easque collocant certo interstitio itineris instituti, ut eorum splendore, quo voluerint, perficiunt iter. Nec solum hoc præstat Cortex, sed & Truncus putrefactus, ac Fungus ipse Agaricus appellatus, &c.* Ol. Mag. Hist. L. 2. c. 16.

To this we may add *Thistles* in making Glass, whose Ashes Dr. Mervet saith are the best, viz. the Ashes of the common *way Thistle*, though all *Thistles* serve to this purpose. Next to *Thistles* are *Hop-strings*, cut after the Flowers are gathered. Plants that are Thorny and Prickly, seem to afford the best and most Salt. *Mervet's Observ. on Anton. Ner. p. 265.*

*Quid majora sequar? Salices, humilesque Geniste,
Aut illæ pecori frondem, aut pastoribus umbram
Sufficiunt, Sepemque satis, & pabula melli.* Virgil. ubi supr.

(4) Dr. Beal (who was very curious, and tryed many Experiments upon Vegetables) gives some good Reasons to imagine, that there is a direct Communication between the parts of the Tree and the Fruit, so that the same Fibres which constitute the Root, Trunk and Boughs are extended into the very Fruit. And in old *Horn-beams*, I have observed something very like this; in many of which there are divers great and small Ribs (almost like Ivy, only united to the Body) running from the Root up along the outside of the Body, and terminating in one single, or a

admirable Provision made for the Conveyance of the lymphatick and essential Juices, for communicating the Air, as necessary to Vegetable, as Animal Life (5): I might also speak of even the very Covering they are provided with, because it is a curious Work in Reality, although less so in Appearance: and much more therefore might I survey the neat Variety and Texture of their Leaves (6), the admirable Finery, Gaiety, and Fra-

few Boughs: which Bough or Boughs spread again into Branches, Leaves and Fruit. See what Dr. Beal hath in *Lowth. Abr. V. 2. p. 710.*

But as to the particular Canals, and other parts relating to the Anatomy of Vegetables, it is too long a Subject for this place, and therefore I shall refer to *Seignr Malpighi's*, and Dr. *Grew's* Labours in this kind.

(5) *Tanta est Respirationis necessitas, & usus, ut Natura in singulis viventium ordinibus varia, sed analoga, paraverit instrumenta, quæ Pulmones vocamus* [and so he goes on with observing the Apparatus made in the various Genera of Animals; and then saith] *In Plantis vero, quæ infimum animalium attingunt ordinem, tantam Trachearum copiam & productionem extare par est, ut his minima Vegetantium partes præter corticem irrigentur.* — *Planta igitur (ut conjectari fas est) cum sint vivencia, visceribus infixæ terræ, ab hac, seu potius ab aqua & aere, commixtis & percolatis a terra, Respirationis suæ materiam recipiunt, ipsarumque Tracheæ ab habitæ terræ, extremas radices subingresso, replentur.* *Malpig. Op. Anat. Plant. p. 15.*

These Tracheæ or Air-Vessels, are visible, and appear very pretty in the Leaf of Scabions, or the Vine, by pulling asunder some of its principal Ribs or great Fibers; between which may be seen the Spiral Air-Vessels (like Threads of Cob-web) a little uncoyled: a Figure whereof Dr. *Grew* hath given us in his *Anat. Plant. Tab. 51, 52.*

As to the curious coyling, and other things relating to the structure of those Air-Vessels, I refer to *Malpig. p. 14.* and Dr. *Grew* ib. L. 3. c. 3. §. 16, &c. and L. 4. c. 4. §. 19. or Mr. *Ray*, from them succinctly. *Hist. Plant. L. 1. c. 4.*

(6) Concerning the Leaves, I shall note only two or three things. 1. As to the Fibers of the Leaf, they stand not in the Stalk in an even Line, but always in an Angular or Cir-

Circular Posture, and their vascular Fibres or Threads, are 3, 5 or 7. The reason of their Position thus, is for the more erect growth and greater Strength of the Leaf, as also for the security of its Sap. Of all which, see Dr. Grew L. 1. c. 4. §. 8. &c. and L. 4. Part. 1. c. 3. also Tab. 4. Fig. 2. to 11. Another Observable in the Fibers of the Leaf, is their orderly Position, so as to take in an eighth part of a Circle, as in *Malloes*; in some a tenth, but in most a twelfth, as in *Holy-Oak*; or a Sixth, as in *Sirynga*. Id. ib. Tab. 46, 47.

2. The Art in *Folding up the Leaves* before their eruption out of their Gems, &c. is incomparable, both for its Elegancy and Security, viz. in taking up (so as their Forms will bear) the least room; and in being so conveniently couched, as to be capable of receiving protection from other parts, or of giving it to one another. c. g. First, there is the *Bow-lap*, where the Leaves are all laid somewhat convexly one over another, but not plaited——but where the Leaves are not so thick set, as to stand in the *Bow-lap*, there we have the *Plicature*, or the *Flat-lap*; as in *Rose-tree*, &c. And so that curious Observer goes on shewing the various Foldings, to which he gives the names of the *Duplicature*, *Multiplicature*, the *Fore-rowl*, *Back-rowl*, and *Tre-rowl*, or *Treble-rowl*. Grew. ib. L. 1. c. 4. §. 14, &c. To these he adds some others, L. 4. P. 1. c. 1. §. 9. *Consule quoque Malpig. de Gemmis* p. 22. &c.

To these curious Foldings, we may add another noble Guard by the interposition of *Films*, &c. of which Dr. Grew saith, there are about six Ways, viz. *Leaves*, *Surfoyls*, *Interfoyls*, *Stalks*, *Hoods* and *Mantlings*. Grew. ib. and Tab. 41, 42. Malpig. ibid.

(7) In the Flower may be considered the *Empalement*, as Dr. Grew, the *Calyx*, or *Perianthium*, as Mr. Ray and others call it, designed to be a Security and Bands to the other parts of the Flower. *Floris velut basis & fulcimentum est*. Ray. Hist. L. 1. c. 10. Flowers whose *Petala* are strong (as Tulips) have no *Calyx*. *Carnations* whose *Petala* are long and slender, have an *Empalement* of one Piece: and others, such as the *Knapweeds*, have it consisting of several Pieces, and in divers Rounds, and all with a counterchangeable respect to each other, for the greater Strength and Security of themselves, and the *Petala*, &c. they include.

The next is the *Foliation*, as Dr. Grew, the *Petala*, or *Folia*, as Mr. Ray, and others. In these, not only the admirable Beauty and luxuriant Colours are observable, but also

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Affirmative is maintained by *Malpighi*, with cogent Arguments: among which, this is one: *Non præoccupata mente, oculis microscopio armatis, lustrat quæso Phascelorum seminalem plantulam nondum satam, in qua folia stabilia, hæcque ampla evidenter observabit; in eadem pariter gemmam, nodos, seu implantationes varias foliorum caulis deprehendet. Caulem insignem fibris ligneis, & utriculorum seriebus constantem conspicue attinget.* And whereas *Sr Triumbetti* had objected that vegetatione, metamorphosi, inedia plantas in alias degenerare, ut exemplo plurium [constat] præcipue tritici in lolium, & lolii in triticum versi. In answer to this (which is one of the strongest Arguments against *Malpighi's* Assertion) *Malpighi* replies, *nondum certum est de integritate, & successu experimenti, nam facienti mihi, & amicis, tritici metamorphosis non cessit. Admissa tamen metamorphosi, quoniam hæc neglecta cultura, aut vitio soli, aut aeris contingit---ideo ex morbo, & monstruoso affectu non licet inferre permanentem statum a Natura intentum.* Observeo plantas sylvestres cultura varias reddi, &c. I have more largely taken notice of *Malpighi's* Answer, because he therein shews his Opinion about the transmutation of Vegetables. *Vid. Malpig. vit. p. 67.*

So *Mr. Leeuwenhoek*, after his nice Observations of an Orange-Kernel, which he made to germinate in his Pocket, &c. concludes, *Thus we see, how a small Particle, no bigger than a coarse Sand (as the Plant is represented) is increased, &c: a plain Demonstration, that the Plant, and all belonging to it, was actually in the Seed, in the young Plant, its Body, Root, &c.* *Philos. Trans. No. 287.* See also *Raii Cat. Cant. in Acer maj.* from *Dr. Highmore*. But in all the Seeds which I have viewed, the Plant appears the plainest to the naked Eye, and also very elegant in the *Nux Vomica*.

Natura non observat magnitudinis proportionem inter semina & plantas ab iisdem ortas, ita ut majus semen majorem semper producat plantam, minus minorem. Sunt enim in genere herbarum non pauca, quarum semina arborum nonnullarum seminibus non dico equalia sunt, sed multo majora. Sic v. g. *Semina Fabe, &c. semina Ulmi, &c. multis vicibus magnitudine superant.* *Raii ubi supra. L. 1. c. 13.*

Filicem reliquasque Capillares herbas Semine carere Veteres plerique — prodidere; quos etiam secuti sunt e Recentioribus nonnulli, Dodonæus, &c. — Alii e contra, Bauhinus, &c. Filices & congeneres spermatophoras esse contendunt: partim quia Historia Creationis Genes. 11, 12, &c. — Hanc sententiam verissimam esse — autopsia convincit. *Fredericus Cæsius*, he saith, was the first that discovered these Seeds, with the help of a Microscope. And since him, *Mr. W. C.* hath more critically observed them. Among other things ob-

served

of the Species depends upon the Safety of the Seed and Fruit in a great measure, I might therefore take notice of the peculiar Care the great God of Nature hath taken for the Conservation and Safety hereof: as particularly in such as dare to shew their Heads all the Year, how securely their Flower, Seed or Fruit is locked up all the Winter, together with their Leaves and Branches, in their Gems (10), and well fenced and cove-

served by that ingenious Gent. are these, *Pyxidula seu capsula semina continentes in plerisque hoc genus plantis perquam exili granulo arena vulgaris cinerea plus duplo minores sunt; imo in nonnullis speciebus vix tertiam quartamve arenula partem magnitudine equant, vesicularum quarundam annulis aut fasciis vermiformibus obvolutarum speciem exhibentes. Nonnullae ex his vesiculis 100 circiter semina continere deprehendebantur.*—adeo eximia parvitate ut nudo oculo prorsus essent invisibilia, nec nisi Microscopii interventu detegi possent.

—*Osmunda regalis, quae aliis omnibus Filicis speciebus mole antecellit*—vascula seminalia obtinet aequae cum reliquis congeneribus magnitudinis—quorum immensa & visum fugiens parvitas cum magnitudine plantae collata—adeo nullam gerere proportionem invenietur, ut tantam plantam à tantillo semine produci attentum observatorem merito in admirationem rapiat. Ray ibid. L. 3. pag. 132. This W. C. was Mr. Wil. Cole, as he owneth in a Letter I have now in my hands of his to Mr. Ray of Octob. 18. 1684.

(10) *Vegetantium genus, ut debitam magnitudinem sortiantur, & suae mortalitatis jacturam successiva prolis educatione repararet, statim temporibus novas promittit partes, ut tandem emergentes Uteri, recentes edant Soboles. Emanantes igitur à caule, caudice, ramis, & radicibus novellae hujusmodi partes, non illico laxatae extenduntur, sed compendio quodam coagmentatae intra folii axillam cubantes, non parum subsistunt. Gemmae appellantur, &c.* And then that great Man goes on to shew the admirable various Methods of Nature in repositing in that little compats so large a part of a Tree or Plant, the curious Structure of the Gems, the admirable Guard afforded them, and the Leaves, Flowers and Seed contained in them, &c. Of which having taken notice before, I pass over it now, and only refer to our Author *Malpighi*, and *Dr. Grew*, in the Places cited in Note 6, and 7.

covered there with neat and close Tunicks. And for such as dare not so to expose themselves, with what Safety are they preserved under the Coverture of the Earth in their Root (11), Seed (12), or Fruit, till invited out by the kindly Warmth of the Spring! And when the whole Vegetable Race is thus called out, it is very pretty to observe the Methods of Nature in guarding those insensitive Creatures against Harms and Inconveniences, by making some (for Instance) to lie down prostrate, and

(11) Of *Bulbous*, and a great many more, probably of the far greater number of *Perennial Roots* of Herbs, as *Arum*, *Rape-Crowfoot*, &c. it is very observable, that their Root is annually renewed, or repaired out of the Trunk or Stalk it self. That is to say, the *Basis* of the *Stalk* continually, and by insensible degrees descending below the Surface of the Earth, and hiding it self therein, is thus both in Nature, Place and Office changed into a true Root. — So in *Brownwort*, the *Basis* of the *Stalk* sinking down by degrees, till it lies under ground, becomes the upper part of the Root; and continuing still to sink, the next Year becomes the lower part; and the next after that, rots away; a new Addition being still yearly made out of the Stalk, as the elder Parts yearly rot away. *Grew ibid. L. 2. pag. 59. ubi plura vid.*

(12) How safe and agreeable a Conservatory the Earth is to Vegetables, more than any other, is manifest from their rotting, drying, or being rendered infecund in the Waters, or the Air; but in the Earth, their Vigour is long preserved. Thus Seeds particularly, Mr. Ray thinks some may probably retain their fecundity for 10 Years, and others lose it in 5: but saith he, *In terræ gremio latitantia, quamvis tot calor, frigoris, humoris & siccitatis varietatibus ibidem obnoxia, diutius tamen (ut puto) fertilitatem suam tuentur, quam ab hominibus diligentissime custodita; nam & ego & alii ante me multi observarunt Sinapeos vim magnam enatam in aggeribus fossarum recens factis, inque areis gramineis effossis, ubi post hominum memoriam nulla unquam Sinapeos seges succreverat. Quam tamen non sponte ortam suspicor, sed è seminibus in terra per tot annos residuis etiam prolificis.* Ray. Hist. Pl. L. 1. c. 13.

and others to close themselves up (13) upon the Touch of Animals, and the most to shut up their Flowers, their Down (14) or other their like Guard, upon the Close and Cool of the Evening, by means of Rain, or other Matters that may be prejudicial to the tender Seed.

And now to these Considerations relating to the Seed, I might add the various Ways of Nature in dissipating and sowing it, some being for this end, winged with light Down or Wings to be conveyed about by the Winds; others being laid in elastick springy Cases, that when they burst and crack, dart their Seed at convenient distances, performing thereby the Part of a good Husbandman (15); others by their agreeable Taste
and

(13) *Planta nonnulla Æschynomene Veteribus dicta, Recen-
tioribus Viva & Sensitiva & Mimosa haud obscura sensus in-
dicia produnt: siquidem folia earum manu aut baculo tacta,
& paululum compressa, pleno etiam meridie, splendente Sole,
illico se contrahunt; in nonnullis etiam speciebus cauliculi te-
neriores concidunt & velut marcescunt; quod idem ab aere
frigidiore admissio patiuntur.* Ray. Hist. Pl. T. 1. L. 18. App.
S. 2. c. 2. p. 978.

(14) I have observed, that many, if not most Vegetables, do expand their Flowers, Down, &c. in warm Sunshiny Weather, and again close them towards Evening, or in Rain, &c. especially at the beginning of Flowering, when the Seed is Young and Tender; as is manifest in the Down of *Dandelion*, and other Downs; and eminently in the Flowers of *Pimpernel*, the opening and shutting of which are the Country-Man's Weather-wiser; whereby *Gerard* saith, he foretelleth what Weather shall follow the next day; for saith he, if the Flowers be close shut up, it betokeneth Rain and Foul Weather; contrariwise, if they be spread abroad, fair Weather, *Ger. Herb. B. 2. ch. 183.*

Est & alia [arbor in Tylicis] similis, foliosior tamen roseique floris; quem noctu comprimens, aperire incipit Solis exortu, meridie expandit. Incolæ dormire eam dicunt. *Plin. Nat. Hist. L. 12. c. 11.*

(15) So soon as the Seed is ripe, Nature taketh several Methods for its being duly Sown: not only in the opening of the
Uterus,

Uterus, but also in the make of the Seed it self. For first, the Seeds of many Plants, which affect a peculiar Soil or Seat, as of Arum, Poppy, &c. are heavy and small enough, without further care, to fall directly down into the Ground ——— But if they are so large and light, as to be exposed to the Wind, they are often furnished with one or more Hooks, to stay them from straying too far from their proper Place. ——— So the Seeds of Avens have one single Hook; those of Agrimony and Goose-grass, many; both the former loving a warm bank; the latter, an Hedge for its support. On the contrary, many Seeds are furnished with Wings or Feathers; partly with the help of the Wind to carry them, when ripe, from off the Plant, as of Ash, &c. ——— and partly to enable them to make their flight more or less abroad, that so they may not, by falling together, come up too thick; and that if one should miss a good Soyl or Bed, another may hit. So the Kernels of Pine have Wings ——— yet short ——— whereby they fly not into the Air, but only flutter upon the Ground. But those of Typha, Dandelion, and most of the Pappous kind ——— have long numerous Feathers by which they are waisted every way. ——— Again there are Seeds, which are scattered not by flying abroad, but by being either spirted, or slung away. The first of those are Wood-sorrel, which having a running Root, Nature sees fit to sow the Seeds at some distance. The doing of which is effected by a white sturdy Cover, of a tendinous or springy nature. ——— This Cover, so soon as it begins to dry, bursts open on one side, in an instant, and is violently turned inside outward ——— and so smartly throws off the Seed. The Seeds of Hartstongue, is slung or shot away ——— by the curious Contrivance of the Seed-Case, as in Codded-Arsmart, only there the Spring moves and curls inward, but here outward; viz. Every Seed-Case ——— is of a Spherick Figure, and girded about with a sturdy Spring. ——— The Surface of the Spring resembles a fine Screw. ——— So soon as ——— this Spring is become stark enough, it suddenly breaks the Case into two Halfs, like two little Cups, and so slings the Seed. Grew. ib. p. 199. And in Tab. 72. all these admirable Artifices are handsomely represented.

Quin si quantitas modica seminum (Filicis, Phyllitidis quoque) a foliis in subjectam charta munda ——— schedam decutitur, detergaturve, & deinde in acervum converratur, vesicularum seminalium plurimis una dissilientibus, & sibi invicem allisis, acervulus varie moveri per partes videbitur, non secus ac si Syronibus aut istiusmodi bestiolis repletus esset ——— quin si locus tranquillus sit, aure proxime admota, crepitantium inter rumpendum vasculorum sonitu, ——— percipietur; & si microscopio chartam oculis oberres, semina per eam undique sparsa, & ad notabilem ab acervo distantiam projecta comperies. Ray ibid. p.

and Smell and salutary Nature inviting themselves to be swallowed and carried about by the Birds, and thereby also fertilized by passing through their Bodies (16); and others not thus taken Care of

The admirable Contrivance of Nature, in this Plant, is most plain. For the Seed-Vessels being the best Preserver of the Seed, 'tis there kept from the Injuries of Air and Earth, 'till it be rainy, when it is a proper time for it to grow, and then it is thrown round the Earth, as Grain by a skilful Sower. ---- When any Wet touches the End of the Seed-Vessels, with a smart Noise, and sudden Leap it opens it self, and with a Spring scatters it's Seed to a pretty Distance round it, where it grows. Dr. Sloane Voy. to Jamaica p. 150. of the Gentianella flore ceruleo &c. or Spirit-Leaf.

The Plants of the Cardamine-Family and many others may be added here, whose Cods fly open, and dart out their Seed upon a small Touch of the Hand. But the most remarkable Instance is in the *Cardamine impatiens, cujus Siliquæ* (saith Mr. Ray) *vel leviter tactæ acutim ejaculantur [Semina] imo quod longe mirabilius videtur, etsi siliquas non tetigeris, si tamen manum velut tactures proxime admoveas, semina in appropinquantem evibrabunt; quod tum Morisonus se sapius expertum scribit, tum Johnstonus apud Gerardum verum esse affirmat. Hist. Plant. L. 16. c. 20.*

Neither is this Provision made only for Land Vegetables, but for such also as grow in the Sea. Of which I shall give an Instance from my before commended Friend Dr. Sloane. *As to the Euci, ---- their Seed hath been discovered (and shewed me first) by the Industry of the ingenious Herbarist, Mr. Sam. Doody, who found on many of this kind solid Tubercles, or Risings in some Seasons, wherein were lodged several round Seeds, as big as Mustard-Seed, which, when ripe, the outward Membrane of the Tubercle breaking, leaveth the Seed to float up and down with the Waves. This Seed coming near Stones, or any solid Foundation, by means of a Mucilage it carries with it, sticks to them, and shoots forth Ligulæ with Branches, and in time comes to its Perfection and Magnitude. Sloan. Voy. Jamaica p. 50.*

(16) The ancient Naturalists do generally agree, that Mistletoe is propagated by its Seeds carried about by, and passing through the Body of Birds. Thus *Throphrastus de Caus. Plant L. 2. c. 24. Ἰδὲ δὲ ἀπὸ πῆς τῆς οὐροῦ, &c. Initium vero a pastu avium. — Quippe Viso detracto confectoque in alveis,*

alveis, quod frigidissimum est, semen cum excremento purum dimittitur, & facta mutatione aliqua in arbore Stercoris causa pullulat, erumpitque, &c. So also Pliny saith, viz. *Omnino autem satum [Viscum] nullo modo nascitur, nec nisi per alvum Avium redditum, maxime Palumbis ac Turdi. Hec est natura, ut nisi maturatum in ventre Avium, non proveniat.* Plin. N. H. L. 16. c. 44. Whether what *Theophrastus* and *Pliny* affirm, be conducive to the better fertilizing the Seeds of *Misseltoe*, I know not; but that it is not of absolute necessity, I can affirm upon mine own Experience, having seen the Seeds germinate, even in the Bark of Oak. But although they shot above an Inch, and seemed to root in the Tree, yet they came to nothing, whether destroyed by Ants, &c. which I suspected, or whether disagreeing with the Oak I know not. But I since find the Matter put out of doubt by Mr. *Doody*, which see in Mr. *Ray's Hist. Plant. App.* p. 1918.

Nutmegs are said to be fertilized after the same manner, as *Tavernier* saith was confirmed to him by Persons that lived many Years in those Parts; whose Relation was, The Nutmeg being ripe, several Birds come from the Islands toward the South, and devour it whole, but are forced to throw it up again, before it be digested. That the Nutmeg, then besmeared with a Viscous Matter, falling to the Ground, takes root, and produces a Tree, which would never thrive, was it planted. *Tavern. of the Commod. of the G. Mogul.* And *Monsieur Thevenot*, in his Travels to the Indies, gives this Account; the Tree is produced after this manner; there is a kind of Birds in the Island, that having picked off the green Husk, swallow the Nuts, which having been some time in their Stomach, they void by the ordinary way; and they fail not to take rooting in the Place where they fall, and in time, to grow up to a Tree. This Bird is shaped like a Cuckow, and the Dutch prohibit their Subjects under pain of Death, to kill any of them. v. *Sir T. Pope Blunt's Nat. Hist.*

But Mr. *Ray* gives a somewhat different account: *Hunc fructum [Nucem Moschatam] variae quidem aves depascuntur, sed maxime Columbae genus album & parvum, quae debiscente nucamento, illecta suavitate Macis hunc cum Nuce eripiunt & devorant, nec nisi repleta ingluvie capacissima sanguinem deserunt. Nostrates ibi mercatores Columbis istis Neuteters sive Nucivoris nomen imposuerunt. Quas autem vorant Noces, post integras per alvum reddunt. Reddita citius deinde germinant, utpote premacerata fervore Ventriculi. Arborea inde nata, ceu precociora, facile sunt corruptioni obnoxia. fructumque ferunt ceteris multo viliorum, & hac causa neglectum incolis,*

of, do many of them by their Usefulness in human Life, invite the Husbandman and Gardiner carefully to sow and nurse them up.

To this so singular a Care about the Propagation and Conservation of the Species of Vegetables, I might add the nice Provision that is made for their Support and Aid in standing and growing, that they may keep their Heads above ground, and not be rotted and spoiled in the earth themselves, nor thereby annoy us; but on the contrary minister to all their Ends, and our Uses; to afford us Houses, Utensils, Food (17), Physick, Cloathing, yea Diversion too, by the Beauty of their Looks, by the Fragrancy of their Smell, by creating us pleasant Shades against the scorching Beams of Summer, and skreening us against the piercing Winds, and Cold of Winter (18).

And

colis contemptumque, præter Macin, quem ad adulterandum meliorem adhibent. Ray H. P. L. 27. c. 4.

(17) *Arbores blandioribus fruge succis hominem mitigavere. Ex iis recreans membra Olei liquor, viresque potus Vini: tot denique saporès annui sponte venientes: & mensæ, depugnetur licet earum causa cum feris, & pasti naufragorum corporibus pisces expetantur, etiamnum tamen secunda. Mille præterea sunt usus earum, sine quibus vita degi non possit, Arbore sulcamus maria, terrasque admoventur, arbore exedificamus tecta.* Plin. N. H. L. 12. c. 1.

(18) *Plantarum Usus latissime patet, & in omni vita parte occurrit. Sine illis laute, sine illis commode non vivitur, et nec vivitur omnino: Quæcunque ad victum necessaria sunt, quæcunque ad delicias faciunt, è locupletissimo suo penu abunde subministrant. Quanto ex iis mensa innocentior, mundior, salubrior quam ex Animalium cade & laniena? Homo certe natura Animal carnivororum non est, nullis ad prædæ & rapinæ armis instructum, non dentibus exertis & serratis, non unguibus aduncis. Manus ad fructus colligendos, dentes ad mandendos comparati. Non legimus ei ante Diluvium carnes ad esum concessas. At non Victum tantum nobis suppeditant, sed & Vestitum, & Medicinam, & Domicilia aliaque ædificia, & Navigia, & Supellectilem, & Focum, & Oblectamenta Sensuum Animique: Ex his naribus odoramenta & suffumi-*

And it is very observable what admirable Provisions are made for this purpose of their Support and Standing, both in such as stand by their own Strength, and such as need the Help of others. In such as stand by their own Strength by means of the stronger, and more ligneous Parts (equivalent to the Bones in Animals) being made not inflexible, as Bones; because they would then be apt to break, but of an yielding elastick Nature, to escape and dodge the Violence of the Winds: and by means also of the Branches spreading handsomely and commodiously about, at an Angle of about 45 gr. by which means they equally fill up, and at the same time make an Equilibration of the Top (19).

And

suffumigia parantur. Horum flores inenarrabili colorum & Schematum varietate & elegantia oculos exhilarant, suavissima odorum quos expirant fragrantia spiritus recreant. Horum fructus gule illecebra mensas secundas instruunt, & languentem appetitum excitant. Taceo virorem amœnissimum oculis amicum, quem per prata, pascua, agros, sylvas spatiantibus objiciunt, & Umbras quas contra aestum & Solis ardores præbent. Ray. ib. L. 1. c. 24. p. 46.

(19) *All Vegetables of a tall and spreading Growth seem to have a natural Tendency to an Hemispherical Dilatation, but generally confine their Spreading within an Angle of 90 gr. as being the most becoming and useful Disposition of it's Parts and Branches. Now the shortest way to give a most graceful and useful filling to that Space of dilating and spreading out, is to proceed in strait Lines, and to dispose of those Lines in a Variety of Parallels, &c. And to do that in a quadrantal Space, &c. there appears but one way possible; and that is, to form all the Intersections which the Shoots and Branches make, with Angles of 45 gr. only. And I dare appeal to all if it be not in this manner, almost to a nicety, observed by Nature, &c. A visible Argument that the Plastic Capacities of Matter are governed and disposed by an All-wise and Infinite Agent, the native Strictnesses and Regularities of them plainly shewing from whose Hand they come. Account of the Origine and Format. of Foss. Shells, &c. Print. Lond. 1705. pag. 38, 41.*

(20)

And as for such Vegetables as are weak, and not able to support themselves, 'tis a wonderful Faculty they have, so readily and naturally to make Use of the Help of their Neighbours, embracing and climbing up upon them (20), and using them as Crutches to their feeble Bodies: some by their odd convolving Faculty, by twisting themselves like a Screw about others; some advancing themselves, by catching and holding with their curious *Claspers* and *Tendrels*, equivalent to the Hands; some by striking in their rooty Feet; and others by the emission of a natural Glue, closely and firmly adhering to something or other that administers sufficient Support unto them.

All

(20) *In Hederâ surculi, & rami hinc inde claviculos, quasi radículas emittunt, quæ parietibus, vel occurrentibus arboribus veluti digitis firmantur, & in altum suspenduntur. Hujusmodi radiculæ subrotundæ sunt, & pilis cooperiuntur; & quod mirum est, glutinosum fundunt humorem, seu Terebinthinam, quâ arctè lapidibus nectuntur & agglutinantur. — Non minori industriâ Natura utitur in Vite Canadensi, &c. The admirable and curious make of whose Tendrels and their Feet, see in the illustrious Author Malpig. de Capreolis &c. pag. 48.*

Claspers are of a compound Nature between that of a Root, and a Trunk. Their Use is sometimes for Support only; as in the Claspers of Vines, Briony, &c. whose Branches being long, slender, and fragile, would fall by their own Weight, and that of their Fruit: but these Claspers taking hold of any thing that is at Hand: which they do by a natural Circumvolution which they have (those of Briony have a retrograde Motion about every third Circle, in the Form of a double Clasp, so that if they miss one way, they may catch the other.) Sometimes the Use of Claspers is also for a Supply, as in the Trunk Roots of Ivy; which being a Plant that mounts very high, and being of a closer and more compact Substance than that of Vines, the Sap would not be sufficiently supplied to the upper Sprouts, unless these assisted the mother Root: but these serve also for Support too. Sometimes also they serve for Stabiliment, Propagation, and Shade: for the first of these serve the Claspers of Cucumers; for the second, those, or rather the Trunk-Roots of Chamomil; and for all three the Trunk-Roots of Strawberries. Harris Lex. Tech. in verb. Claspers.

All which various Methods being so nicely accommodated to the Indigencies of those helpless Vegetables, and not to be met with in any besides, is a manifest Indication of their being the Contrivance and Work of the Creator, and that his infinite Wisdom and Care condescends even to the Service and Wellbeing of the meanest, most weak and helpless insensitive Parts of the Creation.

In the last Place, to the Uses already hinted at, I might add a large Catalogue of such among Vegetables, as are of peculiar Use and Service to the World, and seem to be designed as 'twere on purpose, by the most merciful Creator, for the good of Man, or other Creatures (||). Among Grain, I might Name the great Fertility (21) of such as serves for Bread, the easy Culture and Propagation thereof, and the Agreement of every Soil and Climate to it. Among Trees and Plants I might instance in some that seem to be designed as 'were on purpose for almost every Use (22), and Convenience: some to heal the most stubborn
and

(||) Vegetables afford not only Food to Irrationals, but also Physick, if it be true which *Aristotle* saith, and after him *Pliny*; which latter in his 8th Book ch. 27. specifies divers Plants made Use of as Specificks by divers both Beasts and Birds; as *Dittany* by wounded *Deer*, *Celandine* by *Swallows*, to cure the sore Eyes of their Young, &c. And if the Reader hath a mind to see more Instances of this nature (many of them fanciful enough) he may consult *Mersenne* in *Genes.* pag. 933.

(21) See before Book 4. Chap. 11. Note 2.

(22) *Planta hæc unica* [*Aloe Americana*] inquit *Fr. Hernandez* quicquid vitæ esse potest necessarium præstare facile potest, si esset rebus humanis modus. Tota enim illa lignorum sepiendorumque agrorum usum præstat, caules tignorum, folia vero tecta tegendi imbricum, lanicum, lanciaum: eorundem nervuli & fibræ eundem habent usum ad linteamina, calceos, & vestimenta conficienda quem apud nos *Linum*, *Cannabis*, *Gossipium*, &c. E mucronibus fiunt clavi, aculei, subula, quibus perforandis cruribus, macerandi corporis gratiâ, Indis

dangerous Distempers (23), to alleviate and ease the Pains (24) of our poor infirm Bodies all the World over: And some designed for the peculiar Service and good of particular Places, either to cure such Distempers as are peculiar to them, by growing more plentifully there than elsewhere (25);

uti mos erat cum Dæmonum vacarent cultui; item aciculæ, acus, tribuli militares, & rostellæ idoneæ pectendis subtegminibus. Præterea e succo mananti, cujus evulsis germinibus internis foliisque tenerioribus cultis [Yztlinis] in mediam cavitatem stillat planta unica ad 50 interdum amphoras (quod dictum est mirabile) Vina, Mel, Acetum ac Saccharum parantur [The Methods of which he tells.] Idem succus menses ciet, alvum lenit, Urinam evocat, Renes & Vesicam emundat. E radice quoque vestes fiunt firmissimæ. Crassiores foliorum partes truncusque decocta sub terâ edendo sunt apta, sapiuntque Citrea frusta saccharo condita: quin & vulnera recentia mirè conglutinat. — Folia quoque assa & affecto loco imposita convulsionem curant, ac dolores leniunt (præcipuè si succus ipse calens bibatur) quamvis ab Indicâ proficiantur lue, sensum hebetant atque torporem inducunt. Radicis succus lue Veneream curat apud Indos. D. Palmer. Ray ibid. L. 22. c. 7. See also Dr. Sloane Voy. to Jamaica. p. 247.

There are also two sorts of *Aloe* besides mentioned by the same Dr. Sloane, one of which is made use of for Fishing-Lines, Bowstrings, Stockins, and Hammocks. Another hath Leaves that hold Rain-water, to which Travellers, &c. resort to quench their Thirst, in scarcity of Wells, or Water, in those dry Countries. *ibid.* p. 249.

(23) For an instance here I shall name the *Cortex Peruvianus*, which Dr. Morton calls *Antidotus in levamen ærumnarum vitæ humanæ plurimarum divinitus concessa*. De Febr. Exer. 1. c. 3. In Sanitatem Gentium proculdubio a Deo O. M. conditus. Cujus gratia, *Arbor Vitæ*, siqua alia, jure merito appellari potest. Id. ib. c. 7. Eben! quot convitiis Herculeæ & divina hæc *Antidotus* jactabatur? *Ibid.*

To this (if we may believe the *Ephemer. German. An. 12. Obser. 74*, and some other Authors) we may add *Trifolium paludosum*, which is become the *Panacæa* of the Germans and Northern Nations.

(24) *Pro doloribus quibuscunque sedandis, præstantissimi semper usus Opium habetur; quomobrem meritò Nepenthe appellari solet, & remedium verè divinum existit. Et quidem satis mirari vix possumus, quomodo urgente visceris aut membri cujuscumque tortura insigni, & intolerabili cruciatu, pharmacum hoc, incantamenti instar, levamen*

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(25); or else to obviate some Inconvenience there, or to supply some constant Necessity, or Occasion, not possible, or at least not easy, to be supplied any other Way (26,) 'Tis, for instance,
an

Ἐ ἀναλγησίαν subitam, immo interdum absque somno, aut saltem prius quam advenerit, concedit. Porro adhuc magis stupendum est, quod donec particula Opiaticæ operari, Ἐ potentiam suam narcoticam exerere continuant, immo etiam aliquamdiu postquam somnus finitur, summa alleviatio, Ἐ indolentia in parte affecta persistit. Willis Phar. rat. par. 1. S. 7. c. 1. §. 15.

(25) Tales Plantarum species in quacunque regione a Deo creantur quales hominibus Ἐ animalibus ibidem natis maxime conveniunt; imo ex plantarum nascentium frequentia se fere animadvertere posse quibus morbis [endemiis] qualibet regio subjecta sit, scribit Solenander. Sic apud Danos, Frisios, Hollandos, quibus Scorbutus frequens, Cochlearia copiose provenit. Ray H. Pl. L. 16. c. 3.

To this may be added *Elsner's* Observations concerning the Vertues of divers things in his *Observations de Vincetoxico Scrophularum remedio*. Eph. Germ. T. 1. Obf. 57.

John Benerovinus a Physician of Dort may be here consulted, who wrote a Book on purpose to shew, that every Country hath every thing serving to it's Occasions, and particularly Remedies afforded to all the Distempers it is subject unto. V. Bener. *Ἀυτάρχεια Βατῶν*. sive *Introd. ad Medic. indigenam*.

(26) The Description Dr. *Sloane* gives of the *Wild-Pine* is, that its Leaves are channelled fit to catch and convey Water down into their Reservoirs, that these Reservoirs are so made, as to hold much Water, and close at top when full, to hinder its evaporation; that these Plants grow on the Arms of the Trees in the Woods every where [in those Parts] as also on the Barks of their Trunks. And one contrivance of Nature in this Vegetable, he saith, is very admirable. The Seed hath long and many Threads of *Tomentum*, not only that it may be carried every where by the Wind—but also that it may by those Threads, when driven through the Boughs, be held fast, and stick to the Arms, and extant parts of the Barks of Trees. So soon as it sprouts or germinates, although it be on the under part of a Bough,—its Leaves and Stalk rise perpendicular, or strait up, because if it had any other Position, the Cistern (before mentioned, by

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which

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an admirable Provision made for some Countries
subject to Drought, that when the Waters every
where fail, there are Vegetables which contain
not only Moisture enough to supply their own
Vegetation and Wants, but afford Drink also both
to Man, and other Creatures, in their great Ex-
tremities (27) ; and a great deal more might be
in-

which it is chiefly nourished——) made of the hollow Leaves,
could not hold Water, which is necessary for the Nourishment
and Life of the Plant.—— In scarcity of Water, this Reser-
vatory is necessary and sufficient, not only for the Plant it self,
but likewise is very useful to Men, Birds, and all sorts of In-
sects, whither they come in Troops, and seldom go away with-
out refreshment. Id. ib. p. 188 and Phil. Transact. No. 251.
where a Figure is of this notable Plant, as also in Lowthorp's
Abridg. V. 2. p. 669.

The Wild-Pine, so called, &c. hath Leaves that will hold
a Pint and half, or Quart of Rain-Water ; and this Water
refreshes the Leaves, and nourishes the Root. When we find
these Pines, we stick our Knives into the Leaves just above the
Root, and that lets out the Water, which we catch in our Hats,
as I have done many times to my great Relief. Dampier's
Voy. to Campeachy. ch. 2. p. 56.

(27) Navarette tells us of a Tree called the Bejuco, which
twines about other Trees, with its End hanging down-
wards ; and that Travellers cut the nib off it, and presently a
spout of Water runs out from it, as clear as Crystal, enough
and to spare for six or eight Men. I drank, saith he, to my
satisfaction of it, found it cool and sweet, and would drink it
as often as I found it in my way. It is a Juice and natural
Water. It is the common Relief of the Herds-men on the Moun-
tains. When they are Thirsty, they lay hold on the Bejuco, and
drink their Fill. Collect. of Voy. and Trav. Vol. 1. in the
Suppl. to Navarettes Account of China. p. 355.

The Waterwith of Jamaica hath the same Uses, concern-
ing which my before commended Friend Dr. Sloane favoured
me with this Account from his original Papers : This Vine
growing on dry Hills, in the Woods where no Water is to be
met with, its Trunk, if cut into pieces two or three Yards long
and held by either End to the Mouth, affords so plentifully
limpid, innocent and refreshing Water, or Sap, as gives new
Life to the droughty Traveller or Hunter. Whence this is ver-
much

instanced in of a like nature, and things that bear such plain Impresses of the divine Wisdom and Care, that they manifest the super-intendence of the Infinite Creator.

Thus I have given a Sketch of another Branch of the Creation, which (although one of the meanest, yet) if it was accurately viewed, would abundantly manifest itself to be the Work of God. But because I have been so long upon the other Parts, although less than they deserve, I must therefore content my self with those general Hints I have given; which may however serve as Specimens of what might have been more largely said about this inferiour Part of the animated Creation.

As to the *Inanimate Part*, such as Stones, Minerals, Earths and such like, that which I have already said in the Beginning shall suffice.

much celebrated by all the Inhabitants of these Islands, as an immediate Gift of Providence to their distressed Condition.

To this we may add what Mr. Ray takes notice of concerning the Birch-Tree. *In initiis Veris antequam folia prodire, vulnerata dulcem succum copiose effundit, quem siti pressi Pastores in sylvis sepe numero potare solent. Nos etiam non semel eo liquore recreati sumus, cum herbarum gratia vastas peragravimus sylvas, inquit Tragus. Raii Cat. Plant. circa Cantabr. in Betula.*



BOOK XI.

Practical INFERENCES from the foregoing SURVEY.



HAVING in the preceding Books carried my Survey as far as I care at present to engage my self, all that remaineth is to draw some Inferences from the foregoing Scene of the great Creator's Works, and so conclude this Part of my intended Work.

CHAP. I.

That GOD's Works are Great and Excellent.

THE first Inference I shall make, shall be by way of Confirmation of the Text, *That the Works of the Lord are great* (1). And this is necessary to be observed, not against the Atheist only, but all other careless, incurious Observers of God's Works. Many of our useful Labours, and some of our best modern Books shall be condemned with only this Note of Reproach, That they are
about

(1) *Equidem ne laudare quidem satis pro merito possum ejus Sapientiam ac Potentiam, qui animalia fabricatus est. Nam ejusmodi opera non Laudibus modo, verum etiam Hymnis sunt majora, quæ priusquam inspexissemus, fieri non posse persuasum habeamus: conspicati vero, falsos nos opinione fuisse comperimus.* Galen de Us. Part. L. 7. c. 15.

about trivial Matters (2), when in truth they are ingenious and noble Discoveries of the Works of GOD. And how often will many own the World in general to be a Manifestation of the Infinite Creator, but look upon the several Parts thereof as only Toys and Trifles, scarce deserving their Regard? But in the foregoing (I may call it) transient View I have given of this lower, and most slighted Part of the Creation, I have, I hope, abundantly made out that all the Works of the Lord, from the most regarded, admired, and praised, to the meanest and most slighted, are great and glorious Works, incomparably contrived, and as admirably made, fitted up, and placed in the World. So far then are any of the Works of the LORD, (even those esteemed the meanest) from deserving to be disregarded or condemned by us (3), that on the contrary they deserve (as shall be shewn in the next Chapter) to be *sought out, enquired after, and curiously and diligently pryed into* by us; as I have shewed the Word in the Text implies.

C H A P.

(2) *Non tamen pigere debet Lectores, ea intelligere, quemadmodum ne Naturam quidem piguit ea reipsa efficere. Galen. ibid. L. II. fin.*

(3) *An igitur etiam si quemadmodum Natura hac & ejusmodi summa ratione ac providentia agere potuit, ita & nos imitari aliquando possemus? ego vero existimo multos nostrum ne id quidem posse, neque enim artem Naturæ exponunt: eo enim modo omnino eam admirarentur: sin minus, eam saltem non vituperarent. Galen. ib. L. 10. c. 3.*

C H A P. II.

That G O D's Works ought to be enquired into, and that such Enquiries are commendable.

TH E Creator doubtless did not bestow so much Curiosity, and exquisite Workmanship and Skill upon his Creatures, to be looked upon with a careless, incurious Eye, especially to have them slighted or contemned; but to be admired by the Rational Part of the World, to magnify his own Power, Wisdom and Goodness to all the World, and the Ages thereof. And therefore we may look upon it as a great Errour, not to answer those Ends of the infinite Creator, but rather to oppose and affront them. On the contrary, my Text commends G O D's Works not only for being great, but also those curious and ingenious Enquirers that *seek them out, or pry into them*. And the more we pry into, and discover of them, the greater and more glorious we find them to be, the more worthy of, and the more expressly to proclaim their great Creator.

Commendable then are the Researches, which many amongst us have of late Years made into the Works of Nature, more than hath been done in some Ages before. And therefore when we are asked, *Cui Bono?* To what purpose such Enquiries, such Pains, such Expence? The Answer is easy, It is to answer the Ends for which G O D bestowed so much Art, Wisdom and Power about them, as well as given us Senses to view and survey them; and an Understanding and Curiosity to search into them: it is to follow and trace him, when and whither he leads us, that we may
see

see and admire his Handy-work our selves, and set it forth to others, that they may see, admire and praise it also. I shall then conclude this Inference with what *Elibu* recommends, Job. 26, 24, 25. *Remember that thou magnifie his Work, which Men behold. Every Man may see it, Man may behold it afar off.*

CHAP. III.

That GOD's Works are manifest to all : whence the Unreasonableness of Infidelity.

THE concluding Words of the preceeding Chapter suggests a third Inference; that the Works of GOD are so visible to all the World, and withal such manifest Indications of the Being and Attributes of the infinite Creator, that they plainly argue the Vileness and Perverseness of the Atheist, and leave him inexcusable. For it is a sign a Man is a wilful perverse Atheist, that will impute so glorious a Work, as the Creation is, to any thing, yea a meer *Nothing* (as Chance is) rather than to GOD (1). 'Tis a sign the Man is wil-

(1) *Galen* having taken Notice of the neat Distribution of the Nerves to the Muscles, and other Parts of the Face, cries out, *Hec enim fortunæ sunt opera ! Ceterum tum omnibus [partibus] immitti, tantosque esse singulos [nervos] magnitudine, quanta particula erat necesse ; haud scio an hominum sit sobriorum ad Fortunam opificem id revocare. Alioqui quid tandem erit, quod cum Providentia & Arte efficitur ? Omnino enim ho: ei contrarium esse debet, quod Casu ac Fortuito fit.* And afterwards, *Hec quidem atque ejusmodi Artis scil. ac Sapientie opera esse dicemus, si modo Fortuna tribuenda sunt quæ sunt contraria ; fietque jam quod in proverbiiis — Fluvii sursum fluent ; si opera quæ nullum habent neque ornamentum* neque

wilfully blind, that he is under the Power of the Devil, under the Government of Prejudice, Lust, and Passion, not right Reason, that will not discern what *every one can see, what every Man may behold afar off*, even the Existence and Attributes of the CREATOR from his Works. For as *there is no Speech or Language where their Voice is not heard, their Line is gone out through all the Earth, and their Words to the End of the World*: so all, even the barbarous Nations, that never heard of GOD, have from these his Works inferred the Existence of a Deity, and paid their Homages to some Deity, although they have been under great Mistakes in their Notions and Conclusions about him. But however, this shews how naturally and universally all Mankind agree in deducing their Belief of a God from the Contemplation of his Works, or as even Epicurus himself in Tully (2) saith, *from a Notion that Nature it self hath imprinted upon the Minds of Men. For, saith he, what Nation is there, or what kind of Men, that without any Teaching or Instructions, have not a kind of Anticipation, or preconceived Notion of a Deity?*

An Atheist therefore (if ever there was any such) may justly be esteemed a Monster among Rational Beings; a thing hard to be met with in the whole Tribe of Mankind; an Opposer of all
the

neque rationem, neque modum Artis esse; contraria vero Fortuna duxerimus, &c. Galen. ubi supra. L. II. c. 7.

(2) *Primum esse Deos, quod in omnium animis, &c. And a little after, Cum enim non instituto aliquo, aut more, aut lege sit opinio constituta, maneatque ad unum omnium firma consensio, intelligi necesse est, esse Deos, quoniam insitas eorum vel potius innatas cognitiones habemus. De quo autem omnium Natura consentit, id verum esse necesse est. Esse igitur Deos confitendum est. Cicero, de Nat. Deor. L. I.*

the World (3) ; a Rebel against human Nature and Reason, as well as against his G O D.

But above all, monstrous is this, or would be, in such as have heard of G O D, who have had the Benefit of the clear Gospel Revelation. And still more monstrous this would be in one born and baptized in the Christian Church, that hath studied Nature, and pryed farther than others into God's Works. For such an one (if it be possible for such to be) to deny the Existence, or any of the Attributes of G O D, would be a great Argument of the Infinite Inconvenience of those Sins of Intemperance, Lust, and Riot, that have made the Man abandon his Reason, his Senses, yea I had almost said his very human Nature (4), to engage him thus to deny the Being of G O D.

So also it is much the same monstrous Infidelity, at least betrays the same atheistical Mind, to deny G O D's Providence, Care and Government of the World, or (which is a Spawn of the same *Epicurean Principles*) to deny *Final Causes* (5) in God's Works of Creation ; or with the Profane in *Psal. 73. 11.* to say, *How doth God know? and is there*

(3) The Atheist in denying a God, doth, as *Plutarch* saith, endeavour ——— *immobiliq movere, & bellum inferre non tantum longo tempore, sed & multis hominibus, gentibus, & familiis, quas religiosus Deorum cultus, quasi divino furore correptas, tenuit.* *Plutar. de Iside.*

(4) See before Note 2.

(5) *Galen* having substantially refuted the Epicurean Principles of *Asclepiades*, by shewing his ignorance in Anatomy, and Philosophy, and by demonstrating all the *Causes* to be evidently in the Works of Nature, viz. *Final, Efficient, Instrumental, Material and Formal Causes*, concludes thus against his fortuitous Atoms, *ex quibus intelligi potest, Conditorem nostrum in formandis particulis unum hunc sequi scopum, nempe ut quod melius est eligat.* *Galen. de Us. Part. L. 6. c. 13.*

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*there Knowledge in the most High ? For as the witty
and eloquent Salvian saith (6) They that affirm no-
thing is seen by G O D, will, in all probability, take
away the Substance, as well as Sight of God. — But
what so great Madness, saith he, as that when a Man
doth not deny G O D to be the Creator of all things, he
should deny him to be the Governour of them ? or when
he confesseth him to be Maker, he should say G O D ne-
glecteth what he hath so made ?*

C H A P. IV.

*That G O D's Works ought to excite us to Fear and
Obedience to G O D.*

SINCE the Works of the Creation are all of them
so many Demonstrations of the infinite Wis-
dom and Power of God, they may serve to us as so
many Arguments exciting us to the constant *Fear*
of God, and to a steady hearty *Obedience* to all
his Laws. And thus we may make these Works
as serviceable to our spiritual Interest, as they all
are to our Life, and temporal Interest. For if
whenever we see them, we would consider that
these are the Works of our infinite *Lord and Master*,
to whom we are to be accountable for all our
Thoughts, Words and Works, and that in these
we may see his infinite Power and Wisdom ; this
would check us in Sinning, and excite us to
serve and please him who is above all Controul,
and who hath our Life and whole Happiness in
his Power. After this manner G O D himself argues
with his own foolish People, and without Understand-

(6) *De Gubern. Dei.* L. 4. p. 124. *meo Libro* : also L. 7. c. 14.
(1)

ing, who had Eyes, and saw not, and had Ears, and heard not, Jer. 5. 21, 22. Fear ye not me saith the Lord? will ye not tremble at my Presence, which have placed the Sand for the Bound of the Sea, by a perpetual Decree, that it cannot pass it, and though the Waves thereof toss themselves, yet can they not prevail, though they roar, yet can they not pass over it?

This was an Argument that the most ignorant stupid Wretches could not but apprehend; that a Being that had so vast and unruly an Element, as the Sea, absolutely at his Command, ought to be feared and obeyed: and that he ought to be considered as the sovereign Lord of the World, on whom the World's Prosperity and Happiness did wholly depend; v. 24. *Neither say they in their Heart, let us now Fear the Lord our God, that giveth Rain, both the former and the latter in his Season; he reserveth unto us the appointed Weeks of the Harvest.*

CHAP. V.

That GOD's Works ought to excite us to Thankfulness.

AS the Demonstrations GOD hath given of his infinite Power and Wisdom should excite us to Fear and Obedience; so I shall shew in this Chapter, that the Demonstrations God hath given of his infinite Goodness in his Works, may excite us to a due Thankfulness and Praise. It appears throughout the foregoing Survey, what Kindness GOD hath shewn to his Creatures in providing every thing conducing to their Life, Prosperity, and Happiness (1); how they are all

(1) *Si pauca quis tibi donasset jugera, accepisse te diceres beneficium; immensa terrarum late patentium spatia negas esse*

all contrived and made in the best Manner, placed in the fittest Places of the World for their Habitation and Comfort ; accoutered in the best Manner, and accommodated with every, even all the minutest things that may minister to their Health, Happiness, Office, Occasions, and Business in the World.

Upon which account Thankfulness and Praise is so reasonable, so just a Debt to the Creator, that the Psalmist calleth upon all the Creatures to praise God, in Psalm 148. *Praise him all his Angels, Praise him all his Hosts ; Sun, Moon, Stars of Light, Heavens of Heaven, and Waters above the Heavens.* The Reason given for which is v. 5, 6. *For he commanded, and they were created : he hath also established them for ever and ever : he hath made a Decree which they shall not pass.* And not these Celestials alone, but the Creatures of the Earth and Waters too, even the Meteors, Fire and Hail, Snow and Vapours, stormy Wind fulfilling his Word. Yea, the very Mountains and Hills, Trees, Beasts and all Cattel, Creeping things, and flying Fowl. But in a particular manner, all the Ranks and Orders, all the Ages and Sexes of Mankind are charged with this Duty ; *Let them praise the Name of the Lord, for his Name alone is excellent : his Glory is above the Earth and Heavens.* v. 13.

And

esse beneficium ? Si pecuniam tibi aliquis donaverit, — beneficium vocabis : tot metalla defodit, tot flumina emisit in ora, super quæ decurrunt sola aurum vebentia : argenti, aris, ferri immane pondus omnibus locis obrutum, cujus investigandi tibi facultatem dedit, — negas te accepisse beneficium ? Si domus tibi donetur, in qua marmoris aliquid resplendeat, &c. Num mediocre munus vocabis ? Ingens tibi domicilium, sine ullo incendii, aut minæ metu struxit, in quo vides non tenues crustas, — sed integras lapidis pretiosissimi moles, &c. negas te ullum munus accepisse ? Et cum ista quæ habes magno aestimes, quod est ingrati hominis, nulli debere te judicas ? Unde tibi istum quem trahis spiritum ? Unde istam, per quam actus vitæ tuæ disponis atque ordinas, lucem ? &c. Senec. de Benef. L. 4. c. 6.

And great Reason there is we should be excited to true and unfeigned Thankfulness and Praise (2) to this our great Benefactor, if we reflect upon what hath been shewn, in the preceding Survey, the *Creator* hath done for Man alone, without any regard to the rest of the Creatures, which some have held were made for the Sake of Man. Let us but reflect upon the Excellence and Immortality of our Soul; the incomparable Contrivance, and curious Structure of our Body; and the Care and Caution taken for the Security and Happiness of our State, and we shall find that among the whole Race of Beings, Man hath especial Reason to magnify the Creator's Goodness, and with suitable ardent Affections to be thankful unto him.

C H A P. VI.

That we ought to pay G O D all due Homage and Worship, particularly that of the Lord's-Day.

FOR a Conclusion of these Lectures, the last thing I shall infer, from the foregoing Demon-

(2) *Tempestivum tibi jam fuerit, qui in hisce libris versaris considerare, in utram Familiam recipi malis, Platoniamne ac Hippocraticam, & aliorum virorum, qui Naturæ opera mirantur; an eorum qui ea insectantur, quod non per Pedes natura constituit effluere Excrementa.* Of which having told a Story of an Acquaintance of his that blamed Nature on this account, he then goes on, *At vero si de hujusmodi peccatis plura verba fecero, melioris mentis homines merito mihi forte succenseant, dicantque me polluere sacrum sermonem, quem ego CONDITORIS nostri verum Hymnum compono, existimoque in eo veram esse pietatem, — ut si noverim ipse primus, deinde & aliis exposuerim, quam sit ipsius Sapientia, quæ Virtus, quæ Bonitas. Quod enim cultu conveniente exornaverit omnia, nullique bona inviderit, id perfectissimæ Bonitatis specimen esse statuo: & hac quidem ratione ejus Bonitas*

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 monstration of the Being and Attributes of GOD,
 shall be, that we ought to pay G O D all that *Ho-*
mage and *Worship* which his Right of Creation and
 Dominion entitle him unto, and his great Mercies
 call for from us. And forasmuch as the *Creator*
 appointed, from the very Creation, one Day in
 seven to this Service, it will not therefore be im-
 proper to say something upon that Subject: and
 if I insist somewhat particularly and largely there-
 on, the Congruity thereof to the Design of these
 Lectures, and the foregoing Demonstration, to-
 gether with the too great Inadvertency about,
 and neglect of this antient, universal, and most
 reasonable and necessary Duty, will I hope plead
 my Excuse. But that I may say no more than is
 necessary on this Point, I shall confine my self to
 two things, the *Time* God hath taken, and the *Bu-*
siness then to be performed.

1. The *Time* is one Day in seven, and one of the
 ancientest Appointments it is which G O D gave
 to the World. For as soon as G O D had finish-
 ed his six Days Works of Creation, it is said Exod.
 2. 2, 3. *he rested on the seventh Day from all his Work*
which he had made. And G O D blessed the seventh
Day, and sanctified it, because that in it he had rested
from all his Work. This Sanctification, and
 Blessing the Seventh Day, was setting it apart as
 a Day of Distinction from the Rest of the Week-
 Days, and appropriating (1) it to Holy Uses and
 Pur-

nitas Hymnis nobis est celebranda. Hoc autem omne invenisse
quo pacto omnia potissimum adornarentur, summæ Sapientiæ
est: effecisse autem omnia, quæ voluit, Virtutis est invictæ.
 Galen. de Us Part. L. 3. c. 10.

(1) *UT* Usibus divinis accommodavit, a communi & pro-
 fano usu segregavit, in usum sacrum ad cultum Dei destina-
 vit. Kirch. Concord. p. 1336. *Destinari ad aliquid, Sacrari,*
&c. Buxtorf. in Verbo. (2)

Purposes, namely, the Commemoration of that great Work of the Creation, and paying Homage and Worship to that infinite Being, who was the Effector of it.

This Day, thus consecrated from the Beginning, for the Celebration of the *τῆς κόσμου γενέσεως*, the *World's Birth-Day*, as *Philo* calls it, was probably in some measure forgotten in the following wicked Ages, which God complains of, *Gen. 6. 5.* and so after the Flood likewise. But after the Return out of *Egypt*, when G O D settled the Jewish Polity, he was pleased to renew this Day, and to establish it for a perpetual standing Law. And accordingly it was observed down to our blessed S A V I O U R's Time, countenanced, and strictly observed by our great L O R D and Master himself, and his Apostles and Disciples in, and after his time; and although for good Reasons the Day was changed by them, yet a Seventh Day hath been constantly observed in all Ages of Christianity down to our present time.

Thus we have a Day appointed by G O D himself, and observed throughout all Ages, except some few perhaps, which deserve not to be brought into Example.

And a wise Designation of time this is, well becoming the divine Care and Precaution; serving for the recruiting our Bodies, and dispatching our Affairs, and at the same time to keep up a spiritual Temper of Mind. For by allowing Six Days to labour, the Poor hath time to earn his Bread, the Man of Business time to dispatch his Affairs, and every Man time for the work of his respective Calling. But had there been more, or all our time allotted to Labour and Business, and none to Rest and Recruit, our Bodies and Spirits would have been too much Fatigued and Wasted, and our Minds have been too long engaged about world-

worldly Matters, so as to have forgotten divine Things. But the Infinitely Wise Ruler of the World, having taken the seventh Part of our time to his own Service, hath prevented these Inconveniences ; hath given a Relaxation to our selves, and Ease and Refreshment to our wearied Beasts, to poor fatigued Slaves, and such as are under the Bondage of avaritious cruel Masters. And this is one Reason *Moses* gives of the Reservation and Rest of the seventh Day, Deut. 5. 13, 14, 15. *Six Days shalt thou labour, and do all thy work : but the Seventh is the Sabbath of the LORD thy GOD ; in it thou shalt not do any work, thou, nor thy Children, Servants, Cattle, or Stranger, that thy Man Servant, and Maid Servant may rest as well as thou. And remember, that thou wast a Servant, &c. therefore the Lord thy God commanded thee to keep the Sabbath-day.* That carnal, greedy People, so bent upon Gain, without such a Precept, would have scarce favoured their own Bodies, much less have had Mercy upon their poor Bonds-men and Beasts ; but by this wise Provision, this great Burden is taken off. But on the other hand, as a longer Liberty would too much have robbed the Master's time, and bred Idleness, so by this wise Provision, of only one day of Rest to Six of Labour, that Inconvenience was also prevented.

Thus the wise Governour of the World, hath taken care for the dispatch of Business. But then as too long engagement about worldly Matters, would take off Mens Minds from God, and Divine Matters, so by this reservation of every Seventh Day, that great Inconvenience is prevented also ; all being then bound to worship their great Lord and Master, to pay their Homages and Acknowledgments to their infinitely kind Benefactor ; and in a word, to exercise them-

themselves in Divine, Religious Business, and so keep up that spiritual temper of Mind, that a perpetual, or too long application to the World would destroy.

This, as it was a good Reason for the order of a Sabbath to the Jews; so is as good a Reason for our Saviour's continuance of the like time in the Christian Church.

And a Law this is becoming the infinitely wise Creator and Conservator of the World, a Law, not only of great use to the perpetuating the remembrance of those greatest of God's Mercies then commemorated, but also exactly adapted to the Life, Occasions, and State of Man; of Man living in this, and a-kin to another World; a Law well calculated to the dispatch of our Affairs, without hurting our Bodies or Minds. And since the Law is so Wise and Good, we have great reason to practise carefully the Duties then incumbent upon us: which will fall under the Consideration of the

2. Thing I proposed, the *Business* of the Day, which God hath reserved to himself. And there are two Things enjoined in the Commandment, a *Cessation* from Labour and worldly Business, and that we *remember to keep* the Day holy.

1. There must be a Cessation from worldly Business, or a Rest from Labour, as the Word *Sabbath* (2) signifies. *Six Days thou shalt do all thy work, but the Seventh is the Sabbath of the Lord thy GOD* (not thy Day but his) *in which neither thou, nor any belonging to thee, shall do any work.* In which Injunction it is observable, how express and particular this Commandment is, more than others, in ordering all sorts of Persons to cease from Work.

2.

(2) נָחַם Cessatio, Requies.

2. We must *remember to keep the Day holy*. Which *Remembrance* is another thing also in this, more than in the other Commandments, and implies

1. That there is great danger of our forgetting, neglecting, or being hindered from keeping the Day holy, either by the Infirmary and Carnality of our own Nature, or from the Avocations of the World.

2. That the keeping it holy, is a Duty of more than ordinary Consequence and Necessity. And of greatest consequence this is,

1. To perpetuate the Remembrance of those grand Works of GOD commemorated on that Day; in the first Ages of the World, the Creation; in the middle Ages, the Creation and Delivery from *Egypt*; and under Christianity, the Creation and Redemption by Christ. Which Mercies, without such frequent Occasions, would be ready to be forgotten, or disregarded, in so long a tract of time, as the World hath already stood, and may, by God's Mercy, still stand.

2. To keep up a spiritual Temper of Mind, by those frequent weekly Exercises of Religion, as hath been already mentioned.

3. To procure GOD's Blessing upon the Labours and Business of our six Days, which we can never expect should be prosperous, if we are negligent of GOD's time. For how can we expect GOD's Blessing upon a Week so ill begun, with a Neglect, or Abuse of GOD's first Day. And therefore if we become unprosperous in the World; if Losses, Troubles or Danger befall, let us reflect how we have spent the *Lord's Day*; whether we have not wholly neglected it or abused it in Riot, or made it a Day for taking Journeys, for more private Business, and less scandalous Labour, as the Custom of too many is.

Thu

Thus having shewn what reason there is to remember to keep holy the Day dedicated to GOD, I shall consider how we are to keep it holy, and so conclude. Now the way to keep it holy, is not by bare resting from Work; for that, as a Father saith, is *Sabbatum Boum & Asinorum*, a Sabbath of Beasts: but holy Acts are the proper Business for a holy Day, celebrated by rational Beings. Among all which, the grand, principal, and most universally practised, is the *Publick Worship of GOD*, the Assembling at the *Publick Place* of his *Worship*, to pay, with our Fellow-Creatures, our Homages, Thanks, and Praises to the infinite Creator and Redeemer of the World. This, as it is the most reasonable Service, and proper Business for this Day, so is what hath been the Practice of all Ages. It was as early as *Cain and Abel's Days*, *Gen. 4. 3*, what was practised by Religious Persons in the following Ages till the giving of the Law; and at the giving of that, God was pleased to order Places and his particular Worship, as well as the Seventh Day. The Tabernacle and Temple were appointed by God's express Command; besides which, there were Synagogues all over the Nation: so that in our Saviour's time, every great Town or Village had one, or more in it, and *Jerusalem* 460, or more. (3)

The Worship of these Places, our blessed SAVIOUR was a constant and diligent frequenter of. 'Tis said, *he went about all the Cities and Villages, Teaching in their Synagogues, and Preaching, and Healing, &c. Matt. 9. 35.* And S. Luke reporteth it, as his constant Custom or Practice, *Luke 4. 16. And as his custom was, he went into the Synagogue on the Sabbath-Day.*

(3) Vid. *Lightfoot's Works* Vol. 2. p. 35. & 646.

Having thus mentioned the Practice of CHRIST, it is not necessary I should say much of the Practice of his *Apostles*, and the following purer Ages of Christianity, who, in short, as their Duty was, diligently followed their great Master's Example. *They did not think it enough to Read, and Pray, and Praise God at home, but made conscience of appearing in the publick Assemblies: from which nothing but Sicknes and absolute Necessity did detain them: and if Sick, or in Prison, or under Banishment, nothing troubled them more, than that they could not come to Church, and joyn their Devotions to the common Services.* If Persecution at any time forced them to keep a little close, yet no sooner was there the least Mitigation, but they presently returned to their open Duty, and Publickly met all together. No trivial Pretences, no light Excuses were then admitted for any ones Absence from the Congregation, but according to the merit of the Cause, severe Censures were passed upon them, &c. to express it in the Words of One of our best Antiquaries. (4)

The Publick Worship of GOD then, is not a Matter of Indifference, which Men have in their own Power to do, or omit, as they please; neither is it enough to Read, Pray, or Praise God at home (unless some inevitable necessity hindereth) because the appearing in GOD's House, on *his Day*, is an Act of *Homage and Fealty*, due to the CREATOR, a *Right of Sovereignty* we pay him. And the with-holding those Rights and Dues from GOD, is a kind of rejecting GOD, a disowning his Sovereignty, and a withdrawing our Obedience and Service. And this was the very Reason why the Profanation of the Sabbath was

(4) *Dr. Cave's Prim. Christ. Par.* 1. c. 7.

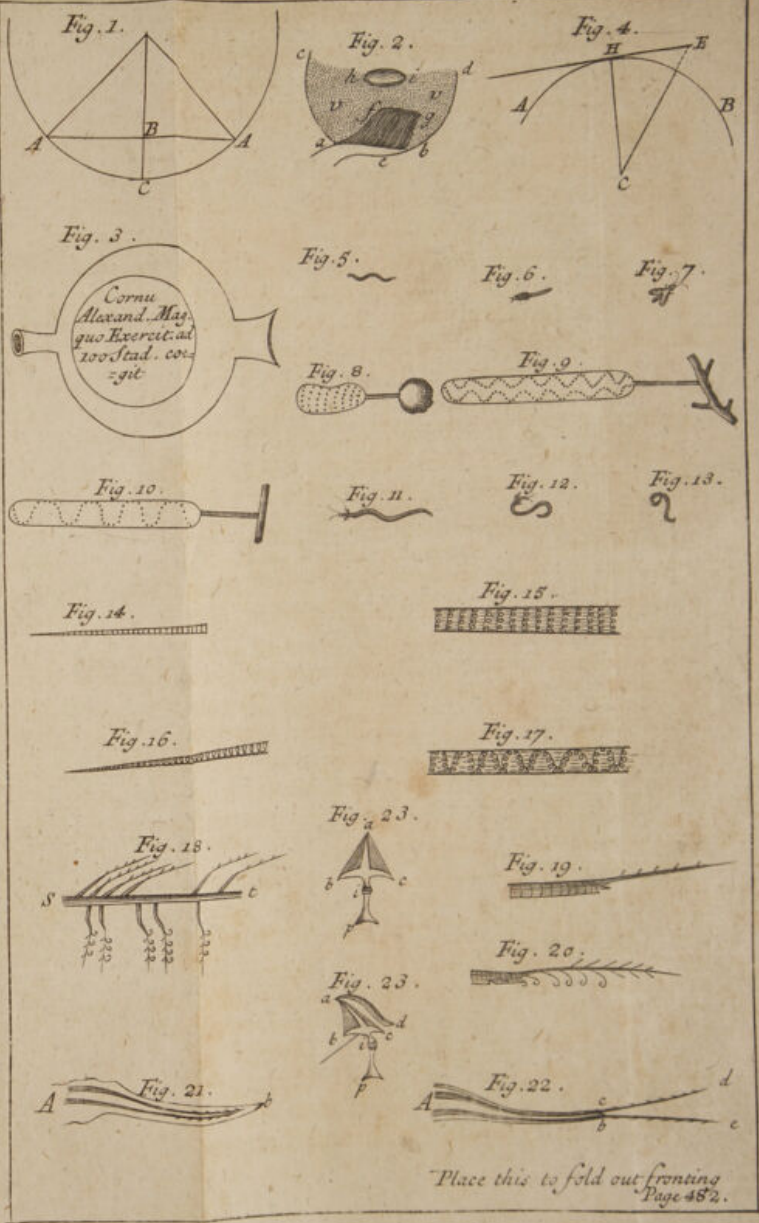
was punished with Death among the Jews, the Sabbath being a Sign, or Badge of the GOD they Owned and Worshipped. (5) Thus Exod. 31. 13. *My Sabbaths ye shall keep ; for it is a SIGN between me and you, throughout your Generations ; that ye may know that I am the LORD, that doth sanctify you : or as the Original may be rendered ; a Sign to acknowledge, that I Jehovah am your Sanctifier, or your God.* For as our Learned Mede observes, *to be the Sanctifier of a People, and to be their God, is all one.* So likewise very expressly in Ezek. 20. 20. *Hol-*

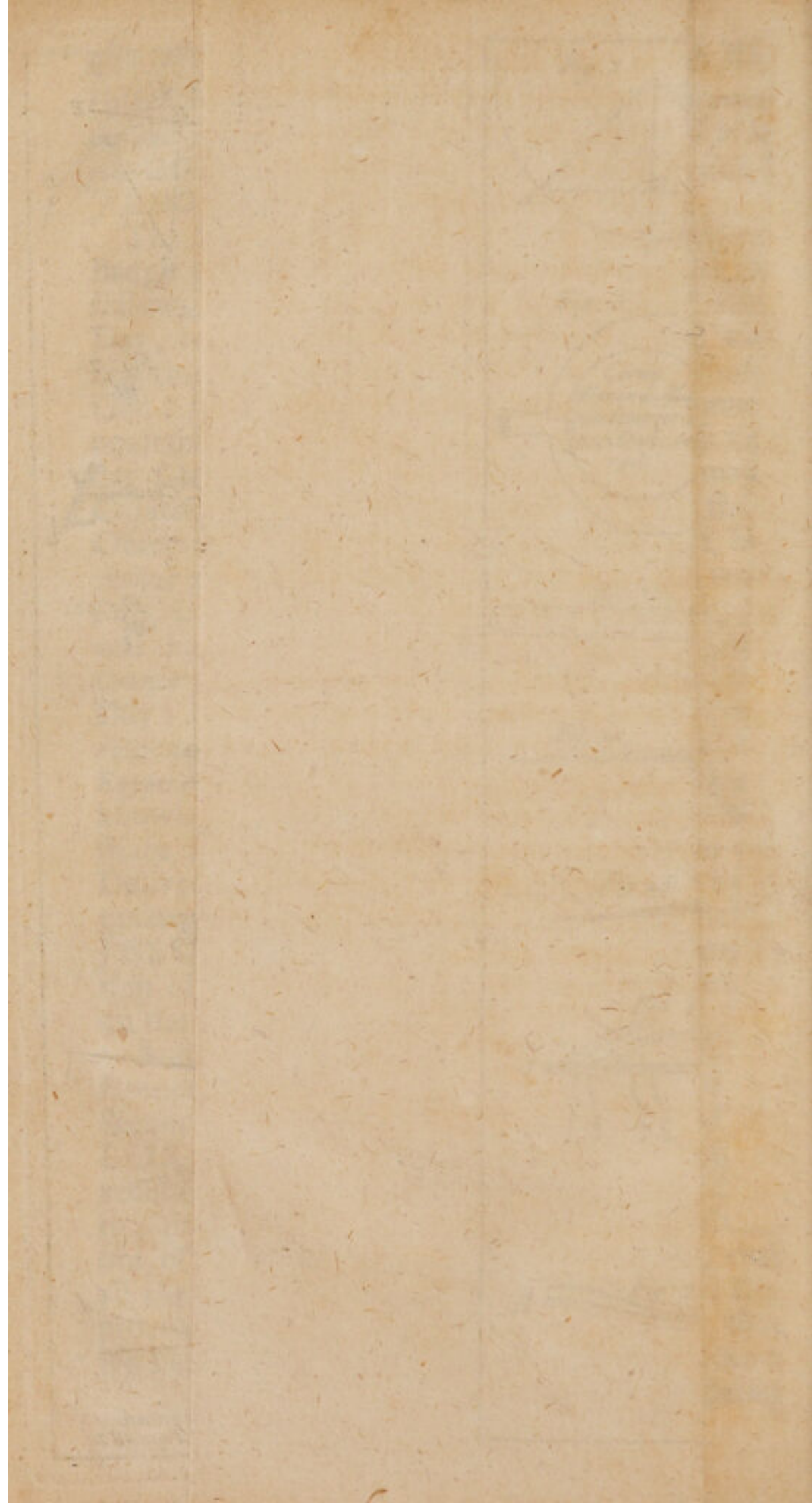
(5) As at this Day it is customary for Servants to wear the Livery of their Masters, and others to bear Badges of their Order, Profession, Servility, &c. So in former Ages, and divers Countries, it was usual to bear Badges, Marks and Signs on divers Occasions. In Ezek. 9. 4. *a Mark was to be set on the Forehead of those that lamented the Abominations of the City.* The like was to be done upon them in Rev. 7. 3. and 9. 4. So the Worshipers of the Beast, Rev. 13. 16. were to receive a *χάρισμα*, a Mark in their right Hand, or their Foreheads. Those *χαρῖσματα, σημεῖα*, Badges, &c. were very common. Soldiers and Slaves bare them in their Arms or Foreheads: such as were matriculated in the *Hæterie*, or Companies bare the Badge or Mark of their Company ; and whoever lifted himself into the Society of any of the several Gods, received a *χάρισμα*, or a Mark in his Body (commonly made with red-hot Needles, or some burning in the Flesh) of the God he had lifted himself under. And after Christianity was planted, the Christians had also their *Sign of the Cross*. And not only Marks in their Flesh, Badges on their Cloathes, &c. were usual, but also the Dedication of Days to their imaginary Deities. Not to speak of their Festivals, &c. the Days of the Week were all dedicated to some of their Deities. Among the Romans, Sunday and Monday, to the Sun and Moon ; Tuesday to Mars, Wednesday to Mercury, &c. So our Saxon Ancestors did the same ; Sunday and Monday (as the Romans did) to the Sun and Moon ; Tuesday to *Tuysco* ; Wednesday to *Woden* ; Thursday to *Thor* ; Friday to *Friga* ; and Saturday to *Seater* ; an Account of which Deities, with the Figures under which they were Worshipped, may be met with in our Learned *Verstegan*. Ch. 3. p. 68, &c.

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Hollow my Sabbaths, and they shall be a Sign between me and you, that ye may know that I am the LORD your GOD; or rather as before, to acknowledge that I JEHOVAH am your GOD.

The Sabbath being thus a Sign, a Mark, or Badge to acknowledge God to be their God, it follows, that a Neglect, or Contempt of that Day, redounded to GOD; to slight that, was slighting God; to profane that, was to affront God: for the Punishment of which, what more equitable Penalty than Death. And although under Christianity, the Punishment is not made Capital, yet have we no less Reason for the strict Observance of this holy Day, than the Jews, but rather greater Reasons. For the GOD we worship, is the same: if after six Days Labour, he was by the Seventh owned to be GOD, the Creator; no less is he by our Christian Lord's Day: if by the Celebration of the Sabbath, the remembrance of their Deliverance from the Egyptian Bondage was kept up, and GOD acknowledged to be the Effector thereof; we Christians have a greater Deliverance, we own our Deliverance from Sin and Satan, wrought by a greater Redeemer than Moses, even the blessed JESUS, whose Resurrection, and the Completion of our Redemption thereby, was performed on the Christian Lord's Day.

And now to sum up, and conclude these Inferences, and so put an end to this part of my Survey: Since it appears, that the Works of the LORD are so great, so wisely contrived, so accurately made, as to deserve to be enquired into; since they are also so manifest Demonstrations of the Creator's Being and Attributes, that all the World is sensible thereof, to the great Reproach of Atheism; what remaineth, but that we Fear and Obey so Great and Tremendous a Being





Being ; that we be truly Thankful for, and Magnify and Praise his infinite Mercy manifested to us in his Works. And forasmuch as he hath appointed a Day on purpose, from the Beginning, for these Services, that we may weekly meet together, commemorate and celebrate the great Work of Creation, that we may pay our Acts of Devotion, Worship, Homage and Fealty to him ; and since this is a Wise and Excellent Distribution of our time, what should we do, but conscientiously and faithfully pay GOD these his Rights and Dues ? and as carefully and diligently manage GOD's time, and discharge his Business then, as we do our own upon our six Days : particularly that with the Pious Psalmist, *we love the Habitation of God's House, and the place where his Honour dwelleth ;* and therefore take up his good Resolution in *Psal. 5. 7.* with which I shall conclude ; *but as for me, I will come into thine House in the multitude of thy Mercy, and in thy fear will I worship towards thy holy Temple.*

Now to the same infinite GOD, the omnipotent Creator and Preserver of the World, the most gracious Redeemer, Sanctifier, and Inspirer of Mankind, be all Honour, Praise and Thanks, now and ever. *Amen.*

A TABLE

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