Godw. 58 Subt.

A

SURVEY

OF THE

Wiſdom of GOD *in the* CREATION:

OR A

COMPENDIUM

OF

Natural Philoſophy.

In TWO VOLUMES.

VOL. I.

These are thy glorious Works, Parent of Good,
Almighty! Thine this universal Frame,
Thus wondrous fair! Thyself how wondrous then!

MILTON.

BRISTOL:
Printed by WILLIAM PINE, 1763.

THE

PREFACE.

I. HAVE long desired to see such a *Compendium of Natural Philosophy*, as was, 1. Not too diffuse, not expressed in many Words, but comprized in so moderate a compass, as not to require any large Expence, either of Time or Money: 2. Not maimed or imperfect, but containing the Heads of whatever (after all our Discoveries) is known with any degree of Certainty, either with regard to the Earth or Heavens. And this I wanted to see, 3. In the plainest Dress, simply and nakedly expressed, in the most clear, easy and intelligible manner, that the Nature of the things would allow: Particularly free from all the Jargon of *Mathematics*, which is mere *Heathen Greek* to common Readers. At the same time I wished to see this short, full, plain Account of the visible Creation, directed to its right End: Not barely to entertain an idle, barren Curiosity, but to display *the invisible things of* GOD, his Power, Wisdom and Goodness.

2. BUT I cannot find such a Treatise as this in any Modern, any more than Antient Language. And I am certain, there is none such in the *English* Tongue. What comes neareſt to it of any thing I have ſeen, is Mr. *Ray's Wiſdom of* GOD *in the Creation*, Mr. *Derham's Phyſico* and *Aſtro-Theology*, *Niewentyt's Religious Philoſopher*, *Mather's Chriſtian Philoſopher*, and *Nature delineated*. But none of theſe, ſingle, anſwers the Deſign. And who will be at the Pains, to extract the Subſtance of them all, and to add the later Diſcoveries, of which they had little Knowledge, and therefore could take but little notice? This is a *Deſideratum* ſtill; and one that a Lover of Mankind would rejoice to ſee even tolerably ſupplied.

3. I AM throughly ſenſible, there are many who have far more Ability, as well as Leiſure, for ſuch a Work than me. But as none of them undertakes it, I have myſelf made ſome little Attempt in the enſuing Volumes. Herein following Mr. *Derham's* Plan, I divide the Work into *Text* and *Notes*. The Text is in great Meaſure tranſlated from the *Latin* Work of *John Francis Buddæus*, the late celebrated Profeſſor of Philoſophy, in the Univerſity of *Jena*, in *Germany*. But I have found occaſion to retrench, inlarge or alter every Chapter, and almoſt every Section. So that it is now, I believe, not only *pure*, containing nothing falſe or uncertain, but as *full* as any Tract can be expected to be, which is comprized in ſo narrow a compaſs; and likewiſe *plain*, clear and intelligible to one of a tolerable Underſtanding. The Notes contain the Sum of what is moſt valuable, in the above-named Writers: To which are added the choiceſt Diſcoveries both of our own, and of the Foreign Societies; chiefly extracted from that great Treaſury of Learning, Mr. *Chambers's Dictionary*.

Theſe

Theſe likewiſe, I truſt, are as plain and clear, as the Nature of the things ſpoken will allow: Altho' ſome of them, I know, will not be underſtood, by an unlearned or inattentive Reader.

4. MEANTIME I muſt apprize the Reader, that I have ſometimes a little digreſſed, by reciting both uncommon Appearances of Nature, and uncommon Inſtances of Art: And yet this is not properly a Digreſſion, from the main Deſign I have in view. For ſurely in theſe Appearances alſo, the Wiſdom of GOD is diſplayed: Even that manifold Wiſdom, which is able to anſwer the ſame Ends by ſo various Means. And thoſe ſurprizing Inſtances of Art, do likewiſe reflect Glory upon Him, whoſe *Spirit in Man giveth* that *Wiſdom*, whoſe *Inſpiration teacheth Underſtanding*.

5. IT will be eaſily obſerved, that I endeavour throughout, not to *account for* things, but only to *deſcribe* them. I undertake barely to ſet down what *appears* in Nature, not the *Cauſe* of thoſe Appearances. The *Facts* lie within the reach of our Senſes and Underſtanding; the *Cauſes* are more remote. *That things are ſo*, we know with certainty: But *why they are ſo*, we know not. In many caſes we cannot know; and the more we inquire, the more we are perplext and intangled. GOD *hath ſo done his Works*, that we may admire and adore: But *we cannot ſearch them out to perfection*.

6. AND does not this open to us another Proſpect? Altho' one we do not care to dwell upon. Does not the ſame Survey of the Creation, which ſhews us the Wiſdom of GOD, ſhew the aſtoniſhing Ignorance and ſhort-ſightedneſs of Man? For when we have finiſhed our Survey, what do we know? How inconceivably little? Is not every thinking Man conſtrained to cry out, And is *this*

All? Do all the boasted Discoveries of so *enlightened* an Age, amount to no more than This? *Vain Man would be wise!* Would know all things! But with how little Success does he attempt it? How small a Part do we know even of the things that encompass us on every side? I mean, as to the very *Fact:* For as to the *Reasons* of almost every thing which we see, hear or feel, after all our Researches and Disquisitions, they are hid in impenetrable Darkness.

7. I TRUST therefore the following Tract may, in some degree, answer both those important Purposes. It may be a means, on the one hand, of humbling the Pride of Man, by shewing that he is surrounded on every side, with things which he can no more account for, than for Immensity or Eternity: And it may serve, on the other, to display the amazing Power, Wisdom and Goodness of the great Creator; to warm our Hearts, and to fill our Mouths with Wonder, Love and Praise!

John Wesley.

A

VIEW

OF THE

Wisdom of GOD in the CREATION:

OR A

COMPENDIUM OF

Natural Philosophy.

The INTRODUCTION.

Of the gradual Improvement of Natural Philosophy.

1. *The Order observed in this Treatise:*
2. *The Method of philosophizing among the* Hebrews *and* Egyptians:
3. *Among the* Greeks: *The Philosophy of* Pythagoras, Plato, Aristotle:
4. *The different Method pursued by the four* Greek *Sects:*
5. *The Philosophy of the* Schoolmen:
6. *The Revival of Philosophy by Lord* Bacon;
7. *Greatly promoted by Philosophical Societies:*
8. *The*

8. *The Improvement made in every Branch of it: In Anatomy, the Discovery of the Circulation of the Blood, of the Lacteal Veins, and the Thoracic Duct;*

9. *Of the Generation of all Animals from Eggs;*

10. *Of the Transfusion of Blood;*

11. *Diseases themselves and the Operations of Medicines give Occasion for farther Discoveries.*

12. *Many Anatomical Discoveries have been made by* Microscopes:

13. *Many, with regard to Brutes, particularly Fishes and Insects:*

14. *Many likewise, with regard to Plants, Stones, Metals and Minerals:*

15. *Great Improvements from the Art of* Chemistry:

16. *Discoveries concerning the Loadstone;*

17. *Concerning Glass and Burning-Glasses.*

18. *The Nature of the Air is more accurately discovered, by means of the Barometer, the Thermometer and the Air-Pump:*

19. *Discoveries relating to Water:*

20. *Discoveries which shew the Nature of Fire: Of Gunpowder, Phosphorus, Aurum Fulminans:*

21. *Of the Earth, and the chief Systems of the Universe:*

22. *Of the Sun, the Planets and their Satellits:*

23. *Of the causes of Natural Bodies:*

24. *Of Spirits and Divine things.*

1. NATURAL Philosophy treats both of God Himself, and of his Creatures, visible and invisible. Of these I purpose to speak in such a manner, as to ascend from the Consideration of Man, thro' all the Orders of things, as they are farther and farther removed from us, to God the Center of all Knowledge. (I mean, of *visible* things: Of the *invisible* World we cannot know much, while we dwell in Houses of Clay.) Thus Speculative Philosophy ascends from Man to God, Practical descends from God to Man.

2. The most antient Nations, the *Egyptians* and *Hebrews* in particular, philosophized much concerning God, and concerning *Genii*, good or evil Spirits, of an Order superior to Man. What they taught concerning

cerning the visible World, related chiefly to its Origin, the Changes it was to undergo, and its final Dissolution. But on all these Heads they only delivered to their Posterity, what they had received from their Forefathers.

3. Among the *Greeks*, *Thales*, *Milesius*, and his Followers, applied themselves, with great Industry, to discover, with the best Helps they had, the material Causes of natural things. They were succeeded by others, who more curiously searched into the Structure of Natural Bodies. Here the Foundation of Natural History was laid, in various Observations on Plants, Animals and other things: And herein the Endeavours of *Aristotle*, and *Theophrastus* in particular are to be commended. Yet in other respects, *Aristotle* did not promote, but rather obstruct the Knowledge of Nature: For he made Philosophy as unintelligible by his abstract and metaphysical Notions, as *Plato*, *Pythagoras* and others did, by their Ideas, Numbers and Symbols.

4. In succeeding Times, when the four *Greek* Sects, the *Platonic*, *Peripatetic*, *Epicurean* and *Stoic* divided the World between them, the *Platonists* almost confined themselves and their Opinions to the Subject of Divinity; the *Peripatetics* regarded little but Logic; the *Stoics* little but Moral Philosophy; and the *Epicureans* had small concern about any, being immersed in sensual Pleasures: So that none of them made any considerable Improvement in any branch of Natural Philosophy.

5. When the utter Barbarism which followed was a little dispelled, *Aristotle* began to reign. His Followers (the *School-men*, as they were called) might have improved Natural Philosophy, if (like their Master) they had diligently cultivated the Knowledge of Nature, and searched out the Properties of particular things: But it was their Misfortune, to neglect what was commendable in him, and to follow only what was blame-worthy; so as to obscure and pollute all Philosophy, with abstract, idle, vain Speculations. Yet some of them, after the *Arabians* had introduced the Knowledge of Chemistry into *Europe*, were wise above

above the Age they lived in; and penetrated so far into the secret Recesses of Nature, as scarce to escape the Suspicion of Magic. Such were *Roger Bacon* and *Albertus Magnus*.

6. After the Revival of Learning, as all other Branches of Philosophy, so this in particular received new Light. And none was more serviceable herein than Lord *Bacon*; who well understanding the Defects of the School-Philosophy, incited all Lovers of Natural Philosophy, to a diligent Search into Natural History. And he himself led them the way, by many Experiments and Observations.

7. After this, not single Persons only, but whole Societies applied themselves carefully to make Experiments; that having accurately observed the Structure and Properties of each Body, they might the more safely judge of their Nature. And the Advantages which have arisen from hence manifestly appear from the Memoirs of the Royal Society at *London*, of the Academy of Sciences at *Paris*, and those of the same kind in *Germany*, as well as several other Parts of *Europe*.

8. To mention but a few of the late Discoveries in each branch of Natural Philosophy. With regard to the Structure of an Human Body, how many things have modern Anatomists discovered, which were either little understood by the Antients, or wholly unknown to them? Such for instance, is the Circulation of the Blood, discovered by Dr. *William Harvey*, whose "Anatomical Exercitations" concerning it were first published in the Year 1628. Such were the Lacteal Veins, discovered first in Brutes by *Caspar Asellius*, of *Cremona*; and soon after in Men: Such the Thoracic Duct, and Receptacle of the Chyle, observed first by Dr. *John Pecquet*, of *Paris*, whereby the whole Course of the Blood is now clearly understood.

9. Dr. *Harvey* improved Natural Philosophy, by another no less eminent Discovery: For he was the first of the Moderns that shewed all Animals to be generated from Eggs. That the Antients knew and taught this, (*Orpheus* in particular) cannot reasonably be doubted. But as the knowledge of it was intirely lost,

loſt, to revive was the ſame thing as to invent it. It is obvious, how great a light this pours upon that dark Subject, with regard to the Generation of Men, as well as of other Animals.

10. Another remarkable Diſcovery in the laſt Century, was that of the Transfuſion of Blood. The Blood of a young, lively, healthy Animal was transfuſed, by means of a ſmall, ſilver Tube properly adjuſted, into the Veins of another, which was old, weak and ſickly. And the Effect has amazed all the Beholders. When the Experiment was tried before ſeveral of the Royal Society, a feeble, worn-out Dog, ready to die with Age, and hardly able to trail his Legs after him, was no ſooner filled with young Blood, than he leaped up, as from Sleep, ſhook himſelf, and ran up and down, as lively and active as a Puppy. In *France* the Experiment has been made upon Men, and with as ſurprizing Succeſs. What pity, that ſo important an Experiment ſhould ever fall into diſuſe! That it is not ſtill repeated upon proper Occaſions? Eſpecially where all other Means fail.

11. It cannot be denied, that *Phyſicians* have ſignally improved this Branch of Philoſophy, as they have continual Opportunities of making new Diſcoveries in the Human Body. In Diſeaſes themſelves, the wonderful Wiſdom of the Author of Nature appears: And by means of them many hidden Receſſes of the Human Frame are unexpectedly diſcovered. The Powers of Medicines alſo variouſly exerting themſelves, lay open many Secrets of Nature.

12. And how many things in all Bodies, as well as in the Human, which eluded all the Art and Induſtry of the Antients, have the Moderns diſcovered by the Help of *Microſcopes*? Altho' theſe are not properly a modern Invention: It being certain, ſomething of this kind was in uſe, many hundred Years ago. There are ſeveral Works of great Antiquity ſtill extant, the Beauties of which cannot even be diſcerned, much leſs could they have been wrought, by the fineſt naked Eye, which ever was in the World. Such is that Seal, now in the Cabinet of the King of *France*, allowed to be

be at leaſt fifteen hundred Years old, Six-tenths of an Inch long, and four broad, which to the naked Eye preſents only a confuſed Groupe, but ſurveyed with a Microſcope, diſtinctly exhibits Trees, a River, a Boat, and ſixteen or ſeventeen Perſons.

13. Now whatever aſſiſts us in ſearching out the Structure of an Human Body, equally helps us to find out the Nature and Properties of other Animals. Hence in theſe likewiſe we have received great light, from Anatomical and Microſcopical Obſervations. Thoſe eſpecially who have beſtowed their whole Time and Thoughts on one kind of Animals, (as Dr. *Willoughby*, on Fiſhes, Dr. *Swammerdam*, of *Amſterdam*, on Inſects) have illuſterated to a ſurprizing degree, the Subjects on which they wrote.

14. MANY have diligently ſearched into the Nature of Plants; particularly Mr. *Ray*, who has not only ranged them in a new Method, but alſo wrote an elaborate Hiſtory of them. Others have deſcribed with equal Diligence either Plants in general, or thoſe of a particular Country. And others have ſhewn the like Induſtry in finding out and explaining the Nature of Stones, Metals, Minerals, and other Foſſils.

15. NOR is it ſtrange that the Moderns have penetrated farther into the Receſſes of Nature than the Antients, conſidering the Advantages they have received, from the Art of *Chemiſtry*. Not that this is an Invention of later Ages: It was in ſome meaſure known long ago. But as this art has been cultivated in our Age, with far greater Accuracy than ever, ſo by this means many Properties of Natural Bodies have been diſcovered; of Foſſils in particular.

16. BUT none of theſe have ſo much engaged the Study of the Learned, or ſo well deſerved it, as the *Loadſtone*. Its attractive Force was known to the Antients, and the Origin of that Diſcovery is recorded by *Pliny*. But it does not appear that they knew of its pointing to the Pole, or of the Uſe of the Compaſs. This (the Compaſs) was invented by *John Gaia*, in the Year 1300. But it has been ſince obſerved, that the magnetic Needle ſeldom points exactly to the Pole, but

but varies from it ſome Degrees to the Eaſt or Weſt, in a fixt and regular Order.

17. NEARLY related to the Nature of Foſſils is *Glaſs*, which was well known to the Antients, being mentioned by *Plutarch* and *Lucian* among the *Greeks*, by *Lucretius*, *Pliny* and others among the *Latins*. Yet the Art of making Glaſs has been ſince their times abundantly improved. One Branch of this is, the Art of making Burning-Glaſſes, which are now brought to ſo great Perfection, as either to melt or reduce to aſhes the moſt ſolid Bodies, in a very few Moments. If theſe were known to the Antients at all, (which may reaſonably be doubted) yet the Art was wholly loſt for many Ages, and not recovered till of late Years.

18. LATER Ages have likewiſe made many Diſcoveries, with regard to Earth, Water, Fire and Air: The laſt of which, Air, tho' it be of ſo fine a Texture as to be wholly inviſible, yet producing ſuch amazing Effects, has excited the moſt diligent Enquiries of the curious. Nor does any Part of Philoſophy afford a wider field for Experiments and Diſcoveries. The Weight of it we can aſcertain by that curious Inſtrument, the *Barometer*, invented by *Torricellius*, the Degrees of Heat and Cold, by the *Thermometer*. By the Air-pump (invented by *Otto Guerick* Mayor of *Magdeburg*) the Air is drawn out of any Bodies, or more largely thrown into them. And hereby many Effects are produced, which deſerve our diligent Conſideration.

19. WITH regard to *Water*, the Diſcoveries of later Times are numerous and important. Such are the Diving-Bell, invented by *George Sinclair*; the Diving-Machine of *Alphonſo Borelli*, a kind of Boat, which is ſo contrived as to be navigated under water: And the Art of making Salt-water freſh, which is now done with little Expence, ſo far that the Saltneſs is taken away, and it is fit for almoſt all Uſes.

20 THE Nature and Properties of *Fire* alſo have been accurately traced in late Ages: For which new Occaſion was given by the Invention of *Gunpowder*, by

Berthold Schwartz, in the fourteenth Century. *Aurum Fulminans*, a yet later Invention, goes off with a louder Explosion than Gunpowder. Other Bodies there are, which do not burn, and yet emit Light. Such is the *Bononian Stone*, which placed in the dark, diffuses Light like a burning Coal. It is well known that the preparation called *Phosphorus*, has the same Property.

21. VARIOUS Theories of the *Earth* have lately appeared. But they are no more than ingenious Conjectures. The same may be said of the Systems of the Universe, a few particulars excepted. The *Ptolamaic* System, which supposes the Earth to be the Centre of the Universe, is now deservedly exploded: Since *Copernicus* has revived that of *Pythagoras*, which was probably received by most of the Antients. *Tycho Brahe's*, which jumbles both together, is too complex and intricate, and contrary to that beautiful Simplicity, conspicuous in all the Works of Nature.

22. THE Telescope however (invented by *Galileo*) has discovered many Stars unknown to the Antients, together with the Nature and Motion of the Planets, both Primary and Secondary. By this also have been discovered the Spots on the Sun, the Inequality of the Surface of the Moon, the Nature of the Galaxy or Milky Way, and many other Particulars relating to the Heavens.

23. WITH regard to *Body* in general, it is commonly supposed, that our Age has a vast advantage over Antiquity, by having found out new Principles and Hypotheses, whereby we can account for all the Secrets of Nature. But this will bear a Dispute. For beside that the chief of our Hypotheses are not new, but known long ago, the Learned have hitherto very little profited by all their Hypotheses. And in truth all their Disquisitions touching the Causes of Natural Bodies, terminate in mere Conjectures: One whereof is often more probable than another, but none admits of any solid Proof.

24. WHAT remains of Natural Philosophy, is The Doctrine concerning GOD and Spirits. But in the tracing of this, we can neither depend upon Reason nor

nor Experiment. Whatſoever Men know, or can know concerning them, muſt be drawn from the Oracles of GOD. Here therefore we are to look for no new Improvements, but to *ſtand in the good old Paths:* To content ourſelves with what GOD has been pleaſed to reveal; with *the faith once delivered to the ſaints.*

Part the First,

Of Man.

CHAP. I.

Of the Structure of the Human Body.

1. *The Similar, solid Parts,*
2. *A Fibre,*
3. *A Bone,*
4. *A Cartilage,*
5. *A Membrane,*
6. *An Artery,*
7. *A Vein,*
8. *The Lymphatic Vessels,*
9. *A Nerve,*
10. *The Flesh,*
11. *A Gland,*
12. *A Muscle,*
13. *The Cuticula and Skin,*
14. *The Fat,*
15. *The Panniculus Carnosus,*
16. *The Dissimilar Parts, in particular the Head, Cerebrum, Cerebellum, Medulla oblongata,*
17. *The Meninges,*
18. *The Brain,*
19. *The Origin of the Nerves,*
20. *The Pineal Gland.*
21. *The Guards of the Eye,*
22. *The Muscles of the Eye, Tunica Adnata, Structure of the Eye,*
23. *The Coats of the Eye,*
24. *The Humours of the Eye,*

25. *The*

25. *The External Parts of the Ear; the Internal, particularly, the Drum,*
26. *The Bones, Paſſages, Windows, Labyrinth,*
27. *The Noſtrils,*
28. *The Tongue, and Teeth,*
29. *The Palate,*
30. *The Uvula and Tonſils,*
31. *The Hair,*
32. *The Heart,*
33. *The Pericardium,*
34. *The Lungs,*
35. *The Thorax, Intercoſtal Muſcles, Diaphragm,*
36. *The Pleura & Mediaſtinum:*
37. *The External Parts of the Middle Cavity,*
38. *The Stomach,*
39. *The Inteſtines and Meſentery,*
40. *The Lacteal Veins,*
41. *The Omentum, Pancreas,*
42. *The Liver,*
43. *The Gall-bladder, Ducts, Spleen,*
44. *The Kidneys, Ureters, Bladder,*
45. *The Hands,*
46. *The Feet,*
47. *The Animal Spirits,*
48. *The Secretion of the other Fluids,*
49. *The Blood,*
50. *What are the firſt Elements of the Body?*

1. AS Man ought to know Himſelf beſt, we begin our Treatiſe here. And firſt, let us contemplate the Human Body. The Parts of this are either *ſolid* or *fluid*. Thoſe of the Solid, of which the reſt are formed, are termed *Similar* Parts. Such are Fibres, Bones, Membranes, Ligaments, Arteries, Veins, Lymphatic Veſſels, Nerves, Fleſh, Muſcles, Tendons: And thoſe General Coverings of the Body, the Cuticle, the Skin, Fat, and the Panniculus Carnoſus.

2. A *Fibre* is a kind of ſlender Thread, of which all the other Parts of the Body are woven: According to the Difference of which, the Subſtance of the Fibres is different alſo.

3. THE hardeſt Part of the Body, white and void of Senſe, is termed a *Bone*. The Bones are covered with a thin Skin, called the Periofteum, extremely ſenſible. [a]

[a] THE Bones conſiſt of thin Plates, lying one upon another; and theſe again, of Fibres running lengthways, ſome to the Extremity of the Bone, ſome not ſo far. Yet none of them terminate

4. ANNEXT to the Bones are the *Cartilages*, white, flexible and ſmooth; moſt of which in proceſs of time become Bones, hard and quite void of Senſe.

5. THE

there, but are continued tranſverſely, and as it were arched, the Fibres of one ſide meeting and uniting with thoſe of the other, and this at each Extremity.

THESE Plates are differently diſpoſed in different Bones; In thoſe that have a large Cavity, they are contiguous on each ſide, and very cloſely united. In thoſe whoſe Cavities are ſmall, many of the inner Plates are diſtant from each other, having little long Cells between them. In Bones whoſe Plates are contiguous, there are Pores thro' and between them, (beſide thoſe for the Blood-Veſſels.) The firſt pierce them tranſverſely, from the Cavity to the external Surface of each Plate. The ſecond run lengthways between the Plates, and diffuſe an oil with which they are ſupplied by the tranſverſe Pores.

THE Bones are generally bigger at each End than in the Middle, that the Joints may be firm, and the Bones not ſo eaſily diſlocated. But to ſtrengthen the middle of the Bone, the Fibres there are more cloſely compacted. Likewiſe the Bone, being large and hollow, is not ſo eaſily broke, as if it had been ſolid and ſmaller: For of two Bones of equal Length and equal number of Fibres, that is ſtronger which has the larger Diameter.

THE *Blood-Veſſels* uſually enter the Ends of the Bones, the Arteries at one end, the Veins at the other. The *Medullary Veſſels* commonly enter the Sides of the Bone, and that obliquely.

THE Marrow is covered with a Membrane, wherein are incloſed little Bags. In theſe Bags are glandulous Bladders, ſerving both to ſecern the Marrow from the Blood, and to receive it. Both theſe and the Bags have Paſſages into each other, whereby the Marrow has free courſe. It paſſes firſt thro' the tranſverſe Pores of the firſt internal Plate into the longitudinal ones. Thence it proceeds into other tranſverſe Pores, when it alters its courſe again, and exſudes farther. Thus it paſſes alternately thro' and between the Plates, 'till it is diffuſed throughout. In this manner it is diffuſed thro' Bones, whoſe Plates are contiguous. But where the Plates are at a diſtance, the ſmall Cells contain Glands, which directly ſupply the Plates with Marrow.

THE Marrow not only ſerves to keep the Subſtance of the Bone moiſt, but to lubricate the Joints, and to hinder the Ends of the Bone, from being worn or over-heated with Motion. It alſo moiſtens the Ligaments which tie them to each other: As do likewiſe the Glands found in all the Joints. The *Back-bone* hath theſe two Things peculiarly remarkable. 1. Its different Articulations from the other Joints of the Body. For here moſt of the Joints are flat, and withal guarded with Aſperities and Hollows, made for catching and holding; ſo as firmly to lock and keep the

5. The various Parts of the Body are clothed with *Membranes*, which are whitiſh Tunicles, extremely thin and flexible, compoſed of Fibres interwoven with each other, as a piece of Cloth is of Threads. They are faſtened together by a kind of Cartilages, which are termed *Ligaments*.

6. An

Joints 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 Joints in the Neck, Back and Loins. In the Neck the two upper *Vertebræ*, are curiouſly made, and jointed (different from the reſt) for the commodious and eaſy bending and turning the Head every way. In the *Thorax*, and Back, the Joints 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 a quite contrary Way, to anſwer the Occaſions the Body hath to bend more there, than higher in the Back. So that its Structure is the very beſt that can be contrived; for had it been all Bone, we could have had no Motion in our Body; had it been two or three Bones articulated for Motion, the *Medulla Spinalis* muſt have been neceſſarily bruiſed at every Angle or Joint; beſides, the whole would not have been ſo pliable, for the ſeveral Poſtures we have Occaſion to put ourſelves 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 Cartilage, it might have been eaſily diſlocated. And laſtly, the oblique Proceſſes of each ſuperior and inferior *Vertebra*, keep the middle one that it can neither be thruſt backwards nor forwards to compreſs the *Medulla Spinalis*.

The *Pelvis* made in the Belly by the *Ilium*, *Oſſa Coxendicis* and *Pubis*, is larger in a Female than in a Male Skeleton, that there may be more room for the lying of the *Viſcera* and *Fœtus*. So the Cartilage bracing together the two *Sharebones*, is twice thicker and laxer in Women than Men. As alſo is the Cartilage that ties the *Os Sacrum* to its *Vertebra*; and all to give way to the Paſſage of the Fœtus.

Another conſiderable Difference is in the cartilaginous Production 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 Infants, &c.

It is remarkable in the Joints, and a manifeſt Act of Caution and Deſign, 1. That altho' 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, and the Joints would be exceeding weak. But the Joint conſiſting of two large Superficies, concave and convex, ſome furrowed and ridged, ſome like a Ball and Socket, and all lubricated with an oily Sub-

6. An *Artery* is an hollow Canal, compoſed of Fibres cloſely twiſted together, which conveys the Blood from the Cavity of the Heart to all the Parts of the Body. All the Arteries Spring from Two, the *Aorta* or *Great Artery*, and the *Pulmonary Artery*. The latter conveys the Blood from the Right Ventricle of the Heart, thro' the Lungs, into the Left Ventricle. The former conveys it from the Left, to all other Parts of the Body. The *Pulſe* which is in every Artery is only a Continuation of the Motion impreſt upon it by the Motion of the Heart. [b]

7. A

ſtance, they are incomparably prepared both for Motion and Strength. 2. That the Bones next the Joint are not ſpungy, as their Extremities commonly are, nor hard and brittle, but capped with a ſtrong, tough, ſmooth, cartilaginous Subſtance, ſerving both for Strength and Motion.

For affording this oily Matter, there are *Glandules* very commodiouſly placed near the Joints, ſo as not to ſuffer too great Compreſſion by the Motion of the neighbouring Bones, and yet to receive a due Preſſure, to cauſe a ſufficient Emiſſion of the Oil into the Joints. Another Thing conſiderable is, that the excretory Ducts of the *Mucilaginous Glands* have ſome Length in their Paſſage from their Glands to their Mouths; which is a good Contrivance, to prevent their Mouth being oppreſſed by the Mucilage, and alſo to hinder the too plentiful Effuſion thereof, but yet to afford a due Expreſſure of it at all Times, and on all Occaſions; particularly in violent and long-continued Motions of the Joints, when there is a greater than ordinary Expence of it.

[b] The Arteries ordinarily conſiſt of Three *Coats* or Membranes: The Outermoſt has been generally thought to be compoſed of fine Blood-veſſels. The Second is Muſcular, and made up of firm and ſtrong circular, or rather ſpiral Fibres: Of which there are more or fewer Strata, as the Artery is larger or ſmaller. Theſe Fibres are extremely elaſtic. The Inmoſt Coat is a fine, denſe, tranſparent Membrane, containing the Blood, which otherwiſe would eaſily ooze thro' the Spiral Fibres.

On a more accurate Examination it has been found, that the Outermoſt Coat of all Arteries is a Cellular Subſtance, compoſed of fine, pellucid Membranes, which may be ſtretched even ſuddenly to a great Extent without breaking. And they as ſuddenly collapſe, when that ſtretching Force is removed. Theſe Cells contain an oily Liquor, which their Coats ſecern from the Branches of the Artery that are ſpread over them. This cellular Subſtance of the Arteries ſerves to connect them with the ſurrounding Parts, without hindring their Actions or Motions. It gives a ſafe Paſſage to

7. A *Vein* is a hollow Canal, which receives the Blood from the Artery, and conveys it back to the Heart. The chief Veins are three, The *Vena Cava*, which pours the Blood thro' a wide Paſſage into the Right Ventricle of the Heart, the *Pulmonary Vein*, which in like manner pours it into the left Ventricle: And the *Vena Portæ*, which does not, like the two former, end in a large Trunk, but ſpreads itſelf at each Extremity into numerous Branches.

In the Cavity of the Veins, there are certain thin Tunicles, which are termed *Valves*. Theſe, during the regular motion of the Blood, lie cloſe to the Side of the inner Coat: But in caſe of any Obſtruction, recede from it and cloſe the Paſſage, to prevent the Blood's falling back.

8. The *Lymphatic Veſſels* are ſmall Canals full of Valves, conſiſting of a thin, tranſparent Tunic, which convey an extremely clear Liquid into the Maſs of Blood. Probably theſe (as well as the Veins,) and all the other Veſſels, are only Continuations of the Arteries.

9. A *Nerve* is a whitiſh, round, ſlender Body, ariſing from the Brain, which is ſuppoſed to convey the Animal Spirits, to all Parts of the Body. What theſe Spirits are none can ſhew: Nay we are not ſure, they have any Being. For none can certainly tell, Whether the Nerves are hollow Canals, or only ſolid Threads, incloſed in proper Integuments.

10. The

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the Veſſels of their other Coats, and ſupplies oil for lubricating them. There is alſo another Cellular Subſtance, between the Membranous and the Muſcular Coat.

All the Arteries begin with a larger Trunk, and grow leſs and leſs till they are no longer ſeen by the naked Eye. Hence they are continued, 'till they inoſculate with the Veins, and ſo form one uninterrupted Channel.

They appear white, becauſe their Coats are of ſo denſe a Contexture, that the Blood is not viſible thro' them. This proceeding from wider to narrower Canals, is continually obſtructed in its Paſſage. But being puſhed on by the Motion of the Heart, it diſtends the Coats, and cauſes that leaping Motion called the Pulſe. By this, as well as by their Whiteneſs, Arteries are diſtinguiſhed from Veins.

10. The fibrous, soft, reddish Part of the Body is termed *Flesh*. All fleshly Fibres are hollow, and divided thro' their whole length into little Caverns, wherein the Blood is detained, as occasion requires.

11. A *Gland* is a soft and spungy Body, which separates some particular Liquid from the Blood. The larger Glands contain Arteries, Veins and Lymphatic Vessels: But the Glands of the Intestines are only the Tops of the Arteries. c

12. A *Muscle* is a bundle of Fibres joined and fastened together, with their proper Veins, Arteries and Nerves. It is divided into little Cells by transverse Fibres, parallel to each one, whereby it may be contracted and shortened, or relaxed and lengthened again. Its extreme Parts are more closely compacted, which we term *Tendons*. By these the Muscles are connected with the neighbouring Parts. A Muscle generally consists of Three Parts; The Upper, termed the *Head*, the middle, termed the *Belly*, and the lower Part, or *Tail*.

Every Muscle is divisible into smaller Muscles, and those into others still smaller: And so on, beyond all Imagination. The last and smallest Parts are Muscular

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c There is a kind of Down in the Cavity of every Gland, which probably does the Office of a Filter, and is that whereby a particular Humour is separated from the Blood.

The Structure of this Down-vessel is different, according to the different Purposes of Nature. Sometimes the Liquor filtrated thro' it, falls drop by drop on a Membrane, to which one End of the Vessel is fastened, as where it is designed only to moisten the Part. Sometimes many of these Down-vessels spread over the inner Surface of a Membranous Cell, into which they all pour their Liquor, which is discharged at a small Orifice.

These Vessels are often of a great Length, tho' they take up little room, being wound over one another, sometimes in a single Knot, and sometimes in several, inclosed in a common Membrane. And hence is the Distinction of Glands into *Conglobate* and *Conglomerate*.

A conglobate Gland is a little, smooth Body, wrapt up in a fine, double Skin, with only an Artery and Nerve passing in, and a Vein and *Excretory Duct* going out.

A conglomerate Gland is an irregular Assemblage of several simple Glands, which are tied together and wrapt up under one common Membrane.

cular Fibres. But there is no assignable point in any Muscle, wherein there is not some Nerve. And here all the Nerves disappear; (In other Parts their Extremities expand into Membranes.) It is therefore probable, that the Muscular Fibres, are only the Nervous continued.

13. The *Cuticle* or *Scarf-Skin* is an extremely thin and transparent Membrane, void of Sense, and covering the *Skin* all over. [d] The *Skin* covers almost the whole Body, and is formed of whitish Fibres, intermixt with numberless Branches of Nerves, Veins and Arteries. On its Surface are many Furrows or indented Lines, having generally Hairs on each side, and *Pores*, or little holes of various sizes, serving for the Transpiration of superfluous Particles. Under the Skin lie the *Subcutaneous Glands*, which are supposed to transmit thro' the Pores an insensible Steam, commonly believed to be of the same kind with what, when sensibly thrown out, is called *Sweat*. [e]

14. *Fat*,

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[d] The Cuticle sticks fast to the Surface of the Skin, to which it is also tied by the Vessels that feed it. It consists of several Layers of exceeding small Scales, which cover one another where it is thick. But in the Lips, where it is extremely thin, they little more than touch one another.

In some Creatures, (as Fishes) these Scales are only the excretory Ducts of the Glands of the Skin. In others those Glands have their proper Ducts, opening between the Scales.

It is supposed, there are in one Scale 500 Excretory Ducts, and that a grain of Sand will cover 250 Scales. If so, a Grain of Sand will cover 125000 of our Pores.

The Cuticle serves to defend the Nerves of the Skin, both from the Air, which would dry and make them less sensible, and from rough and hard Bodies, which would make a painful Impression on the naked Nerves.

Negroes have a Skin between the Cuticle and the true Skin. They are born white; but the middle Skin, in a little Time turns black and gives that Colour to the whole Body.

[e] Thro' the Pores there continually transudes a subtle Vapour from every Point of the Body, being what redounds of the Aliment, comminuted to the highest Degree, and sent to repair every Particle of it. And the Matter thus evacuated is more than is thrown out, by all the other Passages together.

A Person of middle Age found what he perspired was five Eights of the Food taken in: So that there remained only three Eights for

14. *Fat*, a whitiſh, oily Subſtance, void of Senſe, is ſecreted from the Blood, and lodged in ſmall, oval, membranous

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Nouriſhment and all other Evacuations. He obſerv'd alſo, that as much is perſpired in one Day, as paſſes by Stool in fourteen: And more particularly, that in a Night's time, about Sixteen Ounces are uſually thrown out by Urine, four by Stool, and about forty by inſenſible Perſpiration.

If a Man eats and drinks Eight Pounds in a day, five Pounds of it paſs by Perſpiration: Namely, about One Pound within five Hours after Eating; (Perſpiration being leaſt of all ſoon after Eating) from the fifth to the twelfth Hour, about three Pounds, and from the 12th. to the 16th. ſcarce half a Pound. Exerciſe increaſes Perſpiration much. But it is naturally leſs in Women than Men.

While this Steam flows from our Body, it conſtantly imbibes a Supply of Moiſture from the Air, which ſerves to keep all its Parts ſoft, pliant and fit for Motion. Hence, from the greater Moiſture of the Air, we perſpire leſs in Winter than in Summer, and in rainy Weather than in fair. Live therefore if poſſible, in a clean Houſe, and in a pure, dry Air.

This Inhalation is very conſiderable. Dr. *Keil* found his Body to have imbibed in one Night Eighteen Ounces of Moiſture. And on a ſudden Change of Weather from dry to wet, the Inſpiration ſometimes exceeds the Expiration: There being *Abſorbent-Veins*, which accompany the numberleſs Arteries from which the Perſpiration is diſcharged. To the Matter thus imbibed (not the Obſtruction of the Pores) he aſcribes what we term a *Cold*. Sweating cures this, by throwing out the noxious Matter which was imbibed before.

The Benefits of inſenſible Perſpiration are ſo great, that Life cannot be preſerved without it. And the Subtility, Equability and Plenty of what we perſpire, are the grand Symptoms of Health.

But how little do we know even of our own Frame! It has hitherto paſſed as an unqueſtionable Truth, that the ſame Matter which paſſes by inſenſible Perſpiration, paſſing in greater quantities, is Sweat. Whereas an ingenious Phyſician now alive, has found by numerous Experiments, That a perſon perſpires abundantly leſs, when he Sweats than when he does not: That one who perſpires 24 Ounces in ſeven Hours Sleep, if he ſweat, does not perſpire above Six. This he has tried many Times, and never found it to fail. Whence he infers, 1. That it is not the ſame Matter which is evacuated by inſenſible Perſpiration and by Sweat: 2. That it is not evacuated thro' the ſame Pores: 3. That the Sweat-Pores are abundantly larger and fewer, than thoſe which ſerve inſenſible Perſpiration: 4. That Sweat greatly hinders that Perſpiration, both by covering thoſe Pores with a clammy Liquor, and by conſtringing them ſo that they cannot open; which muſt be the Caſe, when the Sweat-Pores are dilated. What a Field does this open!

membranous Bags, which ſhoot out of the Arteries. It is found in various Parts, but chiefly under the Skin, where (unleſs a man be emaciated) it runs co-extended with the Skin over moſt Parts of the Body. [f]

15. The Fourth General Integument is the *Panniculus carnoſus*, which in ſome Parts is of a fleſhy Subſtance, in others a mere Membrane, lying juſt under the Fat.

16. The Diſſimilar Parts are compoſed of the Similar. The chief of theſe is the *Head*. The Cavity of the *Skull* is nearly filled with a ſoft Subſtance, termed in general The *Brain*. But this is properly that Part of it which lies forward. The Hinder Part (conſiderably ſmaller) is called the *Cerebellum*. Under both, but chiefly the latter, and ſpringing from the internal Subſtance of both, is the *Medulla Oblongata*. [g]

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[f] *Fat* is ſecerned from the Arterial Blood by the *adipoſe Glands*, and tranſmitted again from the membranous Cells to the Blood thro' the Veins. It ſeems to be a Portion of the Blood coagulated by the nitrous Air mixt with it in the Lungs. Artificial Fat is made, by mixing for ſome days Oil of Olives with Spirit of Nitre. Hence divers Animals grow fat in froſty Weather, the Air then abounding with Nitre.

It is a natural Balſam that, by inveloping the Salts of the Blood, keeps them from corroding the Parts thro' which they paſs. It likewiſe nouriſhes the Body. And hence fat Perſons are able to bear much Abſtinence.

Yet too much Fat is a real Diſeaſe, which hinders the Motion of the Lungs, intangles the moſt active Particles of the Blood, and naturally creates Dulneſs and Heavineſs.

You may cure this, by following Three plain Rules: Eat and drink little; Sleep little; Work much.

[g] The *Skull* is divided into two Plates, one laid over the other. Between theſe is a ſpongeous Subſtance, made of bony Fibres detached from each Plate. Hereby the Skull is made not only lighter, but far leſs liable to Fractures.

The Skull is covered with a Membrane called the *Pericranium*. This has ſeveral Holes, which give paſſage to the Spinal Marrow, the Nerves, Arteries and Veins. But theſe fill them ſo nicely, that nothing can paſs into, or out of the Head, but thro' theſe Veſſels.

It is round, that it may contain the more; but a little dereſt and longiſh, advancing a-behind, and flatted on the Sides, which contributes to the Enlargement of the Sight and Hearing.

17. All these are involved in two Membranes, the Inner (called *Pia Mater)* extremely thin; the Outer, (called *Dura Mater)* considerably harder and thicker. Where they involve the Cerebellum, there is interposed between them the *Arachnöides*, a very subtle and transparent Membrane, which descending thro' the hinder Part of the Skull, together with them involves the whole *Spinal Marrow*.

18. The Outer Part of the Brain (called the *Cortex* or *Bark)* is of an ashy or greyish Colour. It is formed from the minute Branches of the neighbouring Arteries, which being wove together in the Pia Mater, incloſe the Inner Part, ordinarily to the thickneſs of about half an Inch.

It conſiſts therefore of innumerable little Glands, contiguous to each other, (ſuppoſed to ſecern the Animal Spirits) which are of themſelves oval, but by their mutual Preſſure become angular, and run waving with each other.

The Inner Part (called the *Medulla)* is white, and terminates in another medullary Subſtance, very white and hard, called the *Corpus calloſum*. The Medulla is thought to conſiſt of fine Tubes, which when collected into little Bundles, and covered with Membranes, are termed Nerves.

19. To trace this a little farther. From every point of the Outer Brain ariſe minute Fibres, which in their Progreſs uniting together, are eaſily perceptible. Theſe conſtitute the Subſtance of the Inner Brain, and of the Spinal Marrow. In their farther Progreſs they are diſtinguiſhed by Coats detached from the two Membranes of the Brain, into ſeveral Bundles called *Nerves*, reſembling ſo many Horſe-tails, each wrapt up in a double Tunic.

Several of theſe part from the reſt in the Brain itſelf, of which there are Ten Pair; One on each ſide. From the Spinal Marrow there ariſe Thirty pair more.

All

It is divided into pieces by its Sutures. This makes it leſs liable to break, gives paſſage to the Membranes of the Pericranium, and Vent to the Matter of inſenſible Perſpiration.

All theſe, while within the Skull or the Spine, are pulpous; but afterwards harden, acquire a Coat, and ſpread thro' the ſmalleſt points of the ſolid Parts of the Body. Their Coats are every where furniſhed with Blood-veſſels, Lymphatics, and Veſicles of a very tight Texture, which ſerve to collect, ſtrengthen and contract their Fibres. And if we conſider 1. The great Bulk of the Brain, Cerebellum and Spinal Marrow (whereof the whole Subſtance goes to conſtitute Nerves, being continued into, and ending in them); 2. The great Number of Nerves diſtributed hence, throughout the whole Body: 3. That the Brain and Spinal Marrow are the Baſis of an Embryo, whence the other Parts are afterward formed: And laſtly, That there is ſcarce any Part of the Body, which does not feel or move: It may ſeem not altogether improbable, that all the ſolid Parts of the Body, are woven out of nervous Fibres, and wholly conſiſt of them.

20. The Brain is divided [h] into four *Ventricles*. Near the riſe of the Fourth, there is a round Hole,

[h] The Brain is abundantly bigger in proportion in Man than in other Animals. In other Animals, it is biggeſt, cæteris paribus, in thoſe that have moſt Sagacity.

There are in the Brain multitudes of Veſſels ſo extremely ſmall, that if a Globule of Blood (a Million of which exceed not a Grain of Sand in bigneſs) were divided into 500 Parts, thoſe Parts would be too large to paſs thro' them. And theſe Veſſels are as large in the Brain of a Sparrow, as in that of an Ox. Nor is there any difference between the Brain of a large Animal and a ſmall, but that one contains far more of theſe Veſſels than the other. But the Globules of the Fluid paſſing thro' them are in all Animals of the ſame Size.

The outer Part of a Turkey's Brain is a very clear and tranſparent oily Matter. Innumerable fine Blood-veſſels are ſpread thro' every Part of this. And if a ſmall Part is cut, there flows out a a ſmall Globule of pellucid fluid.

The Brain is not abſolutely neceſſary to Animal Life. Infants have been born, and lived ſome time without any. We have an authentic Account from *Paris*, of a Child that ſurvived the Birth four days, not only without a Brain, but even an Head: Inſtead of which it had a Maſs of Fleſh, ſomewhat like Liver. In 1673 a Child was born alive without any Brain, Cerebellum or Medulla oblongata; The Skull being ſolid: Nor had it any Communication

over which is suspended the *Pineal Gland*, so called from its resembling the Shape of a Pine-Apple. It is furnished with Veins and Arteries, and inclosed in a thin Membrane, derived from the Pia Mater. *Des Cartes* imagined this to be the Seat of the Soul; but without any solid Reason. Nor has any one yet been able to discover, what is the Use of it. Is it such a Reservoir of Blood for extraordinary Occasions, as some imagine the Spleen to be?

21. The *Eyes* next offer themselves to our Observation, guarded by the *Eye-lids*, *Eye-lashes* and *Eye-brows*. The Eyelids consist of the Cuticle, the Skin, a thin Expansion of the Panniculus carnosus, and an Inward Coat. A Palisade of short, but stiff Hairs grows out of their cartilaginous Edge, both to break the too fierce Impression of the Rays of Light, and to prevent any thing from getting into the Eye, when open. These Hairs only grow to a convenient Length, and their Points stand out of the way, those of the Upper Eye-lids being bent upward, and those of the Lower, downward. Meantime the Eye-brows hinder Sweat, or any thing else which might be hurtful, from falling down from the Forehead.

Both the Eye-lids are moveable, but chiefly the Upper. Animals which have hard Eyes, as Lobsters, need none, and therefore have no Eye-lids. But most Brutes have an additional Eye-lid (called the *Nictitating Membrane*) which draws like a Curtain, to wipe off what might incommode the Eye. The Monkey indeed has it not, as being furnished with Hands like a man.

22. The Eye can move upward, downward, to either side, and round, either toward the Right or Left.

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with the Spinal Marrow. Mr. *du Verney* took out the Brain and Cerebellum of a Pigeon: Yet it lived and walked about. Monf. *Chirac* took out the Brain of a Dog; yet he lived. On taking out the Cerebellum, he seemed dead; but revived, when he blew into the Lungs and continued alive an hour. Nay, there are many Instances of Insects living a long time, after their Head is cut off. Hence it appears, that the Spinal Marrow alone may, for a season, suffice both for Life, Sensation and Motion.

Left. For these six Motions six Muscles are allotted, which spread their Tendons far into the Eye. At each inner Corner of the Eye, there is a Gland with two or three Ducts, which opening on the inner Surface of the Eye-lid, keep the Eye-ball moist, to facilitate its Motion. By these Glands Tears also are secerned. The Eye is connected with the surrounding Bones by the *Tunica adnata*, commonly called, *The White of the Eye:* In the midst of which is a large Hole for the *Tunica Cornea*, thro' which the *Iris* and *Pupil* appear. The whole Ball of the Eye rises from the *Optic Nerve*, and is formed of three Coats propagated from it, and as many Humours; Two of which have each a Coat of its own also. The Eye therefore has five Coats in all: Three Common, and Two to contain their several Humours.

23. The Outermost Coat, proceeding from the Dura Mater, and surrounding the whole Eye, is termed the *Sclerotica:* The Forepart of it being transparent like Horn, is thence stiled the *Cornea*. This is more convex than the rest of the Eye. It is composed of several parallel Plates, which are nourished by many Blood-vessels, but so fine, as not to hinder the smallest Rays of Light. It has an exquisite Sense, that on the least touch of any thing, the Tears may be expressed, to wash off any Filth, which by adhering to it might render it dim or cloudy. The rest of the Sclerotica is opake, and of the same colour with the Dura Mater. The Second Coat is called the *Uvea*. It is much thinner than the former, tho' thicker than the *Pia Mater*, from which it proceeds. In the Forepart of it is a round Hole, which with the Chrystalline Humour interposed, constitutes the *Pupil*, surrounded by the *Iris*, so named from its supposed resemblance to the Colours of the Rainbow. The Third and inmost Coat is termed the *Retina*. It is extremely thin and soft, and darker-coloured than the lower Part of the Optic Nerve, of which it is a Continuation.

A late Writer asserts, "The Retina is not, as is Supposed, the great Organ of Vision. By late Experiments it appears, that it is as transparent as the Humours, and consequently not a proper Instrument,

to ſtop and terminate the Rays of Light, or to receive the Images of Objects. The Light paſſes thro' this, and can only be ſtopt by the *Choroïdes*, which is opake; and conſequently bids much fairer, for being the principal Organ of Viſion: As, being black, it abſorbs all the Rays and reflects none. Likewiſe the Action of Light is ſtronger on Black than any other Colour. The Situation of the Choroïdes behind the Retina, is another Circumſtance in its favour. So the Skin, the principal Organ of Feeling, is placed beneath the Cuticle. The Retina ſeems to be a kind of Secondary Organ, ſerving to preſerve the Choroïdes, (as the Cuticle the Skin) and to break the too ſtrong Impreſſion of the Rays upon it. Add to this, that the Retina is inſenſible, as proceeding from the Medulla of the Brain: But the Choroïdes, ariſing from the Pia Mater, is acutely ſenſible. The Optic Nerve is not compoſed of Fibres, like the other Nerves; but is only Part of the Medulla, incloſed in a Canal. This ſhews that the Retina is not a Membrane (as has been hitherto ſuppoſed) but only a Dilatation of the Medulla, incloſed under two Membranes. Perhaps it may ſerve to filtrate the Spirits neceſſary for the Action of Viſion. But the Vibration whereon the Senſation follows, muſt be made on a more firm and ſolid Part."

24. THE *Aqueous Humour*, reſembling the Colour and Conſiſtence of Water, lies in the forepart of the Eye, juſt behind the Cornea: Its anterior Surface is convex, the other a little concave. Whence this Humour is derived we cannot tell: but its Source muſt be plentifull; For if the Coat containing it be ſo wounded, that all the Humour runs out, it needs only to keep the Eye cloſe for a Seaſon, and the Wound will heal, and the Humour recruit.

INDEED an eminent *Italian* affirms, That he has ſlit the Pupil of divers Animals, and ſqueezed out all the Humours, and has afterwards reſtored them perfectly to ſight: Nay, that the Eyes of many, inſtead of being damaged thereby, ſeemed more lively and vigorous than before.

THE Second Humour, termed (improperly enough) the *Chryſtalline*, conſiſts of many thouſand Filaments, tending

tending from the Circumference to the Center, and closely woven together into thin Scales. It is a little convex before, and more behind. It serves to refract the Rays of Light, so that they may meet and form an Image, on the bottom of the Eye. It is set in the Forepart of the Vitreous Humour, like a Diamond in its Collet, and is retained there by a Membrane that surrounds it, thence called its *Capsula*. It is toward the Outside like a Jelly, but toward the Center as hard as Salt. The Figure of the Outer Part is varied by a Ligament annext, which can either make it more or less convex, or move it to or from the Retina. And this is absolutely necessary, in order to distinct Vision: For as the Rays of different Objects diverge less than those of near Objects, the Chrystalline must either be made less convex, or be set farther from the Retina.

When dried, it appears to consist of a vast number of thin, round Scales one upon another, 2000 of which have been counted in one Chrystalline. Each of these consists of a single Fibre, wound this way and that, in a stupendous manner, so as to run several Courses, and meet in as many Centers, and yet not interfere or cross in any place.

The Third, which is termed the *Vitreous Humour*, is not unlike melted Glass. It is covered with an exceeding thin Coat. The Forepart is concave, as receiving the Chrystalline; the other side is Convex. [1]

25. We

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1 The whole Apparatus of the Eye tend's to this, that there be produced in the bottom of it, a distinct Collection of all the Rays, which proceeding from any point of an Object, penetrate the Chrystalline Humour, that so an Image of that Object may be painted there. In order to this, the Rays striking on the Cornea, are reflected toward the perpendicular, and thus directed thro' the Pupil to the Chrystalline. Meantime the Iris, contracting or dilating the Pupil, admits fewer or more Rays, as the Object is more or less vivid.

Now the flatter the Cornea is, the fewer Rays does it collect and transmit to the Chrystalline, and those more diverging. The rounder it is, the more Rays does it collect and transmit, and those more converging. It is too flat in Old men; it is too round in them that are short-sighted. The Rays transmitted thro' the Pupil to the Chrystalline Humour, are there refracted anew, collected and rendered converging, and those that come from the same point, are

25. We proceed to the *Ear*, formed with exquisite Wisdom, for the Reception of Sounds. The *Outward Ear* consisting of an Oval Cartilage, externally convex, concave within, leads by various Windings to

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thrown in one point on the bottom of the Eye. But if the Chrystalline be too dense, the *Focus* (or Point wherein they unite) will be too near: If that be not dense enough, it will be too remote. And this is another Cause of short sightedness, or the contrary Defect.

In all Vision both the Eyes are used at once. And both together (as any one will find upon trial) behold an Object in another Situation than either of them apart would do. Hence a Gentleman who had one of his Eyes struck out, for some Months after was apt to mistake the Situation of things: And when he attempted to pour Liquors into Phials, often poured them quite beside the Neck of the Phials.

The *Form* of the Eye is the most commodious which can be imagined. It is fittest both to contain the Humours within, and to receive the Images of Objects from without. Was it Square, or of any multangular Form, some of its Parts would lie too far off, and some too nigh those lenticular Humours, which by their Refractions cause Vision. But by means of this Form, the Humours are fitly placed to perform their office of Refraction, and the little darkened Cell neatly adapted to receive the Image of the Object.

Again. As it is necessary for the Eye to move various Ways in order to adjust itself to various Objects, so by this Figure it is well prepared for such Motions, and can with ease direct itself as occasion requires.

No less commodious is the *Situation* of the Eye: In the most eminent Part of the Body, and near the most sensible Part, the Brain. By its Eminence in the Body, it can take in the more Objects: And by its Situation in the Head, beside its nearness to the Brain, it is most conveniently placed for Defence and Security. In the Hand it might have been more ready for Service: But to how many Dangers would it have been exposed? The same may be said, as to its Site in any other Part but where it is. But the Head is a part that seems contrived and made, chiefly for the Use of the principal Senses.

In some Men the Iris has a Faculty of darting out Light. Dr. *Willis* mentions one, who after drinking Wine plentifully, could see to read in the darkest Night. And *Pliny* records of *Tiberius Cæsar*, that if he awaked in the night, he could see every thing for a while, as in the broad day light. Dr. *Briggs* gives a parallel Instance of a Gentleman in *Bedfordshire*.

We find various Substitutes for the Use of the Eyes, in many blind Persons. In some the Defect has been supplied, by an excellent Gift of remembring what they had seen: In some by a delicate Sense of Smelling: In others, by a fine Sense of Hearing. So *Richard Clutterbuck* of *Redborough* in *Gloucestershire*, who was a one-blind, had so curious an Ear, that he could hear the fine Seed of an

to the *Meatus Auditorius*, which is first Cartilaginous, and then bony. It is filled with a viscid Matter, called the *Ear-wax* which is supplied from the Vessels placed in the Skin, surrounding the *Meatus*, to hinder any hurtful Animal from creeping into the Ear. The *Meatus* is closed within by a thin, dry, transparent Membrane, affixt to a bony Circle, which is called the *Membrana Tympani*. Behind it is that Cavity of the *Os Petrosum*, which is termed the *Drum*.

26. In

Hour-Glass fall. In some it has been supplied by an exquisite Sense of Feeling: So the famous *Richard Clutterbuck* was able to perform all Sorts of curious Works. He could not only take a Watch in pieces, and set it together again, but could also make all sorts of Stringmusical Instruments. He likewise played on them by Notes out in their usual Form, and set upon protuberant Lines on the Wood. Yet even this hardly came up to the Skill of *Van-Eych*, the Organist of *Utrecht*, who, tho' he had been blind from two years old, played on all Sorts of Instruments.

Others have been able to take a Face by the Touch, and mould it in Wax with the utmost Exactness: As was the blind Sculptor, who thus took the likeness of the *Duke de Bracciano*, and made a marble Statue of King *Charles* the First extremely well.

But more than all this, some Persons have been able even to distinguish Colours by the Touch. *Peter* of *Maestricht*, tho' perfectly blind, distinguished by his touch the different Colours of Cloth. *John Vermaasen* of *Utrecht* did the same, judging by the different Degrees of Roughness which he felt.

Yet blind Persons, even tho' they distinguish them by the Touch, have no Idea of Visible Objects. Thus the Gentleman couched by Dr. *Cheselden*, tho' he knew the Colours in a good Light during his former State, yet when he saw them after Couching, could not distinguish them, by the faint Ideas he had of them before. It was even a considerable time before he could remember, which was the Cat, and which the Dog without feeling them. Add to this, that he had no Idea of Distance, but imagined all the Objects he saw, touched his Eyes, in the same manner as those he felt did his Skin.

The outward Ear has two Parts, That which stands out from the Head, called the *Auricle*, and the narrow Passage which enters the Skull, called *Meatus Auditorius*.

The Auricle is furrowed with divers winding Canals, which receive and collect the various Undulations of the Air. They who have lost this, hear very confusedly, unless they use a Trumpet, or form a Cavity round the Ear, with their hands.

26. In this, beſides a little Branch of Nerves, there are four little *Bones*, two *Paſſages*, and two *Windows*. Three of thoſe Bones, from ſome imagined reſemblance, are ſtiled the *Hammer*, the *Anvil* and the *Staple*: The Fourth is termed, *The orbicular Bone*. Theſe are faſtened by ſtrong Ligaments to each other, and to the neighbouring Parts. The Paſſages go from the Side of the Drum: One of which, termed the *Labyrinth*, by a very winding way, carries a Part of the Auditory Nerve to the external Muſcles of the Head. The other paſſes from the bottom of the Drum to the Palate; whereby not only Air, if needful, may be received, but the Defect of Hearing, in ſome meaſure ſupplied by ſpeaking to the Mouth.

The Labyrinth contains, beſide the Entrance, three bony, ſemicircular Cavities, and a bony Canal, in the form of a *Screw*, divided into two Parts, from the top to the bottom. The Labyrinth is lined throughout with a thin Membrane, furniſhed with Veins, Arteries and Nerves. And this Membrane may not improbably be the Organ of Hearing.

The curious Structure of the Labyrinth and Screw tend to make the weakeſt Sounds audible. Thoſe Canals, by their Winding, contain large Portions of the

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It is a wiſe Proviſion, that the Subſtance of the Auricle is cartilaginous. Had it been bone, it would have been troubleſome, and might by many Accidents have been broken off. If Fleſh, it would neither have remained expanded, nor ſo well have received or conveyed the Sounds. Rather it would have blunted them, and retarded their Progreſs into the Organ. But being hard, and curiouſly ſmooth and winding, Sounds find an eaſy Paſſage, with a regular Refraction, as in a well-built Arch.

It is obſervable, that in Infants in the Womb and newly born, the *Meatus Auditorius* is cloſe ſhut up, partly by the Conſtriction of the Paſſage, and partly by a glutinous Subſtance, whereby the Drum is guarded againſt the Water in the *Secundine*, and againſt the Injuries of the Air, as ſoon as the Infant is born.

It is remarkable, that in the Ears of moſt if not all Animals, where the *Meatus Auditorius* is long enough to afford Harbour to *Ear-wigs*, or other Inſects; *Ear-wax* is conſtantly to be found. But in Birds, whoſe Ears are covered with Feathers, and where the Drum lies but a little within the Skull, no *Ear-wax* is found, becauſe none is neceſſary to the Ears ſo well guarded, and ſo little tunnelled.

the *Auditory* Nerve, upon every point of which at once the Sound being impreſt becomes audible; and by their Narrowneſs the Sounds are hindered from dilating, which muſt have weakened them proportionably.

The Strength of the Impreſſion is likewiſe encreaſed by the Elaſticity of the Sides of the Bony Canal, which receiving the firſt Impulſes of the Air, reverberate them on the Auditory Nerve.

THE *Auditory Nerves* are diſtributed, One to the Ear, the other to the Eye, Tongue and Parts adjoining. By the Diſtribution thereof to different Parts, an admirable Conſent is eſtabliſhed between them. Hence it is, that moſt Animals, hearing a ſtrange Sound, erect their Ears to catch it, open their Eyes, and are ready with their Mouth, to ſhriek or call for Help. A farther Uſe of this nervous Communication between the Ear and the Mouth is, that the Voice may correſpond with the Hearing, and be a kind of Echo thereof: and that what is heard with one of theſe Nerves, may readily be expreſſed by the help of the other.

AND now what leſs than an infinitely wiſe GOD, could contrive ſo fine an Organ, and ſuch a Medium, ſo ſuſceptible of every Impreſſion, that the Senſe of Hearing hath occaſion for, To impower all Animals to expreſs their Meaning to each other, with endleſs Variety? Yea, what leſs could form ſuch an Œconomy as that of Muſic is? So that the Medium conveys the melodious Vibration of every Animal Voice or well-tuned Inſtrument, and the Ear receives them, to allay the Perturbations, and calm and chear the Heart of Man? [1]

27. THE

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[1] THO' the Ear be the ordinary Organ of Hearing, yet it is not the only one. We may hear by the Teeth. For if one End of a Knife be applied to a Spinet, and the other held between the Teeth, the Muſic will be diſtinctly heard, tho' the Ears be ever ſo cloſely ſtopped. This is not by the Teeth, but by the Auditory Nerve which paſſes from the Drum to the Palate.

IN thoſe who are born Deaf, the Eyes may in ſome meaſure ſerve in the place of Ears. Some can underſtand what is ſaid, by nicely obſerving the Lips and Tongue of the Speaker: And may even

27. The *Noſtrils* are made not of Fleſh or Bone, but of Cartilage, the better to be kept open, and as occaſion requires, to be dilated or contracted: For which purpoſe they are furniſhed with proper and curious Muſcles. The Tubes therein growing narrower and narrower, lead into ſeveral little Cells and winding Cavities, covered with a ſoft Coat, and provided with Arteries, Veins, Glands, and Filaments of the *Olfactory Nerves*. This therefore is without all doubt the proper Organ of Smelling.

And foraſmuch as it is by Breathing, that the odorant Particles are drawn in, the *Laminæ* with which the upper Part of the Noſe is barricaded, ſerve two excellent Purpoſes, partly to prevent any thing hurtful from entering the breathing Paſſages in our Sleep (for which end likewiſe the Hairs placed at the Entrance of the Noſtrils ſerve) and partly to receive the Divarications of the Olfactory Nerves, which are here thick ſpread, and by this means meet the Smells entering with the Breath.

28. The *Tongue* has for its Baſis that forked Bone, called the *Os Gutturis*. It conſiſts of various Muſcles interwoven together, that it may be fit for various kinds of Motion. To theſe are added very many ſmall Branches of Nerves, which paſs thro' the Middle of it to the Outſide, and being gathered into little Bundles,

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accuſtom themſelves to uſe their own, 'till they learn a kind of Speech. Thus a Phyſician at *Amſterdam* taught ſeveral Children born deaf, to underſtand what was ſaid, and to give pertinent Anſwers.

Mr. *Goddy's* Daughter of *Geneva* loſt her Hearing at two years old. Yet by obſerving the Lips of others, ſhe had acquired many Words, whereby ſhe would talk whole Days with thoſe that could underſtand her. But ſhe knew nothing of what was ſaid, unleſs ſhe ſaw the Mouth of the Speaker: So that if they wanted to ſpeak to her in the Night, they were obliged to light a Candle. Only ſhe knew what her Siſter ſaid even in the Dark, by laying her hand on her Mouth.

But many deaf Perſons can hear, if a loud Noiſe be made while you ſpeak. Dr. *Willis* mentions one, who, if a drum was beat in the room, could hear very clearly. So that her Huſband hired a Drummer for his Servant, and by that means converſed with her daily.

Bundles, conſtitute thoſe *Papillæ*, which make its Surface rough and uneven. Beſide theſe there appear alſo on the Surface of the Tongue, certain pointed Fibres, not unlike the Ends of Birds Claws, inclining toward the Baſis of it, with which are interſperſed innumerable *Salival Glands*. And all theſe are in their ſeveral Ways ſubſervient to the Senſe of *Taſting*.

THE Time of cutting the *Teeth* is uſually from the Seventh to the Seventeenth Month. It is commonly preceded by an itching of the Gums, and by Convulſions, Fevers and Looſeneſs: moſt of which Symptoms happen to Birds alſo, upon moulting or caſting their Feathers. The Seed of the Teeth is a mucous Matter, like the white of an Egg, contained in the Cells of the Jaw-bone, which grows harder and bigger till it breaks thro' the Gum.

THAT Part of the Tooth which ſtands out of the Gum, is covered with a peculiar Subſtance called *Enamel*. It is compoſed of an infinity of little Tubes, which grow on the Bone by their roots. If any part of this be broken off, ſo that Bone is left bare, it grows carious; there being no Bone which will bear the Air.

WE may farther obſerve, 1. That the Teeth only of all the Bones, grow in length during a Man's whole Life: which is providently deſigned, to repair the Waſte that is continually made by Attrition; 2. That the Teeth are the only Bones which are not covered with that exquiſitely ſenſible Membrane, the *Perioſteum*; 3. That they are harder and firmer than any other Bone, that they may be more durable and fit to chew the moſt ſolid Aliments; 4. That for their Nouriſhment, there is a Cavity contrived in each Side of the Jaw-bone, in which are lodged an Artery, a Vein and a Nerve, which thro' ſmaller Cavities ſend their Twigs to every Tooth; 5. That as Infants are deſigned to live on Milk for ſome Months, they are ſo long without any Teeth: Whereas Animals that need them, have them ſooner, and ſome are even born with them. 6. The different Shape of the Teeth is remarkable. The Fore-teeth

are formed broad, and with a thin and sharp Edge, like Chissels, to cut off a Morsel from any solid Food. The Next, One on each side, are stronger, deeper-rooted, and more pointed, to tear tougher Aliments: The rest are made flat and broad at top, and withal somewhat uneven, that thereby they may the better retain, grind and mix the Aliment. 7. Because Biting and Chewing require much Strength, partly in the Teeth themselves, partly in the Instruments that move the lower Jaw, which alone is moveable; Nature has given it strong Muscles, which make it bear forcibly against the Upper Jaw: And has not only fixt each Tooth in a distinct Cavity, as in a close, strong and deep Socket, but has given Holdfasts to the several Sorts of Teeth, suitable to the Stress that is to be laid upon them. So whereas the *Cutters* and *Eye-teeth* have only One Root, the *Grinders*, designed for harder Work, have Three: In the Upper Jaw, often Four, because they are pendulous, and the Substance of the Jaw somewhat softer. 8. The Situation of the Teeth is most convenient. The *Grinders* are behind, near the Center of Motion, because chewing requires a considerable Force: The *Cutters* before, ready for their easier Work.

29. The *Palate* is of a bony Substance, a little concave, and cloathed with a thick Membrane, which has the same kind of nervous *Papillæ* and small Glands, that are seen in the Surface of the Tongue. And hence it is qualified to assist the Taste as well as the *Speech*.

It would be endless to specify the curious Mechanism of all the Parts that concur to form the Voice. However let us note two things. 1. There are Thirteen Muscles provided for moving the five Cartilages of the *Windpipe*. 2. It is amazing that the *Glottis* (the upper part of it) can so exquisitely contract or dilate itself, to form all Notes. "Suppose (says Dr. *Keil*) the greatest Distance of the two Sides of the Glottis to be one Tenth of an inch, in sounding Twelve Notes, (to which the Voice easily reaches) this Line must be divided into 12 Parts, each of which gives the

the Aperture requiſite for ſuch a Note. But if we conſider the Subdiviſion of Notes into which the Voice can run, the Motion of the Sides of the Glottis is ſtill vaſtly nicer: For if of two Chords, ſounding exactly Uniſons, One be ſhortened but the two thouſandth part of its Length, a juſt Ear will perceive the Diſagreement and a good Voice will ſound the Difference: And yet this is only the one hundred and ninety ſixth Part of a Note. But ſuppoſe the Voice can divide only into an hundred Parts, it follows, that the different Apertures of the Glottis, actually divide the Tenth Part of an inch, into twelve hundred Parts, the Effect of each of which produces a ſenſible Alteration upon a Good Ear.

30. The *Uvula* is a round, oblong, fleſhy Subſtance, ſuſpended near the Paſſage from the Mouth into the Noſtrils, and probably deſigned to hinder the cold Air, from ruſhing too faſt into the Lungs. The *Tonſils*, or Almonds of the Ear, are two ſmall Glands, placed at the Root of the Tongue, which ſupply an Humour, to keep the Mouth and the Tongue continually moiſt.

The *Wind-Pipe* is wonderful in its Conformation: Becauſe continual Reſpiration is neceſſary, it is made with *Annular Cartilages*, to keep it conſtantly open, that its Sides may not fall together: And leſt, when we ſwallow, any Particle of Food ſhould fall in, which might cauſe Convulſions, or even Death, it has a ſtrong Shutter, or Lid, called the *Epiglottis*, which, whenever we eat or drink, falls down of itſelf, and covers it cloſe, ſo that no Crum or Drop can enter. It is for the more convenient Bending of our Necks, that the Wind-Pipe is not made of one entire continued Cartilage, but of many circular ones.

What is farther remarkable in theſe Cartilages is, that all the Way where they are contiguous to the Gullet, they are membranous, to give an eaſy Paſſage to the Food: But after that, they are, ſome completely round, ſome triangular. Another obſervable is, in the Wind-Pipe, the Cartilages run parallel to each other: But, in the Lungs, the lower Parts of the ſuperior Car-

tilages, receive the upper Parts of the Inferior: Hereby enabling them to contract themſelves in Expiration, and to dilate in Inſpiration.

31. THE *Hairs* are all hollow. The Root of each Hair is fixt in a mucous Globule, of an oval Figure, which often adheres to it, when it is pulled up by the Root. They are disjointed like a Reed or Cane, and ſhoot out into ſmall Branches. They ſerve not only for a Covering, but alſo for the Excretion and Expiration of an oily Matter.

EVERY Hair does properly live, and receive Nouriſhment like the other Parts. The Roots do not turn White or Grey in Age, any ſooner than the Extremes. But the whole of each Hair changes Colour at once. Or (to ſpeak more properly) the Hairs of another Colour fall off, and white ones grow in their Place.

YET, its Life is of a peculiar Kind, and approaches to the Nature of Vegetation. Hairs grow much as Plants grow out of the Earth, or as ſome Plants grow upon others: From which they draw their Nouriſhment, and yet each has its Life diſtinct from the other. So Hair derives its Food from ſome Juices in the Body, but not from the nutritious Juices. Accordingly the Hair may live and grow, while the Body is ſtarved to Death. [m]

ALL

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[m] THAT Hair may grow, merely as an Excreſcence of the vegetable kind, appears from that memorable Caſe recited by Mr. *Hock*, of a Body which, having been buried forty-three Years, was found in a manner wholly converted into Hair. The Woman was buried in a Coffin of Wood, and lay the loweſt of three in the ſame Grave. The others being removed and this Coffin appearing, it was obſerved, that much Hair came thro' the Clefts of it: On removing the Lid, the whole appeared a very ſurprizing Sight. There was the whole Figure of the Corpſe, exhibiting the Eyes, Mouth, Ears and every Part. But from the very Crown of the Head, even to the Sole of the Foot, it was covered over with a very thick ſet Hair, long and much curled. The People, amazed at this Appearence, went to touch the Corpſe. But the Shape fell away, as it was handled, leaving only a Quantity of ſhapeleſs Hair, but neither Fleſh nor Bones, only a ſmall Part of the great Toe of the Right Foot.

EACH Hair conſiſts of ſeveral ſmaller ones, wrapt up in one common Covering. They ſend out Branches at the Joints. The Root

All Hairs appear round. But the Microscope discovers some of them to be square, others triangular; which Diversity of Figures arises merely from the Diversity of the Pores. Their Length depends on the Quantity of Humours proper to feed them, and their Colour on the Quality. And hence the Colour usually differs in the different Stages of Life.

The Hair of a Mouse is a transparent Tube, with a Pith of small Fibres convolved, running in some Hairs spirally, in some transversely, in others from Top to Bottom.

32. We proceed to the Middle Cavity of the Body. Herein the principal Part is the *Heart*, consisting of a strong Tendon, extended obliquely from the *Basis* or broader Part, to the *Cone*, into which the fleshly Fibres are inserted, in an elegant Series, with a spiral Bending, one Half opposite to, and crossing the other: By which Means the grand Muscle is admirably fitted, both to receive and to propell the Blood. It has two great Cavities, usually termed The *Ventricles of the Heart*. They are divided from each other by an intermediate Part, called The *Septum*, constituted by the same Fibres, which is convex on the Side next the Right Ventricle, and concave on the other. The *Vena Cava* is inserted in the Right Ventricle, and two Inches from its Insertion, divides into the *Upper* and *Lower*. The former brings the Blood into it from the Upper, the latter, from the lower Parts of the Body. The *Pulmonary Artery* carries the Blood from that Ventricle into the Lungs, which the *Pulmonary Vein* brings

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lies pretty deep in the Skin: And by this they imbibe their proper Nourishment, from the adjacent Humours. Their Extremes also split into two or three Branches, especially if they are very dry, or too long. So that what appears a single Hair to the naked Eye, to the Microscope appears a Brush. They are grey on the Forepart of the Head first, particularly about the Temples: The Back part affords them Nourishment longer. For the same Reason they fall from the Crown of the Head first. Their Thickness depends on the size of the Pores they issue from: If these are small, the Hair is fine. If the Pores be strait, the Hairs are strait; if oblique or sinuous, the Hairs are curled.

from thence into the Left Ventricle. At the upper Side of these Veins, there is added to each Ventricle, a Kind of Purse, called the *Auricle*, which is an hollow Muscle of the same Structure with the Heart, in order to stay the Blood, that it pour not too violently into the Ventricle. Before the Orifices of the Veins of the Heart, there are *triangular* Valves, and *Semilunar* in the Orifices of the Arteries, to hinder the Reflux of the Blood, from the Ventricles into the Veins, and from the Arteries into the Ventricles.

33. The Heart is covered with a fine Membrane; and near the Base of it on the Outside, there is a little Fat, probably designed to facilitate its Motion. It is placed near the Middle of the Breast; only its Cone inclines a little to the Left. It hangs by its Base on Veins and Arteries, communicating with all Parts of the Body. The other Part of it is loose in the *Pericardium*, that it may be the more commodiously constringed and dilated. The Pericardium is a Kind of Membrane, that like a Kind of Purse, loosely incloses the Heart. The Shape of it is suited to that of the Heart, and it contains a thin, saltish, reddish Humour, doubtless proceeding from certain Glands, which may be observed on the Inside of it. [n]

34. The

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[n] The Brain has an alternate Contraction and Dilatation, answering those of the Heart. It is highly probable, the Weight of the Atmosphere is the Counterpoise to the contractile Force of the Heart. That of the Brain, being not near so strong, does not need so strong a Counterpoise.

In the Basis of the Heart of some Animals, there is a Bone frequently found. Such an one was found in the Heart of Pope *Urban*. Probably it was only the Tendons of the Heart ossified.

Wounds of the Heart are not always so immediately mortal, as is generally supposed. A Soldier was brought into one of the Hospitals in *Paris*, with a Wound in the upper Part of the left Breast. He seemed very well for three Days; but on the Fourth was taken with a Fever and Difficulty of breathing and died on the Tenth. On opening the Body, it was found the Sword had pierced the Pericardium, traversed the Right Ventricle of the Heart in its lower Part, pierced the Pericardium on the opposite Side, and gone thro' the Diaphragm and an inch deep into the Liver.

34. The Heart is placed in the Middle of the *Lungs*, which consists of two Parts, the *Right* and *Left Lobe*. Each of these is divided into two other Lobes; One of these frequently into three, sometimes into four, by Fissures, sometimes deeper, sometimes shallower, running from the interior Margin towards the Back Part. The Lungs are divided into Cells, which are no other than Expansions of the small Branches of the *Trachea* or *Wind-Pipe*. And there is an easy Passage from one Branch into many Cells, and again into it from them all. The upper Part of the *Trachea* opens into the Mouth; The Lower, divided into Two Branches, shoots out into various Ramifications, which are termed *Bronchia*. And these little Canals running on, constitute the Lungs, whose Cells are wonderfully connected together, and intermixed with numberless Branches of Veins and Arteries.

The upper End of the Trachea is called the *Larynx*. At the fourth Vertebra of the Back it divides and enters the Lungs. Its Cartilages, ranged at small and equal Distances, are smaller and smaller as they approach the Lungs.

These Cartilages have two Membranes. The External, composed of circular Fibres, covers the whole *Trachea*. That which lines it within, consists of three distinct Membranes, the first woven of two Orders of Fibres, Part Longitudinal, to shorten it, by drawing the Cartilages together, Part, Circular, to contract them. Both these, together with the External Membrane, assist in breathing, coughing and varying the Tone of Voice. ° The Second Membrane is glandulous;

° The Organs which form the Voice of Man, have not been accurately observed by the Antients. As the Trachea bears some resemblance to a Flute, they considered the Voice, according to the Sounds of that Instrument. Mr. *Dodart* was the first who shewd the *Glottis* to be the chief Organ in producing it, and considered it both as a String and Wind-Instrument, far more perfect than any which Art can produce.

The Organs which form the various Voices of other Animals, are likewise worthy of our Attention. Those of each Species have

glandulous; and its Glands opening into the Cavity of the Trachea, ſeparate a Liquor which moiſtens and defends it from the Acrimony of the Air. The Third is a Network of Nerves, Veins, and Arteries.

CUTTING

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peculiar Sounds, whereby they underſtand each other. Wherein do theſe Organs reſemble Ours, and wherein do they differ?

THE Human Voice is almoſt wholly formed by the Glottis, and various Tones are produced by the various Modifications of it. But all theſe depend on one only, the Separation and Junction of its Lips. This comprehends two Circumſtances, the One capital and primitive, the other, a Conſequence of it. The firſt is, That the lips are more and more bent, from the loweſt to the higheſt Note. The Second, that the more they bend, the nearer they draw to each other. It follows from the firſt, that their vibrations will be more frequent, as they come nearer the higheſt tone, and that the Voice will be exact when they are equally bent, and the reverſe when unequally: which correſponds perfectly well, with the Nature of String-Inſtruments. It follows from the Second, that the higher the Tone, the nearer they draw to each other. And this agrees perfectly with thoſe Wind-Inſtruments which are governed by Reeds. From theſe ſimple and almoſt imperceptible Variations proceeds the infinite Variety of Sounds.

IN moſt Quadrupeds too the Glottis is the principal Organ of the Voice. So it is in Cats, Sheep, and ſeveral others. But many have ſomething more than a Glottis. As Horſes, Aſſes, Mules and Swine. Some of theſe have alſo a tendinous Membrane, which concurs in forming the Voice. Others have ſeveral Membranes: Others a kind of Bags, which in ſome are membranous, and in others bony. Others have both Membranes and Bags. Others laſtly have in their Larynx a kind of Cavity or Drum, which aſſiſts them in uttering very ſtrong and long continued Notes.

ALL ſounds are produced by a ſwift ſucceſſion of Vibrations from the Particles of ſonorous Bodies, which agitate the Air. But the vibrations of the Lips of the Glottis would not ſuffice to produce the neighing of a Horſe. This begins by more or leſs acute interrupted tones, accompanied by Quaverings, and ends by tones more or leſs grave, which is performed by Jirks. This Second Part is done by the Lips of the Glottis: the other chiefly by a ſmall, elaſtic Membrane. This is tendinous, very thin, of a triangular Figure, and lies flat on each extremity of the lips of the Glottis. As it adheres but looſely to theſe, it can eaſily flutter up and down: And it is the Play of this Membrane up and down, which produces the acute Sounds of Neighing. Theſe are more or leſs acute, as the Membrane is more or leſs thin, and its Adheſion more or leſs ſlack. The grave Sounds that conclude the Neighing, are excited by the ſhutterings of the thick ſtrings which form the lips of the Glottis.

CUTTING the Trachea was long reputed mortal. But it is now usual to open it in dangerous Quinsies. This Physicians were at first encouraged to do, from the Case of a *Cornish* Gentleman, who had his Wind-Pipe quite cut through, and yet was cured and lived several Years after.

35. IN order to the Admission and Expulsion of the Air by the Lungs, it is necessary the Breast should be contracted and dilated. This End is served by the Bony Part of the *Thorax*, the *intercostal Muscles*, and the *Diaphragm*, a broad, muscular Part, reaching cross the Breast, and dividing the middle from the lower Cavity. It runs obliquely from the *Sternum* and Ribs before, to the Vertebræ of the Loins behind.

36. THE

THE hoarse Sound of the Asses Voice is not so much produced by the lips of the Glottis, as by a tendinous Part which adheres loosely on the Aperture of a kind of Drum, situate under the Extremity of the lips of the Glottis: Above which are also found two large and thick bags, one on the right, the other on the left. Each of these has a roundish Aperture, cut much like the Stopple of an Organ.

SUCH are the Organs which form this amazing Sound. A kind of Drum is the principal: And the two bags above the lips of the Glottis, are the main Auxiliaries: While those lips, as plain Experiments shew, contribute very little thereto. The Mules Voice much resembles that of his Sire, and is formed by much the same Organs: The Drum of so singular a Composition, being found in Mules also.

THERE is another Animal which affords us a particular Disposition of the vocal Organs. This is the Hog: whose shrill Cries are more insupportable than his usual Grunting. Yet neither are these excited by the lips of the Glottis, but by the fluttering of two large membranous Bags: situated on each side, above the lips of the Glottis. What is most remarkable is, that each lip is cloven, almost its whole length. By this cleft each lip has a communication with the bag belonging to it. And the Motions of these bags produce most of the Sounds peculiar to this Animal.

THO' the voice of Birds bears a nearer resemblance to ours than that of Quadrupeds, yet their Organs have far less resemblance to Ours, and contain a greater number of Singularities. They, like us, have a Glottis at the top of the Trachea: But they have another at the bottom of it, which much contributes both to the strengthening and modifying of their Voice. These have different Membranes more or less fine, more or less bent, and in a variety of Positions. In some Birds, as in Geese, there are four of these, figured and disposed like the Reeds in Haut-boys.

36. The whole Thorax is covered on the Inside with a firm, white Membrane, called the *Pleura*. It is double throughout, consisting of two Folds, the innermost whereof has a smooth Surface, that it may not hurt the tender Substance of the Lungs, the Surface of the Outer is rough and uneven. From the Pleura rises the *Mediastinum*, which is a doubled Membrane, that divides the Lungs and the Cavity of the Thorax lengthways into two Parts.

37. On the slightest Observation we cannot but acknowledge, the consummate Wisdom wherewith the *External Parts* of the middle Cavity are formed, for Beauty as well as for the Defence of the Internal. This is commodiously connected with the Head by the *Neck*. The *Breast*, or Forepart of the Thorax, which begins at the Throat, and ends at the *Sternum*, or Breast-bone, is an admirable Guard to the noblest Parts. To the same End serve the *Shoulder-blades* and the *Back-bone*, as well as to support the whole Fabric.

The *Breasts* consist of numberless oval Glands, intermixed with globular Vessels of Fat. Their Ducts as they approach the Nipple unite together, till they form Eight or more small Pipes, communicating with each other by cross Canals, which are of great Use, when some of them happen to be obstructed. These Tubes are in some Parts narrower, in some wider, so as to form Cells, which hinder the Efflux of the Milk. The *Paps* consist chiefly of the Concurrence of these Tubes, but with a glandulous Substance intermixt. There are likewise joined herewith Abundance of Fibres, from the external Teguments of the Breasts, by Means of which the Tubes are constringed, and the Motion of the Milk is modified.

In Virgins the Glands of the Breasts are so contracted, that no Blood can enter them. But when the Womb swells with the Fætus, and compresses the descending Trunk of the great Artery, the Blood forces its Way into them. They admit thicker and thicker Serum, till after the Birth, they run with a thick Milk.

It is more difficult to account for the Milk, which some Men have in considerable Plenty. Thus in the Year

Year 1684 a Country-man called *Billardino di Billo*, living in a Village near *Nocera* in *Umbria*, when his Wife was dead, took the Child, and putting the Nipples of his Breasts into its Mouth, invited it to suck, which the Infant did, and after several Times drawing fetched some Milk. After a while it brought down the Milk so plentifully, as to nourish it for many Months, till it was weaned.

38. In the lower Cavity first occurs the *Stomach* with the *Oesophagus* or *Gullet*, which reaches to it from the Mouth. The Inner Coat of the Stomach is *Nervous*. The Second is *Villous*, or as it were hairy, in which are innumerable fine Blood-vessels, which are supposed to yield a Liquid that helps to dissolve the Nutriment. The inner Surface of the Stomach has many Wrinckles or Folds, which hinder its Contents from passing out too soon. It has two Orifices, the *Left* and the *Right*. The Left is a Continuation of the Gullet, and descends almost perpendicularly, which hinders the food from easily regurgitating. It opens for the Descent of the Food, and closes again, by the Contraction of its Fibres. The Right Orifice, called the *Pylorus*, transmits the digested Food to the Intestines. It is narrower than the other, as being designed to transmit nothing, 'till it is reduced to a kind of Liquid. And it goes by a long and oblique Descent into the Duodenum, that the Chyle may not pass out, either too swiftly or too slowly.

39. The *Intestines* are a Continuation of the Alimentary Tube from the Pylorus, wound together in various Wreaths, yet without Confusion, and to keep them in their Situation, fastened together by the *Mesentery*. The Intestinal Duct is really but One; but because the Parts of it differ in Figure and Use, the upper Part of it, divided into the *Duodenum*, *Iejunum* and *Ileon*, is termed The *small Guts*; the lower Part, divided into the *Cæcum*, *Colon* and *Rectum*, is called The *great Guts*. All these are full of Turnings and Windings, especially the Small, that the more subtle Part of the Chyle, both thro' the Length and Narrowness of the Passage, and the Agitation of the Intestines, may enter the *Lacteal Veins*, and pass from thence into the *Receptacle of the Chyle*.

When

When the Inteſtines are ſeparated from the Meſentery, they are uſually ſix times as long as the Man. They have all a kind of vermicular Motion, called The *Periſtaltic Motion* from the Stomach downwards; and are lubricated with much Fat, eſpecially the Great ones, whoſe Surface being more uneven, and their Contents leſs fluid, they need ſomewhat more to make them ſlide eaſy.

The Duodenum, (ſo called becauſe it is uſually ten or twelve inches long) receives the Gall and Pancreatic Juice, which are here mixt with the Chyle. The Iejunum is ſo termed, becauſe it is generally more empty than the reſt. This may be occaſioned partly by its Capacity, which gives a free Paſſage to its Contents; partly to its Irritation thro' the Bile, which falls in a little above it. It takes up almoſt the whole umbilical Region, and is uſually twelve or thirteen hands long. The Ileon, ſituate below the Navel, fills the Ilia with its numerous Convolutions. It is much the longeſt of all the Inteſtines, generally one and twenty hands long. In both this and the Iejunum the inner Coat is much wrinkled, and lies in looſe Folds. They are formed (as the Folds in the Stomach) only by the inner Coat being larger than the outer.

The firſt of the Great Guts, called the *Cæcum*, is laterally inſerted at the upper End of the *Colon*. It is not perforated at the other End, but hangs to it, like the Finger of a Glove, and is three or four Inches long. In new-born Children and in Beaſts it is found full of Excrements; but in Adults it frequently hangs like a Worm. In a Fætus it is doubtleſs a Receptacle of the Fæces, during the time it does not diſcharge by ſtool. And may it not occaſionally ſerve the ſame End in Adults? Perhaps in thoſe Animals wherein it is very large, it may likewiſe ſerve as a kind of ſecond Stomach. But it is not abſolutely neceſſary. The Cæcum of a Dog has been cut out, without any perceivable Prejudice.

The Colon is the largeſt of the Great Guts. It runs in various Circumvolutions from the Cæcum to the Rectum. It has many Cavities, formed by two Ligaments, running

running on each ſide of it, oppoſite to each other the whole length, and as it were guiding it at certain Diſtances. The Rectum, which reaches from the *Os Sacrum* to the *Anus*, is uſually about an hand and an half long.

40. The *Lacteal Veins*, which are of a whitiſh Colour, are in all the Inteſtines, ſmall and great, and receive the Chyle by imperceptible Paſſages, throughout the whole Canal. And for this End the Food remains ſo long in the Inteſtines, and is carried thro' various Windings, that whatſoever of Nouriſhment it contains, may be expreſt before it leaves the Body.

41. The Inteſtines are covered with the *Omentum* or *Caul*, which is contained within a very thin double Membrane, and wholly conſiſts of little Bags of Fat. Its Uſe is, to keep the Inteſtines warm; to promote their periſtaltic Motion by lubricating them with its oily Subſtance: By following them in their Doublings and Windings, to ſerve them as a Bolſter to ſlide upon, and by filling up their Hollows, to prevent their being too much diſtended by flatulencies; yet giving way to them when filled with Aliments.

Under the Stomach behind lies the *Pancreas*, (extended toward the Spleen) which tranſmits to the Inteſtines a Liquor of the Nature of Spittle, helping to diſſolve the Food.

42. Under the Diaphragm, on the right Side, lies the *Liver*, whence it extends over the Right Part of the Stomach, below the Sternum, toward the left, growing gradually ſmaller, that it may not hinder the Diſtention of the Stomach. It conſiſts partly of Gall-Ducts, partly of fine Ramifications of the Vena Portæ. The Blood contained in theſe depoſits oily Particles in the Ducts, and then returns, chiefly thro' the Vena Cava, to the Heart. It is thus the *Bile* is ſecreted, for which purpoſe the *Gall-bladder* alſo is deſigned. This both receives and retains the Bile, by which Delay the Power of it is greatly heightened. Part of the Bile is conveyed to the Inteſtines by the *Hepatic Duct*, which pours it into the *Ductus Choledochus*. Part goes firſt into the Gall-bladder, thence into

the Ductus Choledochus, and then into the Duodenum.

THE principal Uſe of the Bile is, to abſterge and ſtimulate the Inteſtines, to aſſimilate crude things to things concocted, to bruiſe and blunt ſharp and ſaline Particles, to divide thoſe that are coagulated: To excite Appetite, to open the Paſſages for the Chyle, and where need is, act the part of a Ferment.

43. THE *Spleen* is an elegant Net-work of numberleſs Veſſels, incloſed in a double Membrane. It is placed on the Left Side, between the Short Ribs and the Stomach. Some ſuppoſe it to ſecrete a peculiar Juice, which paſſes with the Blood thro' the Vena Portæ. Others imagine it to be a kind of Reſervoir, wherein on extraordinary Occaſions, that Blood may be received, which would otherwiſe oppreſs the Viſcera and diſturb the Animal Functions.

44. ON the Muſcles of the Loins on each ſide lie the *Kidneys*, to ſeparate from the Blood that part of the Serum which is ſuperfluous, and would be hurtfull were it retained in the Habit. This is carried by the *Ureters* into the Bladder, which is placed in the loweſt Part of the Belly. What remains of the Blood is conveyed to the Heart by the Veins and Lymphatic Veſſels.

THE *Bladder* is compoſed of Three Coats: The Firſt is an Extenſion of the *Peritoneum*; the Second conſiſts of Muſcular Fibres; the Third is both glandulous and nervous, and full of wrinkles, that it may be capable of Contraction and Dilatation. Its Glands ſeparate a ſlimy Matter, which defends the Bladder from the Acrimony of the Urine. The involuntary Emiſſion of this is prevented, by a ſmall Muſcle which goes round the neck of the Bladder.

45. WE proceed to the *Limbs*. The *Hand* (phyſically ſpeaking) is divided, into the *Arm*, the *Cubit*, and the Hand, properly ſo called. In this there are Twelve Bones, beſide Fifteen in the Fingers, all oblong, ſlender, hollow, and ſo fitly joined together by Ligaments, ſo wonderfully provided with various Muſcles, adapted to ſo many different Motions, that the

the Hand alone gives us an abundant Argument of the admirable Wiſdom of God.

46. The *Thigh* conſiſts of One Bone, the largeſt and longeſt in the whole Body. It is a little crooked, bending forward before, that there may be more room for the Muſcles. The Bones of the *Leg* are two, diſtant from each other in the middle, but joined together at each End. They are nearly of the ſame Length, but the Inner is much thicker than the Outer. The Bones of the *Foot* are twelve, beſide Fourteen in the *Toes*, which like thoſe in the Hands, are moſt aptly connected by Ligaments, and fitted with Muſcles of various kinds, ſerving for equally various Motions.

47. Thus far we have ſpoken concerning the *Solid Parts* of the Body. Among the Fluid are uſually reckoned *The Animal Spirits*, ſuppoſed to be ſecreted in the Brain, to flow thro' the Nerves, and to be the Inſtruments of Senſe and Motion. [p]

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[p] "But are the Nerves in general hollow Canals, which contain a circulating Fluid? Or are they ſolid Threads, which being highly elaſtic, vibrate variouſly to occaſion various Senſations"? The latter Suppoſition is wholly overthrown, by the Phenomena of wounded Nerves. A Nerve cut aſunder does not retract its divided Extremities, but becomes rather longer, extruding its Medulla into a round Tubercle. Again, were it elaſtic, it ſhould be compoſed of hard Fibres, having their Extremities fixt to ſome firm Bodies: Since Strings otherwiſe conſtituted and diſpoſed, have no Elaſticity. But it is evident, all Nerves are ſoft at their Origin, as well as void of tenſion: And ſome ſoft in every part, as the Olfactory Nerve, and the ſoft Portion of the Auditory Nerve. Yea, they all grow ſoft in the Viſcera, the Muſcles and the Senſories, before they exert their Functions. Beſides, ſome Nerves are ſo ſituate, that they cannot vibrate, as thoſe of the Heart, which are faſtened to the great Veſſels and the Pericardium. Further, the Influence of an irritated Nerve is never propagated upwards; whereas an elaſtic Chord, communicates its tremors to both ends from the point of percuſſion. Hence it is plain, the Nerves do not act by their Spring, but by the Motion of their proper Fluid. The extreme Smallneſs of theſe Canals, which no Microſcope can reach, is no valid Objection to this: Neither our Inability to diſcern that Fluid. This only proves the Imperfection of our Senſes.

"But what is this Fluid?" Who can tell? We may very probably conjecture, it conſiſts of the ſame Principles with the circulating Fluids from which it ſeems to be derived, and with the ner-

48. Of the other Fluids, ſome ſerve to prepare the Chyle; Some to thin the Blood and preſerve it from Putrefaction. Others only remain till they can be thrown out of the Body, as being uſeleſs and ſuperfluous. All of theſe, but the Chyle, ariſe from the Blood, being ſecreted from it by proper Glands. But as to the Manner of Secretion, after all the moſt accurate and laborious Enquiries, it ſtill remains abſolutely uncertain, and every one abounds in his own Senſe. Some believe it depends, on the *Suitableneſs* of the Fluid ſecerned, to the Shape of the ſecerning Pores. Some lay the ſtreſs rather on the various *Size* and *Diameters* of thoſe Pores: Others on this, That the conſtituent Particles, ſuppoſe of the Bile, from their peculiar Proportion, Texture and Figure, may be more eaſily united to each other, than to the Particles of Lymph, or any other Fluid.

49. The chief of all the Fluids in our Body, and the Fountain of Life is the *Blood*. It conſiſts of a watry *Serum*, *fibrous Particles* and *red Globules*, which laſt are ſcarce a twelfth Part of it. It is generated thus. The Meat and Drink being digeſted into Chyle, paſſes from the Inteſtines, thro' the Lacteal Veins and the Thoracic Duct into the left Subclavian Vein, and thence into the Vena Cava, where it mixes with the Blood, and then circulates with it, till it is wholly aſſimilated.

Blood freſh drawn appears to the naked Eye uniform and homogeneous. But when cold, it ſeparates into two Parts, the one red and fibrous, which clots together, the other thin and tranſparent, called the *Serum*, in which the former ſwims. The Serum is in Bulk three fourths of the Blood, in weight fifteen Seventeenths.

A Red Globule is computed to be 25000 times ſmaller than the ſmalleſt Grain of Sand.

Some

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vous Fibrils which we ſuppoſe it is deſigned to nouriſh and repair. But it may likewiſe conſiſt, and perhaps chiefly, of ſome ſubtle Fire or Ether, diffuſed thro' the whole Syſtem of Nature, and acting by Laws unknown to us.

Some ſuppoſe the Heat of the Blood may riſe from the Action of the Heart, and the Re-action of the Aorta. For the Blood driven by the Heart obliquely againſt the Sides of the Aorta, violently preſſes them and is by the Elaſticity of this Veſſel preſſed back again. Every Particle of it therefore acquires every moment a new Motion and Rotation. Hence follows a perpetual Attrition, Attenuation and Aſſimulation of all its Parts. And hence they think the Maſs derives its Heat as well as Fluidity. [q]

But to what Cauſe is its Colour owing? *Borelli* took ſome of the Red Part, and waſhing it frequently in Water, found it ſeparable into a viſcous, ſlippery Subſtance, conſiſting of colourleſs Fibres, which roſe and gathered into a Scum on the top of the Water, and a deep-red Powder, which precipitated plentifully to the bottom. Hence it appears, that the Redneſs of the Blood ſprings from red-tinging Particles, as in the the Caſe of Dying.

However this red Colour, though generally found in the Blood of Land Animals, is not abſolutely neceſſary, there being ſome Species, whoſe Blood is white or limpid. Nay Dr. *Drake* let out of the Median Vein of a Man, a pure, white Blood, like Milk, which when cold, did not ſeparate into two Parts, as the Red uſually does. Nor yet did it yield any Skim or Cream, neither turn ſour as Milk uſes to do. Dr. *Beal* gives an Inſtance of the ſame kind; and Dr. *Lower* relates one as ſtrange. A Perſon bled at the Noſe, till at length the Broth he drank flowed out very little altered. [r]

q But others deny, that the Motion of Fluids generates any Heat. The truth is, this is one of the ten thouſand Secrets, which the Mind of Man cannot penetrate.

r It is amazing to ſee, how careful Providence has been, to prevent the Bloods running into Concretions which might deſtroy Life, by the very Diſpoſitions of the Veſſels it is to run thro'. Theſe are ſo contrived, as to cauſe the Globules to come together with a briſk Colliſion. The Arteries which convey the Blood from the Heart to the Extremities, continually leſſen, as they recede from their Source; in conſequence of which, the Globules of Blood muſt

50. THESE are the Parts, of which this wonderful Machine is compoſed, which the Chymiſts ſay, conſiſts of four Sorts of Matter, Earth, Water, Salt, and Sulphur, the Particles of which being variouſly mixt together, conſtitute larger Particles of different kinds; out of which, more looſely or cloſely connected, all the Parts of the Body, Solid or Fluid are compoſed.

BUT this is far from being an accurate Account. For what are Salt and Sulphur but Species of Earth? May not we then much more properly ſay, with the Antients, That the Body is chiefly compoſed of Earth and Water, yet cannot enjoy even Animal Life, unleſs Air and Fire alſo be wrought into its Frame? So that at whatſoever time, it is deprived either of Air or Fire, it is an uſeleſs, lifeleſs Clod. And yet the Manner how theſe are ſo intimately mixt, both with our Fluid and Solid Parts as much exceeds our Comprehenſion, as the manner how the Soul is united to its Houſe of Clay.

IT remains only, to add ſome Reflections on the Wiſdom of GOD, diſplayed in the Structure of the Human Body. And how eminently is this diſplayed, Firſt, In the *Situation* of its ſeveral Parts and Members? They are ſituated moſt conveniently for Uſe, for Ornament, and for mutual Aſſiſtance. 1. For Uſe. The Principal Senſes are placed in the Head, as Centinels in a Watch-tower. How could the Eyes have been more commodiouſly fixt, for the Guidance of the whole Body? The Ears likewiſe, made for the Reception of Sounds, which naturally move upward, are rightly placed in the uppermoſt Parts of the Body: And ſo are the Noſtrils, as all Odours aſcend. Again: How could the Hands have been more conveniently placed,

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ruſh with force againſt one another, as they are driven on impetuouſly. And the Veins which bring it back from the Extremities to the Heart, inlarging all the Way as they go on, while the Streams of ſeveral continually run into One, each of theſe Ingreſſes cauſes new Commotions, capable tho' not of diſſolving that Natural Connexion of the Red and ſerous Particles, yet of preventing any preternatural Concretions or Coagulations.

placed, for all ſorts of Exerciſes? Or the Heart, to diſpenſe Life and Heat to the whole Body? Or the Sinks of the Body, than in the moſt remote Parts of it? 2. For Ornament. Not to deſcend to Particulars, what could be better contrived, than that thoſe Members which are Pairs, ſhould be of equal Length, and juſt anſwer one another on each Side? 3. For mutual Aſſiſtance. So the Eye ſtands moſt conveniently to guide the Hand, and the Hand to defend the Eye. The ſame may be ſaid of the other Parts: they are all ſo placed, as to direct or help each other. This will clearly appear, if you ſuppoſe the Poſition of any of them to be changed. Had our Arms been bent backward, what Direction could our Eyes have afforded us in Working? Or how could we even have fed ourſelves? Nay, had one Arm bent backward, and the other forward, half the Uſe of them had been loſt; for one could not have aſſiſted the other in any Action.

How is his Wiſdom diſplayed, Secondly, in the ample Proviſion made for the Security of the principal Parts? Theſe are 1. The Heart, the Fountain of Life. This lies in the Center of the Trunk of the Body, covered with its own Membrane, the Pericardium, lodged within the ſoft Bed of the Lungs, incompaſt round with a double Fence, both of thick Muſcles and Skins, and of firm Ribs and Bones: Beſide the Arms conveniently placed, to ward off any Violence: 2. The Brain, the Principle of all Senſe and Motion, is ſurrounded with ſo ſtrong a Defence, that it muſt be a mighty Force indeed, which is able to injure it. The Skull is ſo hard, thick and tough that 'tis almoſt as firm as an Helmet of Iron. This is covered with Skin and Hair, which both keep it warm, and ſoften the violence of a Stroke. Yet more, a thick and tough Membrane hangs looſe about it, which often ſaves it, even when the Skull is broke. And laſtly, A fine Membrane cloſely adheres, to keep it from quaſhing and ſhaking.

How is it diſplayed, Thirdly, in the abundant Proviſion that is made againſt evil Accidents and Inconveniences?

veniences? To this end, 1. The Members which are of eminent Uſe are in Pairs: We have two Eyes, Ears, Noſtrils, Hands; two Feet, two Breaſts, two Kidneys; that if One ſhould be rendered uſeleſs, the other might ſerve us tolerably well: Whereas had a man but one Hand or Eye, if that were gone, all were gone. 2. All the Veſſels have many Ramifications, which ſend forth Twigs to the neighbouring Veſſels: So that if one Branch be cut or obſtructed, its Want may be ſupplied, by the Twigs from the neighbouring Veſſels. 3. Many Ways are provided to evacuate, whatever might be hurtful to us. If any thing oppreſs the Head, it can free itſelf by Sneezing; if the Lungs, they can caſt it off by Coughing. If any thing burden the Stomach, it can contract itſelf, and throw it up by Vomit. Beſide theſe Evacuations, there are Siege, Urine, Sweat, and Hemorrhagies of various kinds. 4. Whereas Sleep is neceſſary for us in many reſpects, Nature has provided, that tho' we lie long on one ſide, we ſhould feel no Uneaſineſs while we ſleep, no, nor when we awake. One would think, the whole weight of the Body preſſing the Muſcles on which we lie, would be very burdenſome. And we find by Experience, ſo it is, when we lie long awake in the Night. Probably this Proviſion is made, by an Inflation of the Muſcles, making them ſoft, and yet renitent, like Pillows. That they are inflated during Sleep, appears to the very Eye, in the faces of Children; and from the Common Experiment, that if we ſleep in our Cloaths, we muſt looſen our Garters and others Ligatures. Otherwiſe we find uneaſineſs in thoſe Parts. 5. Becauſe Sleep is inconſiſtent with the Senſe of Pain, therefore during Reſt, thoſe Nerves which convey the Motion to the Brain, which excite the Senſe of Pain, are obſtructed. "This I myſelf, ſays Mr. *Ray*, have often experienced, ſince I have had Sores on my Legs. Waking ſuddenly I find myſelf at perfect Eaſe for a while. Then the Pain by degrees returns."

It is displayed, Fourthly, In the *Multitude* of *Intentions* God hath in the Formation of the several Parts, and the multitude of *Qualifications* they require, to fit them for their several Uses. *Galen* observes, "that there are in an human Body, above Six hundred Muscles. And there are at least Ten several Intentions in each, and as many Qualifications needful: So that about the Muscles alone, no less than 6000 Ends are to be attended to. The Bones are reckoned to be 284. The distinct Intentions in each of these are above Forty: In all, about an hundred Thousand. And thus it is in proportion, with all the other Parts, the Skin, Ligaments, Veins, Arteries, Nerves, Glands, Humors: But more especially with the Members of the Body, which as to the Multitude of Intentions and Qualifications, far exceed the Similar Parts. And should One of these Qualifications fail, great Inconvenience would ensue."

It is displayed, Fifthly, in the *Stature* of Man, so admirably well adapted to the Circumstances of his Existence. Had Man been only a foot or two high, he had been quite disproportioned to every thing round about him. Had he been much larger, he could not well have been supplied with Food: All the Edible Animals would not have sufficed. And had they too been proportionably larger, the Surface of the Earth would not have sufficed to feed them.

It is however a common Opinion, and has been so ever since old *Homer*'s Time, That the People in the early Ages of the World, were much larger than Us. And it is true, we read of some Men, of a surprizing Stature. But they were even then esteemd Giants. The ordinary Stature of Men, is probably just the same now, as it was at the beginning. This may be gathered from the Monuments still remaining, particularly the Pyramids of *Egypt*. The Cavities for Bodies now visible herein, are little larger than our ordinary Coffins: Likewise from several embalmed Bodies taken out of them it appears, That Men are of the same Stature now, that they were when those Pyramids were built, which is at least three thousand Years

Years ago. Eighteen hundred Years ago the Emperor *Auguſtus* was five foot, ſeven inches high. Queen *Elizabeth* was taller by two Inches, being five foot, nine.

I CANNOT better conclude this Chapter than by an Extract from the late pious and ingenious Mr. *Hervey*, which may ſerve for a Recapitulation of what has been ſaid, as well as an Improvement of it.

" LET us begin with the leſs adorned, but more *Solid* Parts, thoſe which *ſupport*, and which *contain* the reſt. Firſt, you have a Syſtem of *Bones*, caſt in a Variety of Moulds, in a Variety of Sizes: All ſtrong, that they may bear up the Machine, yet light, that they may not weigh us down: Bored with an inward Cavity, to contain the moiſtning Marrow, and perforated with fine Ducts, to admit the nouriſhing Veſſels. Inſenſible themſelves, they are covered with a Membrane, exquiſitely ſenſible, which warns them of, and ſecures them from the Annoyance of any hurtful Friction; and alſo preſerves the Muſcles from being fretted in their Action, by the hard and rough Subſtance of the Bone. They are largeſt at the Extremities, that they may be joined more firmly, and not ſo eaſily diſlocated. The Manner of their Articulation is truly admirable and remarkably various: yet never varied without demonſtrating ſome wiſe Deſign, and anſwering ſome valuable End. Frequently when two are united, the one is nicely rounded and capped with a ſmooth Subſtance; the other is ſcooped into an Hollow of the ſame Dimenſions to receive it. And both are lubricated with an unctuous Fluid, to facilitate, the Rotation.

THE *Feet* compoſe the firmeſt Pedeſtal, infinitely beyond all that Statuary can accompliſh, capable of altering its Form, and extending its Size, as different Circumſtances require. They likewiſe contain a ſet of the niceſt Springs, which help to place the Body in a Variety of Attitudes, and qualify it for a Multiplicity of Motions. The undermoſt Part of the Heel, and the Extremity of the Sole, are ſhod with a tough, inſenſible Subſtance: A kind of Natural Sandal, which never wears

wears out, never wants Repair: and which prevents an undue Compreſſion of the Veſſels, by the Weight of the Body. The *Legs*, and *Thighs* are like ſtately Columns, ſo articulated, that they are commodious for Walking, and yet do not obſtruct the eaſy Poſture of Sitting. The Legs ſwell out toward the top with a genteel Projection, and are neatly wrought off toward the bottom: A Variation which leſſens their Bulk, while it increaſes their Beauty.

The *Ribs*, turned into a regular Arch, are gently movable, for the Act of Reſpiration. They form a ſafe Lodgment for the Lungs and Heart, ſome of the moſt important Organs of Life. The *Backbone* is deſigned, not only to ſtrengthen the Body, and ſuſtain its moſt capacious Store-rooms, but alſo to bring down the Continuation of the Brain, uſually termed The *Spinal Marrow*. It both conveys and guards this *ſilver Cord*, as *Solomon* terms it, and by commodious Outlets tranſmits it to all Parts. Had it been only ſtrait and hollow, it might have ſerved theſe Purpoſes. But then the Loins muſt have been inflexible: To avoid which, it conſiſts of very ſhort Bones, knit together by Cartilages. This Peculiarity of Structure gives it the Pliancy of an Oſier, with the Firmneſs of an Oak. By this Means it is capable of various Inflections, without bruiſing the ſoft Marrow, or diminiſhing that Strength which is neceſſary to ſupport all the Upper Stories. Such a Formation in any other of the Solids, muſt have occaſioned great Inconvenience. Here it is unſpeakably uſeful, a Maſterpiece of creating Skill.

The *Arms* are exactly proportioned to each other, to preſerve the Equilibrium of the Structure. Theſe being the Guards that defend, and the Miniſters that ſerve the whole Body, are fitted for the moſt diverſified and extenſive Operations: Firm with Bone, yet not weighty with Fleſh, and capable of performing all uſeful Motions. They bend inwards and turn outwards; they move upward or downward. They wheel about in whatever Direction we pleaſe. To theſe are added the *Hands*, terminated by the Fingers, not of the ſame Length,

Length, nor of equal Bigneſs, but in both reſpects different, which gives the more Beauty, and far greater Uſefulneſs. Were they all Fleſh, they would be weak: Were they one entire Bone, they would be utterly inflexible: But conſiſting of various little Bones and Muſcles, what Shape can they not aſſume? Being placed at the End of the Arm, the Sphere of their Actions is exceedingly inlarged. Their Extremities are an Aſſemblage of fine tendinous Fibres, acutely ſenſible: Which notwithſtanding are deſtined to almoſt inceſſant employ, and frequently among rugged Objects. For this reaſon they are overlaid with Nails which preſerve them from any Impreſſions.

In the Hand we have a Caſe of the fineſt Inſtruments. To theſe we owe thoſe beautiful Statues, this melodious Trumpet. By the Strength of the Hand the talleſt Firs fall, and the largeſt Oaks deſcend from the Mountains. Faſhioned by the Hand they are a floating Warehouſe, and carry the Productions of Art and Nature from *Britain* to *Japan*.

The Hand is the original and univerſal Sceptre, which not only repreſents, but aſcertains our Dominion over all the Elements and over every Creature. Tho' we have not the Strength of the Horſe, the Swiftneſs of the Greyhound, or the quick Scent of the Spaniel, yet directed by the Underſtanding, and enabled by the Hand, we can as it were make them all our own. Theſe ſhort Hands have found a way, to penetrate the Bowels of the Earth, to touch the Bottom of the Sea. Theſe feeble Hands can manage the Wings of the Wind, arm themſelves with the violence of Fire, and preſs into their Service the forcible Impetuoſity of Water. How greatly then are we indebted to our wiſe Creator, for this diſtinguiſhing, this invaluable Member?

Above all is the *Head*, for the Reſidence of the Brain; ample to receive, and firm to defend it. It has a Communication with all, even the remoteſt Parts; has Outlets, for diſpatching Couriers to all Quarters, and Avenues for receiving ſpeedy Intelligence, on all needful Occaſions. It has Lodgments wherein to poſt Centinels,

for

for various Offices: To expedite whose Operations, the whole turns on a curious Pivot, nicely contrived to afford the largest and freest Circumvolutions.

This is screened from Heat, defended from Cold, and at the same time beautified by the *Hair*: A Decoration so delicate, as no Art can supply, so perfectly light, as no way to incumber the Wearer.

While other Animals are prone in their Aspect, the Attitude of Man is *erect*, which is by far the most graceful, and bespeaks Superiority. It is by far the most commodious, for Prosecution of all our Extensive Designs. It is likewise safest, less exposed to Dangers, and better contrived to repel or avoid them. Does it not also remind us of our noble Original and our sublime End? Our Original, which was the Breath of the Almighty: Our End, which was the Enjoyment of Him in Glory?

Thus much for the *Rafters* and *Beams* of the House. Let us now survey the Lodgings within. Here are *Ligaments*, a tough and strong Arrangement of Fibres, to unite the several Parts, and render what would otherwise be an unwieldy Jumble, a well-compacted and self-manageable System: *Membranes*, thin and flexile Tunicles, to inwrap the fleshy Parts, to connect some, and form a separation between others: *Arteries*, the Rivers of our little World, that striking out as they go, into numberless small Canals, visit every Street, yea every Apartment in the vital City. These being wide at first, and growing narrower and narrower, check the Rapidity of the Blood. This thrown from the Heart, dilates the Arteries, and their own elastic Force contracts them; by which Means they vibrate against the Finger, and much assist both in the Discovery and Cure of Diseases. The larger Arteries, wherever the Blood is forced to bend, are situate on the bending Side; lest being stretched to an improper Length, the Circulation should be retarded. They are not, like several of the Veins, near the Surface, but placed at a proper Depth. And hereby they are more secure from External Injuries. In those Parts which are most liable to Pressure, an admirable Expedi-

ent takes place. The Arteries *inoſculate* with each other: breaking into a new tract, they fetch a little Circuit, and afterwards return into the main Road. So that if any thing block up or ſtraiten the direct Paſſage, the Current by diverting to this New Channel, eludes the Impediment, flows on, and ſoon regains its wonted Courſe.

THE *Veins* receive the Blood from the Arteries, and re-convey it to the Heart. The Preſſure of the Blood is not near ſo forcible in theſe, as in the Arteries. Therefore their Texture is conſiderably ſlighter. Such an exact Œconomiſt is Nature, amidſt all her Liberality! In many of theſe Canals, the Current, tho' widening continually, is obliged to puſh its way againſt the perpendicular: Hereby it is expoſed to the danger of falling back and overloading the Veſſels. To prevent this, *Valves* are interpoſed at proper diſtances, which are no hindrance to the regular Paſſage, but prevent the Reflux, and facilitate the Paſſage of the Blood to the grand Receptacle. But theſe Valves are only where the Blood is conſtrained to climb: Where the Aſcent ceaſes, they ceaſe alſo.

HERE are *Glands* to filtrate the paſſing Fluids, each of which is an Aſſemblage of Veſſels, complicated with ſeeming Confuſion, but with perfect Regularity. Each forms a Secretion far more curious than the moſt admired Operations of Chymiſtry: *Muſcles*, compoſed of the fineſt Fibres, yet endued with incredible Strength, faſhioned after a Variety of Patterns, but all in the higheſt Taſte for Elegance and Conveniency. Theſe are the Inſtruments of Motion, and at the Command of the Will, execute their Functions quick as Lightning: *Nerves*, ſurprizingly minute, which ſet the Muſcles at work, diffuſe the Power of Senſation thro' the Body, and upon any Impreſſion from without, give all needful Intelligence to the Soul: *Veſicles*, diſtended with an unctuous matter, in ſome places compoſe a ſhort Cuſhion; as in the Calf of the Leg, whoſe large Muſcles, mixt with *Fat* are of ſingular ſervice to thoſe important Bones. This flanks and

and fortifies them, like a ſtrong Baſtion, Supports and cheriſhes them, like a ſoft Pillow. In other places they fill up the Vacuities, and ſmooth the Inequalities of the Fleſh. Inwardly they ſupply the Machine for Motion; Outwardly they render it ſmooth and graceful.

THE *Skin*, like a curious Surtout, covers the whole, formed of the moſt delicate Net-work, whoſe Meſhes are minute, and whoſe Threads are multiplied, even to a Prodigy: The Meſhes are ſo minute, that nothing paſſes them which is diſcernible by the Eye; tho' they diſcharge every moment Myriads and Myriads of ſuperfluous Incumbrances. The Threads are ſo multiplied, that neither the point of the ſmalleſt Needle, nor the infinitely finer Lance of a Gnat, can pierce any part, without drawing Blood, and cauſing an uneaſy Senſation. Conſequently, without wounding by ſo ſmall a Puncture, both a Nerve and a Vein!

BUT a Courſe of inceſſant Action muſt exhauſt the Solids and waſte the Fluids, and unleſs both are properly recruited, in a ſhort time deſtroy the Machine. For this reaſon it is furniſhed with the *Organs*, and endued with the *Powers* of *Nutrition*: *Teeth* the foremoſt, thin and ſharp, to bite aſunder the Food; The hindermoſt, broad and ſtrong, indented with ſmall Cavities, the better to grind in pieces what is tranſmitted to them. But in Children, the formation of Teeth is poſtponed till they have occaſion for them.

WERE the Teeth, like other Bones, covered with the Perioſteum, Chewing would give much pain. Were they quite naked, they would ſoon decay and periſh. To guard againſt both, they are overlaid with a neat *Enamel*, harder than the Bone itſelf, which gives no pain in Chewing, and yet ſecures them from various Injuries.

THE *Lips* prevent the Food from ſlipping out of the Mouth, and aſſiſted by the Tongue, return it to the Grinders. While they do this in concert with the Cheeks, they ſqueeze a thin Liquor from the adjacent Glands. This moiſtens the Food and prepares it for Digeſtion. When the Mouth is inactive theſe

are nearly closed. But when we speak or eat, their Moisture being then necessary, is exprest as need requires.

But the Food could not descend merely by its own Weight, thro' a narrow and clammy Passage into the Stomach. Therefore to effect this, Muscles both *strait* and *circular* are provided. The former inlarge the Cavity, and give an easy Admittance. The latter, closing behind the descending Aliment, press it downward. But before the Food enters the Gullet, it must of necessity pass over the Orifice of the Windpipe: whence it is in danger of falling upon the Lungs, which might occasion instant Death. To obviate this, a *moveable Lid* is placed, which when the smallest Particle advances, is pulled down and shut close, but as soon as it is swallowed, is let loose and stands open. Thus the important Pass is always made sure against any noxious Approaches; yet always left free for the Air and open for Respiration.

The Food descending into the *Stomach* is not yet ready for the Bowels. Therefore that great Receiver is strong to bear, and proper to detain it, till it is wrought into the smoothest Pulp imaginable. From hence it is discharged by a gentle Force, and passes gradually into the Intestines.

Near the Entrance waits the *Gall-bladder*, ready to pour its salutary Juice upon the Aliment, which dissolves any thing viscid, scoures the Intestines, and keeps all the fine Apertures clear. This Bag, as the Stomach fills, is prest thereby, and then only discharges its Contents. It is also furnished with a Valve of a very peculiar, namely of a Spiral Form; thro' which the detersive Liquid cannot hastily pour, but must gently ooze. Admirable Construction! Which without any care of ours, gives the needful Supply, and no more.

The Nutriment then persues its way, thro' the Mazes of the *Intestines*: Which by a *worm-like Motion* protrude it and force its small Particles into the *Lacteal Vessels*. These are a Series of the finest Strainers,

ers, ranged in countleſs Multitudes all along the Sides of the winding Paſſage. Had this been ſtrait or ſhort, the Food could not have reſigned a ſufficient Quantity of its nouriſhing Particles. Therefore it is artfully convolved and greatly extended, that whatever paſſes may be ſifted throughly. As the Aliment proceeds, it is more and more drained of its nutritious Juices. In conſequence of this, it would become hard and pain the tender Parts, but that Glands are poſted in proper Places, to diſcharge a lubricating Fluid. Theſe are ſmaller or fewer near the Stomach, becauſe there the Aliment is moiſt enough: Whereas in the Bowels remote from the Stomach, they are either multiplied or inlarged.

The *Chyle* drawn off by the Lacteals is carried thro' Millions of Ducts, too fine even for the Microſcope to diſcover. To this it is owing, that nothing enters the Blood, but what is capable of paſſing thro' the fineſt Veſſels. It is then lodged in ſeveral commodious Cells (the Glands of the *Meſentary*) and there mixt with a thin, diluting Lymph, which makes it more apt to flow. Hence it is conveyed to the *Common Receptacle*, and mounts thro' a perpendicular Tube into the Left *Subclavian Vein*. This Tube lies contiguous to the *Great Artery*, whoſe ſtrong Pulſation drives on the Fluid, and enables it to aſcend and unload its Treaſure, at the very Door of the Heart.

But the Chyle is as yet in too crude a State, to be fit for the Animal Functions. Therefore it is thrown into the Lungs. In the ſpongy Cells of this amazing Laboratory, it mixes with the External Air, and its whole Subſtance is made more ſmooth and uniform. Thus improved it enters the Left Ventricle of the *Heart*, a ſtrong, active, indefatigable Muſcle. The large Muſcles of the Arm or of the Thigh are ſoon wearied: A Days Labour, or a Days Journey exhauſts their Strength. But the Heart toils whole Weeks, whole Months, nay Years, unwearied; is equally a Stranger to Intermiſſion and Fatigue. Impelled by this, Part of the Blood ſhoots upward to the Head; Part rolls thro' the whole Body.

But how ſhall a Stream divided into Myriads of Channels, be brought back to its Source? Should any Portion of it be unable to return, Putrefaction, if not Death, muſt enſue. Therefore the All-wiſe Creator has connected the Extremities of the Arteries, with the beginning of the Veins: So that the ſame Force which darts the Blood thro' the former helps to drive it thro' the latter. Thus it is re-conducted to the great Ciſtern, and there played off afreſh.

Where two oppoſite Currents would be in danger of claſhing, where the Streams from the Vena Cava and Vena aſcendens co-incide, a fibrous Excreſcence interpoſes, which like a projecting Pier, breaks the Stroke of each, and throws both into their proper Receptacle. Where the Motion is to be ſpeedy, the Channels either forbear to wind (as in the Great Artery which deſcends to the Feet) or to leſſen in their Dimenſions, as in every Interval between all the Ramifications. When the Progreſs is to be retarded, the Tubes are variouſly convolved or their Diameter contracted. Thus guarded, the living Flood never diſcontinues its courſe, but night and day, whether we ſleep or wake, ſtill perſeveres to run briſkly thro' the Arteries, and return ſoftly thro' the Veins.

But farther. The great Creator has made us an invaluable Preſent of the Senſes, to be the Inlets of innumerable Pleaſures, and the Means of the moſt valuable Advantages.

The *Eye*, in its elevated Station, commands the moſt enlarged Proſpects. Conſiſting only of Fluids, incloſed within Coats, it ſhews us all the Graces and Glories of Nature. How wonderful, that an Image of the hugeſt Mountains, and the wideſt Landſcapes ſhould enter the ſmall Pupil! that the Rays of Light ſhould paint on the Optic Nerve, paint in an inſtant of Time, paint in their trueſt Colours and exacteſt Lineaments, every Species of external Objects!

The *Eye* is ſo tender, that the ſlighteſt Touch might injure its delicate Frame. It is guarded therefore with peculiar Care, intrenched deep, and barricaded round with Bones. As the ſmalleſt Fly might incommode its

poliſhed

polished Surface, it is farther protected by two substantial *Curtains*. In Sleep when there is no occasion for the Sense, but a Necessity to guard the Organ, these Curtains close of their own accord. At any time they fly together as quick as Thought. They are lined with an extremely fine Sponge, moist with its own Dew. Its briskly Palisades keep out the least mote, and moderate the too strong Impressions of the Light.

As in our waking Hours we have almost incessant need for these little Orbs, they run upon the finest Castors, rolling every way with the utmost Ease: Which Circumstance, added to the Flexibility of the Neck, renders our Two Eyes as useful as a thousand.

The *Ear* consists of an Outward Porch and Inner Rooms. The Porch, somewhat prominent from the Head, is of a Cartilaginous Substance, covered with tight Membranes and wrought into sinuous Cavities. These, like circling Hills, collect the wandring Undulations of the Air, and transmit them with a vigorous Impulse, to the finely stretched Membrane of the *Drum*. This is expanded upon a Circle of Bones, over a polished, reverberating Cavity. It is furnished with *Braces*, that strain or relax, as the Sound is faint or strong. The *Hammer* and the *Anvil*, the winding *Labyrinth*, and the sounding *Galleries*, these and other pieces of Mechanism, all instrumental to Hearing, are inexpressibly curious.

Amazingly exact must be the Tension of the *Auditory Nerves*, since they answer the smallest Tremors of the Atmosphere, and distinguish their most subtle Variations. These living Chords, tuned by an Almighty Hand, and spread thro' the echoing Isles, receive all the Impressions of Sound, and propagate them to the Brain. These give existence to the Charms of Music, and the still nobler Charms of Discourse.

The Eye is useless amidst the Gloom of Night. But the Ear hears thro' the darkest Medium. The Eye is on Duty only in our waking Hours: But the Ear is always accessible.

As there are Concussions of the Air, which are discernible only by the Instruments of Hearing, so there are

are *odoriferous* Particles wafted in the Air, which are perceivable only by the *Smell*. The *Noſtrils* are wide at the bottom, that more Effluvia may enter, narrow at the top, that when entered they may act more ſtrongly. The Steams that exhale from fragrant Bodies, are fine beyond Imagination. Microſcopes that ſhew thouſands of Animals in a drop of Water, cannot bring one of theſe to our Sight. Yet ſo judiciouſly are the olfactory Nets ſet, that they catch the vaniſhing Fugitives. They imbibe all the Roaming Perfumes of Spring, and make us banquet even on the inviſible Dainties of Nature.

Another Capacity for Pleaſure our bountiful Creator has beſtowed, by granting us the Powers of *Taſte*. This is Circumſtanced in a manner ſo benign and wiſe, as to be a ſtanding Plea for Temperance, which ſets the fineſt Edge on the Taſte, and adds the moſt poignant Reliſh to its Enjoyments.

And theſe Senſes are not only ſo many Sources of Delight, but a joint Security to our Health. They are the Inſpectors that examine our Food, and enquire into the Properties of it. For the Diſcharge of this Office they are excellently qualified, and moſt commodiouſly ſituate. So that nothing can gain Admiſſion, till it has paſt their Scrutiny.

To all theſe, as a moſt neceſſary Suppliment, is added the Senſe of *Feeling*. And how happily is it tempered between the Two Extremes, neither too acute, nor too obtuſe! Indeed all the Senſes are exactly adapted to the Exigencies of our preſent State. Were they ſtrained much higher, they would be Avenues of Anguiſh: Were they much relaxt, they would be well-nigh uſeleſs.

The crowning Gift, which augments the Benefits accruing from all the Senſes, is *Speech*. Speech makes me a Gainer by the Eyes and Ears of others, by their Ideas and Obſervations. And what an admirable Inſtrument for articulating the Voice, and modifying it into Speech, is the *Tongue*? This little Collection of muſcular Fibres, under the Direction of the Creator, is the Artificer of our Words. By this we communicate the Secrets

Secrets of our Breasts, and make our very Thoughts audible. This likewise is the efficient Cause of Music; it is soft as the Lute, or shrill as the Trumpet. As the Tongue requires an easy Play, it is lodged in an ample Cavity. It moves under a concave Roof, which gives additional Vigour to the Voice, as the Shell of a Violin to the Sound of the Strings.

WONDERFULLY wife is the Regulation of *voluntary* and *involuntary* Motions. The Will in some Cases has no Power: In others She is an absolute Sovereign. If she command, the Arm is stretched, the Hand is closed. How easily, how punctually are her Orders obeyed! To turn the Screw, or work the Lever, is laborious and wearisome. But we work the Vertebræ of the Neck, with all their appendent Chambers; we advance the Leg, with the whole incumbent Body: We rise, we spring from the Ground, and tho' so great a Weight is raised, we meet with no Difficulty or Fatigue.

THAT all this should be effected without any Toil, by a bare Act of the Will is very surprizing. But that it should be done, even while we are entirely ignorant of the Manner in which it is performed, is most astonishing! Who can play a single Tune upon the Spinnet, without learning the Difference of the Keys? yet the Mind touches every Spring of the Human Machine, with the most masterly Skill, tho' she knows nothing at all of the Nature of her Instrument, or the Process of her operations.

THE Eye of a Rustic, who has no Notion of Optics, or any of its Laws, shall lengthen and shorten its Axis, dilate and contract its Pupil, without the least Hesitation, and with the utmost Propriety: Exactly adapting itself to the particular Distance of Objects, and the different Degrees of Light. By this means it performs some of the most curious Experiments in the Newtonian Philosophy, without the least Knowledge of the Science, or Consciousness of its own Dexterity!

WHERE shall we admire most, the Multitude of Organs? Their finished Form and faultless Order? Or the Power which the Soul exercises over them? Ten Thousand

Reins

Reins are put into her Hands: And she manages all, conducts all, without the least Perplexity or Irregularity. Rather with a Promptitude, a Consistency and a Speed, that nothing else can equal!

So *fearfully and wonderfully* are we *made!* Made of such complicated Parts, each so nicely fashioned, and all so exactly arranged; Every one executing such curious Functions, and many of them operating in so mysterious a manner! And since Health depends on such a numerous Assemblage of moving Organs; since a single secretion stopped may spoil the Temperature of the Fluid, a single Wheel clogged may put an end to the Solids: With what holy fear, should we *pass the time of our sojourning here* below! Trusting for continual Preservation, not merely on our own Care, but on the Almighty Hand, which formed the admirable Machine, directs its Agency and supports its Being!

CHAP. II.

Of the Natural State of the Human Body.

1. *What the Natural State of the Body means?*
2. *Of the Circulation of the Blood;*
3. *Of Respiration;*
4. *Of Chylification;*
5. *Of Nutrition;*
6. *Of the Senses;*
7. *Of the Sight,*
8. *The Hearing,*
9. *The Smelling,*
10. *The Tasting,*
11. *The Feeling;*
12. *Of Hunger and Thirst;*
13. *Of Sleep;*
14. *Of Local Motion;*
15. *Of the voluntary and involuntary Motions.*

1. THAT is the *Natural State* of the Human Body, wherein all Parts of it duly perform their Natural Operations. The chief of these are, the Circulation of the Blood, Respiration, Chylification, Nutrition and Motion.

2. THAT

2. THAT the Blood circulates thro' the whole Body appears hence. Any of the Arteries being tied with a Thread, will ſwell and beat between the Bandage and the Heart, but grow flaccid between the Bandage and the Extremities of the Body. And if the Artery be cut between the Bandage and the Heart, Blood ſtreams out, even to Death: But if it be cut between the Bandage and Extremities, very little Blood comes out. The vital Blood therefore flows from the Heart thro' the Arteries, toward the Extremes of the Body, and ſtill out of a wider Part into a narrower, out of the Trunk into the Branches.

ANY of the larger Veins being tied with a thread, ſwells between the Extremes and the Bandage, but grows flaccid between the Bandage and the Heart. If opened in the former Part, it bleeds largely; if in the latter, ſcarce at all. The Blood therefore flows from all the Extremes, thro' the Veins into the Heart, and ſtill from the narrower Parts of the Vein to the larger, from the Branches to the Trunk.

UPON the whole it is evident, that all the Arteries are continually bringing the Blood from the Left Ventricle of the Heart, thro' the Trunks of the Arteries into their Branches, and from thence to all Parts of the Body: And on the contrary that all the Veins, (except the Vena Portæ) are continually bringing it back from all Parts of the Body, thro' the ſmall Branches into the larger, and thence thro' the Trunks and Vena Cava into the Right Ventricle of the Heart.

ANATOMISTS

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* LATE Writers have perſued the Globules of Blood to a great Length, and found ſeveral Orders of them. The large ones viſible to the naked Eye, are Globules of the *firſt Order*. Each of theſe is compoſed of ſix ſmaller, joined together in a very regular way. But ſometimes a red Globule is ſeen looſening, and breaking into theſe compounding Spherules. And ſometimes one may perceive theſe running together, and beginning the Compoſition of a new red Globule. Theſe ſmaller Spherules they call Globules of the *Second Order*. But we are not to ſtop here. There are in the Blood a great many Particles ſix times leſs than theſe. Globules of the Second Order are compounded of theſe ſmaller ones, which therefore are Globules of the *Third Order*.

Anatomists and Physicians have generally determined the Quantity of Blood in the Human Body, to be between fifteen and twenty-five Pounds. But Dr. *Keil* shews from many Instances of profuse Hemorrhages, that a far greater Quantity must be allowed. Otherwise the Patient could never have furnished, or at least, not survived such Evacuations; the least of which exceeded the whole Quantity of Blood, supposed to be in the Body.

In reality, the Quantity of Blood in an Human Body, is difficult to be determined. Bleeding to Death, the usual Method, can never shew what is its true Quantity: Because no Animal can bleed longer, than while the Great Artery is full; which will be a longer or a shorter time, as the wounded Artery is smaller or greater. And the Great Artery must always be, the first Vessel that empties.

The only certain way of calculating is, to find what Proportion the Cavities of the Vessels of which the whole Body is composed, bear to the Thickness of the Coats. This in the Veins and Arteries may be exactly found. But in the other Vessels we only know the Quantity of Fluid they contain, by carefully evaporating as much as possible. Thus the Doctor found the Fluids to be in the

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Farther. There are innumerable Blood Vessels of such Smalness, that none of the above mentioned Globules can pass them: So that we cannot but suppose still smaller Globules. The Diameter of some Vessels, is less than the Eighth Part of the Diameter of a red Globule: So that the Particles passing thro' them, must be above five hundred times less than those Globules. Nay, on a careful Examination, we perceive Vessels narrower, than the Tenth Part of the Diameter of a red Globule; which consequently can transmit Spherules no greater, than the thousandth Part of a red Globule.

On the whole then, each Globule of the First Order is made up of six of the Second: These of Six of the Third, those of six of the Fourth; these of Six of the Fifth, and so on. And accordingly we find, the Globules of the highest Orders, may be broken down into their compounding Particles.

The Diameter of a common Red Globule is about the One 1938th Part of an Inch. The Diameter of a Globule of the Tenth Order is less than the One 4000000th Part of an inch.

the Arteries as 17 to 1; in the Veins as 15.6 to 1: in the Bones as 1 to 1. The least of these Proportions shews the Liquors to be One-half of the Weight of the Body. And if a Calculation be made, on the Proportion of the Blood in the Arteries only to their Coats, in a Body weighing 160 Pounds, there will be found 100 Pounds of Blood or circulating Fluid.

In a Fœtus the Circulation is performed in a peculiar manner. The Septum which separates the two Ventricles of the Heart is pierced thro' with an Aperture, called the *Foramen Ovale*, and the Pulmonary Artery, a little after it has left the Heart, sends out a Tube into the Descending Aorta, called the *Communicating Canal*. When the Fœtus is born, the Foramen ovale closes, and that Canal dries up into a simple Ligament.

The Fœtus while in the Womb receives little Air. Its Lungs therefore cannot swell and subside. They continue almost at rest: Nor can they allow the Blood to circulate, either in Abundance, or with Ease. Nature therefore has excused them from the Passage of the greatest Part of the Blood, and has contrived the Foramen ovale, by which Part of the Blood of the Vena Cava passes thro' the Right Ventricle into the Left. And by this means it is found as far on its Journey, as if it had passed the Lungs. But this is not all. For that Blood of the Cava, which misling the Foramen ovale, passes from the Right Auricle into the Right Ventricle, being still too much to pass by the Lungs, the Communicant Canal intercepts Part of it, and pours it immediately into the Descending Aorta.

3. Respiration is performed by receiving the Air into the Lungs, and breathing it out alternately. In the former, the Cavity of the Breast is inlarged, by the sinking of the Diaphragm, and the Erection of the Ribs, thro' the force of the Muscles placed between them. In the latter, it is contracted, the Diaphragm rising and the Ribs falling again. Whenever the Cavity of the Breast is inlarged, the Air by its Weight naturally presses into it, and mixing with the Blood in the Vesicles of the Lungs, makes it more fluid, globular and fit for Motion.

Air is likewiſe abſolutely neceſſary in the Body, to counter-act the Preſſure of the Outward Air.

The Blood in the Lungs of a Fœtus has not the Advantage of Reſpiration. But it receives a Portion of Air, tranſmitted with its Mother's Blood by the Umbilical Veſſels, to be diffuſed thro' the Body. This is quite neceſſary, as appears hence: Tie the Navel String very tight, and the Child dies, like a Man ſtrangled.

The principle Uſe of Reſpiration is, to puſh the Blood from the Right to the Left Ventricle of the Heart. Hence it is, that perſons ſtrangled ſo ſuddenly die, becauſe with Reſpiration, the Circulation of the Blood ceaſes. And this is the true Cauſe of the Diaſtole of the Heart: The Weight of the incumbent Atmoſphere, being the true Antagoniſt to all the Muſcles that ſerve both for Inſpiration and the Contraction of the Heart. As in the Elevation of the Ribs, a Paſſage is opened for the Blood into the Lungs, ſo in the Depreſſion thereof, by the ſubſiding of the Lungs and the Compreſſion of the Blood-veſſels thereby, the Blood is driven thro' the Pulmonary Vein, into the Left Ventricle of the Heart. And this, together with the General Compreſſion of the Body, by the Weight of the Atmoſphere, is that Power which cauſes the Blood to mount in the Veins, when the Force impreſt on it by the Heart is nearly ſpent, and which forces the Heart itſelf from its natural State of Contraction, to that of Dilatation.

When in an ordinary Expiration, the Preſſure on the Larynx is two Ounces, the Preſſure on the whole internal Subſtance of the Lungs, is 14412 Pounds. So vaſt is the Extent of the Surface of the Veſicles, on which it was neceſſary the Blood ſhould be ſpread in the fineſt capillary Veſſels, that each Globule of Blood might as it were immediately receive the whole Force of the Air, and thereby be broken into ſmaller Parts, fit for Secretion and Circulation.

And hence we ſee the Reaſon for the Structure of the Lungs. For ſince all the Blood is to paſs thro' them, in order to receive the Effect of the Air, and that this could not be done, unleſs it were diffuſed in very ſmall Veſſels:

It

It was neceſſary the Surface on which they were to be ſpread, ſhould be proportioned to their Number. And this is admirably well provided for, by the Fabric of the Lungs.

If the Diameter of the Trachea at the Time of every Expiration were the ſame in all, and the Weight of the Air always equal, the Preſſure on the Lungs would be always the ſame. But as the Difference between its leaſt and greateſt Gravity, is no leſs than a Tenth Part of the whole, that Preſſure is likewiſe greater by a Tenth Part at ſometimes than it is at others.

This is a Difference which the Aſthmatic muſt ſenſibly feel; eſpecially as they breathe thicker, that is every Expiration is performed in leſs Time. In truth theſe feel a Difference in the Air, upon the greateſt Riſe and Fall of the Barometer, equal to above One third of its Preſſure in ordinary Breathing.

The alternate Dilatation and Contraction of the Thorax are ſo neceſſary to Animal Life, that there is no Animal without this, or ſomething analogous to it. Fiſhes and Inſects have no dilatable Thorax. But Fiſhes have Gills, which receive and expel the Water alternately, whereby the Blood-veſſels ſuffer the ſame Alterations of Dimenſion, as thoſe in our Lungs do. And Inſects have Air-veſſels diſtributed thro' the whole Trunk of their Bodies. By theſe they communicate with the external Air thro' ſeveral Vent-holes, to which are faſtened ſo many Windpipes, which ſend Branches to all Parts, and ſeem to accompany the Blood-veſſels all over the Body, as they do in our Lungs only. And hereby in every Inſpiration the whole Body is dilated, and in every Expiration compreſſed.

4. *Chylification* is preceded by *Digeſtion*, which is much illuſtrated by Mr. *Papin's Digeſter*. This is a Veſſel wherein Meat is put, with juſt as much Water as will fill it. Then the Lid is ſcrewed on ſo cloſe, as to admit of no External Air. The Meat herein is by the Flame of a ſmall Lamp, in Six or Eight Minutes brought to a perfect Pulp. In a few Minutes more the hardeſt Bones are reduced to a Jelly. No Air entering, the Succuſſions cauſed by the Air incloſed in the Fleſh, reſolve the whole

into One homogeneous Body. It is juſt ſo in Digeſtion. In Proportion to its Heat, the Stomach does the very ſame thing as the Digeſter.

ADD to this, that the Muſcular Coat of the Stomach continually contracting, and preſſing its Contents by its Periſtaltic Motion, occaſions a more intimate Mixture, and works the more fluid Parts, thro' the Pylorus into the Duodenum. Along the ſides of this and the other ſmall Inteſtines the Lacteals are planted: Into the minute Orifices whereof, the Chyle, or finer Part of the Maſs is received. The Lacteal Veins of the firſt kind, diſcharge themſelves into the Glands of the Baſis of the Meſentery. The Chyle is afterward received by the Lacteals of the Second kind, and conveyed into Glands between the two Tendons of the Diaphragm. And hence it is carried to the Heart, where it mixes with the Blood.

5. BY the perpetual Motion of the Fluids, (eſpecially in the Minute Veſſels) as well as the conſtant Action of the Muſcles, ſmall Particles are continually worn off, from the Solids of the Body. The Fluids likewiſe are continually diminiſhing. And hence every Animal Body, by the very Condition of its Frame, is liable to Deſtruction. To prevent this, a Reſtitution muſt be made to the Juices and Solids of the Body, equal and ſimilar to what is loſt. And this we call *Nutrition*.

IT ſeems to be performed thus. The Blood forcibly thrown by the Heart into the Arteries, endeavours to go out every way thro' the Pores. But theſe are uſually too ſmall, to give its Particles a free Paſſage. They can only paſs where any of the Pores are open. Here one will naturally follow another in a Line, and conſtitute a Fibre or Part of a Fibre. When as much is thus added to one End of the Fibre, as is waſted at the other, the Body is *nouriſhed*: When more is added than is waſted, we are ſaid to *grow*.

WE ſee then how abſolutely neceſſary Food is, to repair the conſtant Decay of the Body: So that few men or women can live without it, above five or ſix Days. And yet the abſtaining from it for a Seaſon has its Uſe. Indeed great is the Efficacy of Abſtinence, both in prolonging

longing Life, beyond its usual Period, and in the Cure of many stubborn Disorders. †

6. As without Respiration and Nutrition we cannot live at all, so without *Sense*, Life would be like Death. In every Sensation there is 1. An Outward Object, 2. Its Action on the Organ of Sense, 3 A Perception of it in the Mind. The Action of the Object on the Organ, is by means of the Nerves communicated to the Brain. And then, not otherwise, the Perception follows. But how, none but He that made Man can explain.

7. In *Sight* the Action on the Organ is performed just in the manner of that in a Camera Obscura. The

G 3 Rays

† *Lewis Cornaro*, a Nobleman of *Venice*, after all other Means had failed, so that his Life was despaired of at Forty, recovered and lived to near an Hundred, by mere dint of Abstinence.

'Tis surprizing to observe, to what an Age those antient Christians lived, who retired from the Fury of Persecution, into the Deserts of *Arabia* and *Egypt*. They drank only Water, and took no other Food than 12 ounces of Bread in 24 Hours. On this St. *Anthony* lived 105 Years, *Epiphanius* 115, *Simeon Stylites* 112 and *Romuald*, an hundred and twenty.

Among Animals we see surprizing Instances of long Abstinence. Several Species pass 4, 5 or 6 Months every year without eating or drinking. So Tortoises and Dormice regularly retire at the Season to their respective Cells. Some Kinds get into Ruins, or the Hollows of Rocks; others, into Clefts of Trees. Some sleep in Holes under the Earth: others bury themselves under Water.

The Serpent-kind bear Abstinence to a miracle. Rattle snakes will subsist many Months without Food. Dr. *Shaw* saw two *Egyptian* Serpents, which had been kept in a bottle five Years, (on a small Quantity of Sand wherein they coiled themselves up) without any Sort of Food. Yet when he saw them they had just cast their Skins, and were as lively as if just taken.

There have been Instances even of Men passing several Months, with scarce any Sustenance. So *Samuel Chilton* of *Tinsbury*, near *Bath*, in the year, 1693, 1694 and 1695, slept sometimes four Months, and sometimes above six together, with very little Food: And Six Weeks without any, but a little Tent conveyed with a Quill thro' his Teeth.

It is not improbable, that the Air itself furnishes some nutritive Particles. It is certain, there are Substances of all kinds, floating in the Atmosphere. And that an Animal Body may be nourished hereby, is evident in the Case of Vipers. These if taken when first brought forth, and kept from every thing but Air, will yet grow very considerably in a few days.

Rays of Light, reaching from the Surface of Bodies to the Eye, variously penetrate the Coats and Humours of it, and paint on the Bottom of the Eye the Images of the things which we see. This is communicated by the Optic Nerve to the Brain, and then the Perception, which is properly Sight, follows. But the Eye has many Advantages above a Camera obscura: Not only as it can be moved various ways, by the Help of its Muscles; but also as the Pupil, by the Help of the Iris, is instantly either dilated or constringed, according to the Degree of Light. The Eye likewise accommodates itself to the various Distances of the Objects, the bottom of the Eye approaching to or receding from the Chrystalline Humours, as the Object is nearer or farther off.

8. *Sound* is a tremulous Motion of the Air, produced by the Stroke or Collision of Bodies. *Hearing* is performed in the following Manner. The undulating Air enters the outward Cavity of the Ear, and then strikes upon the Drum; from which the Motion is communicated to the little Bones within, and the Air contained in the inner Cavity. This by means of the Nerve conveys it to the Brain, and then follows the Perception which we term Hearing.

9. The fine Effluvia which spread every way from odorous Bodies, ascending with the Air into the Nostrils, variously twitch the filaments of the olfactory Nerves, according to the Variety of their Natures. When this Motion is by those Nerves communicated to the Brain, the Perception follows which is called *Smelling*.

10. It was observed before, that the Surface of the Tongue is filled with small Papillæ, which are no other than fine Ramifications of the Gustatory Nerve. These are variously moved, by the Particles of Meat and Drink. And this Motion being by that Nerve transmitted to the Brain, that Perception arises which we stile *Tasting*.

11. The Organ of *Feeling* is the Skin in general, with which innumerable nervous Papillæ are interwoven, which being moved by the slightest Touch of other Bodies, convey that Motion to the Brain. But these Papillæ abound in all the Extremities, particularly the Palms of the Hand, and the Tips of the Fingers. And hence it is, that

that the Sense of Feeling is far more exquisite in those than in other Parts.

12. Nearly allied to the Senses are the Natural *Appetites*, particularly *Hunger* and *Thirst*. The usual way of accounting for them is this. When the Food now reduced to a Pulp, is expreſt out of the Stomach, it is of course contracted by its muſcular Coat. This causes the Inner Coat to lie in Folds; which by means of the Peristaltic Motion, rubbing lightly on each other, occasion the uneasy Sensation which we term Hunger. This is felt first in the upper Orifice, which is first evacuated. But as by degrees the rest of the Contents are expelled, this rubbing of the Membranes on each other spreads over the whole Stomach, and renders our Hunger more urgent.

This uneasy Sensation is increased by the Acidity, which the Blood in the Arteries of the Stomach contracts thro' long Abstinence, its soft, balsamic Parts having been all drawn off. Likewise its Velocity is considerably augmented, when we have not eaten for some time.

Hence it is, that Hunger, if it continues long, will occasion a violent Fever: That young Persons, and those who labour hard, or are of a bilious Constitution, are soonest hungry: Whereas those whose Humours are thick and viscid, are not so soon incommoded therewith.

Hot Vapours ascending from the Stomach, and drying the Throat and Mouth, are supposed to be the occasion of that uneasy Sensation, which we term *Thirst*.

I say, *are supposed*. For I apprehend nothing can be known with any Certainty upon the Head. In like manner it is supposed, that we are then *awake*, when the Nerves are braced, and filled with Animal Spirits; and that when they are unbraced and empty, we *sleep*. But who can give any satisfactory account of Sleep? Some ascribe it to the Stoppage of the Nerves: Some to the Quiescency, and others to a Deficiency of the Animal Spirits. The truth is, we are ignorant of the whole Affair; and no more understand Sleep than we do Death.

But this we know, that during Sleep several Functions are suspended, the Organs of Sense are at rest, the Muscles

Muſcles are quieſcent, ſo that hardly any Spirits flow thro' them. The Fibres of the Nerves are little changed, and an Equilibrium obtains throughout. There is no Difference of Preſſure on the Veſſels, nor of Velocity in the Humours, which circulate equally thro' all the Canals. Meantime, all diſturbing Cauſes being at reſt, the waſted Humours are reſtored, and the Particles ſupplied, which were worn off the Solids.

We may obſerve farther, that when the Head is hot, and the feet cold, we cannot ſleep; that Perſpiration is twice as great while we ſleep as while we are awake; that too much Sleep makes the Senſes dull, the Memory weak and the whole Body liſtleſs; that Sleep will for a conſiderable time ſupply the place of Meat and Drink: That a Fœtus ſleeps always; Children much; Youths more than Adults, and they than Old Men. [u]

Let-

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u To ſpeak a little more particularly. While we are awake, there is a continual Motion of the voluntary Muſcles, of the Parts ſubſervient to Senſe, and to the Affections, all which ſtimulate the Nerves, Blood-veſſels and Heart. Thus the finer Parts of the Blood are continually waſted, whence Wearineſs enſues; and if the Vigilance be continued, a feveriſh Heat and ſenſible loſs of Strength.

As the Night advances, a weight falls on the large Muſcles and their Tendons, and the Mind becomes heavy: The Powers that hold the Body erect, begin to ſhrink from their Office, the Eye-lids cloſe, the lower Jaw falls down, the head nods, and we take leſs notice of outward Objects, till at length all the Thoughts are in confuſion, and a Sort of Delirium enſues, from whence there is a tranſition to Sleep, not known to us. This is haſtened by Darkneſs, Compoſure of Mind and abſence of Invitation from all Parts of the Body.

Again. Whatever weakens the natural Powers, inclines to and increaſes Sleep: Such as Loſs of Blood, cooling Medicines, yea the Cold of the external Air. Add to theſe, whatever calls off the quantity of Blood flowing to the Heart, as warm Bathing of the feet, a plentiful ingeſtion of food into the Stomach: Likewiſe whatever leſſens the Motions of the Spirits, whether in the Brain, or Stomach, Heart and Arteries. On the contrary, ſome hot Medicines induce Sleep, by cauſing a greater Afflux of Blood to the Brain. The ſame effect have ſome Fevers; as alſo Fatneſs, and whatever elſe retards the venal Blood. In all theſe Caſes, the Blood collected in the Head compreſſes the Brain, ſo as to leſſen the Courſe of the Spirits into the Nerves.

Let us consider in another view these remarkable Incidents of our Frame, *Sleep* and *Dreams*: So remarkable, that they are a kind of Experimental Mystery, a standing Miracle. Behold the most vigorous Constitution, when resigned to the slumbers of the Night. Its Activity is oppressed with Indolence; its Strength suffers a temporary Annihilation. The Nerves are like a Bow unstrung, the whole Animal like a motionless Log. Behold a Person of the most delicate Sensations and amiable Dispositions. His Eyes, if wide open, discern no Light, distinguish no Objects. His Ears with the Organs unimpaired, perceive not the Sounds that are round about them. The exquisitely fine Sense of Feeling is overwhelmed with an utter Stupefaction. Where are his Social Affections? He knows not the Father that begat him, the Friend that is as his own Soul. Behold the most ingenious Scholar, whose Judgment traces the most intricate Sciences, whose Taste relishes all the Beauties of Composition. The thinking Faculties are unhinged, and instead of close-connected Reasonings, there is nothing but a disjointed Huddle of absurd Ideas. Instead of well-digested Principles, nothing but a disorderly Jumble of crude Conceptions.

Yet

Sleepiness is likewise produced by any Compression of the Brain, whether from Extravasated Blood, a depressed Part of some Bones, or a Collection of serous water within the Ventricles.

Sleep therefore sometimes rises from a defect of the Spirits: But always from a collapsing of the nervous Fibres, thro' which the Spirits pass from their fountain to all Parts of the Body.

It is hindered by intense thought, Pain of Body, and strong Emotions of Mind: all which urge the Spirits on, and prevent the nervous Fibres from collapsing.

In Sleep the Heart is gradually restored from its quick and almost feverish Pulsation, to its slow and calm Motion: The Breathing is slower and smaller, the Motion of the Stomach and Intestines, the Digestion of the Aliments and the Progression of the Faeces are diminished. At the same time, the thinner Juices move more slowly, while the more gross are collected together, the Fat is accumulated in its cells, and the nutritive Particles adhere more plentifully to the inner Surfaces of the small Vessels, and the Sides of the Fibres. Thus while the Spirits are secreted with a less Consumption, they are by degrees accumulated in the Brain, so as to distend and fill the collapsed Nerves. And then we awake out of Sleep.

YET no sooner does he awake, than he is possest of all his former Endowments. His Sinews are braced and fit for Action, his Senses alert and keen. The frozen Affections melt with Tenderness; the romantic Visionary is again the Master of Reason. And (what is beyond measure surprizing) the intoxicated Mind does not work itself sober by slow degrees, but in the twinkling of an eye, is possest of all its Faculties! Why does not the Numbness, which seized the Animal Powers, chain the Limbs perpetually? Why does not the Stupor, that deadens all the Sense, hold fast its possession? When the Thoughts are once disadjusted, why are they not always in confusion? How is it, that they are rallied in a moment, and reduced from the wildest Irregularity to the most orderly Array? From an Inactivity resembling Death, and from Extravagancies little differing from Madness, how suddenly is the Body restored to Vigour and Agility? How instantaneously is the Mind re-established in Sedateness and Harmony! Surely *this is the Lord's Doing. And it is marvellous in our eyes!*

14. THAT all *Motion* is performed by Means of the Muscles, all men are now agreed. And it is supposed that the Motions of the Muscles proceed, from the influx of the Animal Spirits; which, entring them by means of the Nerves, swell and shorten the Belly of the Muscle, and thereby draw the Extremities together, and move the Parts connected therewith. But all this likewise is mere Conjecture. GOD only knows his own Work.

15. THAT some Motions are *Voluntary*, and some are not, is another amazing Proof of the Creator's Wisdom. Those which are absolutely necessary for the Conservation of the Machine, as the Beating of the Pulse, and the Circulation of the Blood, go on by a kind of Mechanic Law, which no way depends upon our Will: While a thousand other Motions begin and end, by a single Act of our Will, when we please. But how this Bodily Motion is connected with that Act of our Mind, who is able to explain?

CHAP.

CHAP. III.

Of the preternatural State of the Human Body.

1. *What the preternatural State of the Body means.*
2. *The Variety of Diſeaſes,*
3. *Reduced to three Claſſes, thoſe of the Solids;*
4. *Thoſe of the Fluids, particularly, the Blood;*
5. *Thoſe of the Animal Spirits:*
6. *The remote Cauſes of Diſeaſes:*
7. *Of Fevers:*
8. *The Way to preſerve Health:*
9. *Of Life and Death.*

1. WHEN the Structure or Diſpoſition of the Parts of the Body is ſo diſturbed and diſordered, that the natural Operations are no longer performed, or not in the manner they ought: This is a *preternatural State* of the Body, otherwiſe termed a *Diſeaſe.*

2. THERE cannot but be great Variety of Diſeaſes, whether we conſider the Manner, wherein that Structure or Diſpoſition is diſturbed, the Part wherein each Diſeaſe has its Seat, or the various Effects and Circumſtances of them. Some Diſeaſes only *hurt* the Uſe of the Parts; ſome wholly *deſtroy* it. Some affect this or that Part; others the whole Body. Some diſorder the Body, ſome the Mind; and others both Mind and Body.

5. BUT they are all reducible to three Claſſes, thoſe of the *Solids*, of the *Fluids* and of *Both*. The Solid Parts may be bruiſed, wounded, ſwelled, or removed out of their Natural Place. [w]

4. THE

[w] It is a wonderful Proviſion which Nature makes in one of the moſt dreadful Calamities incident to the Solids. When a Bone is broken, let it only be replaced, and preſerved in that Situation, and Nature does the reſt, by ſupplying the divided Parts with a *Callus.*

4. THE Diſeaſes of the *Fluids* lie chiefly in the Blood, when it is either too thick and fizy, whereby its Motion becomes too languid and ſlow, whence ſpring the Diſeaſes owing to Obſtruction: Or too thin. From the former Cauſe ariſe Leproſies, Schirrhus's Lethargies, Melancholy, Hyſteric Affections, And if at the ſame time it abound in acid Salts, the ſharp points of theſe tear the tender Fibres, and occaſion the Scurvy, Kings-Evil, Conſumption, with a whole train of painful Diſtempers. Fevers in general ariſe from the too great Thinneſs of the Blood.

5. As to the Diſeaſes aſcribed to the *Animal-Spirits*, ſome are thought to proceed from the Suppreſſion or Diminution of their Motion, as Apoplexies and Palſies: Some from their exceſſive or irregular Motion, as Madneſs, Convulſions, Epilepſies.

6. SUCH

This ooze out from the ſmall Arteries and bony Fibres of the divided Parts, in form of a Jelly, and ſoon fills up the Cavities between them. It ſoon grows cartilaginous, afterwards bony, and joins the fractured Parts ſo firmly, that the Bone will be more eaſily broken in any other Part than in that.

A CALLUS of a different kind is formed on our Hands and Feet. This is compoſed of ſeveral Layers of Particles looſely connected. Theſe if ſteeped in fair Water eaſily ſeparate; and then are found, if viewed thro' a Microſcope, to be all of one Shape, reſembling that of a Weaver's Shuttle, broad in the middle, and pointed at each end. Being ſteeped again, they divide into a great number of ſmaller Particles, all of the ſame Figure with the firſt.

THE thickneſs of the Skin in the Hands of thoſe who labour hard, is wholly owing to vaſt numbers of theſe Particles, which combine together, but ſo looſely, that they are eaſily ſeparated on moiſtning. That thick Skin is compoſed of ſeveral Layers of different thickneſs, which have been added from time to time: Each of which Layers is only a Congeries of almoſt an infinity of theſe Particles.

BUT People who labour ever ſo hard, will have little Callus on their Hands if they waſh them often. The Waſhing the Hands daily rubs off a great Quantity of theſe Scales. Indeed is is ſurprizing to ſee, how large a Quantity of them is daily thrown off from our Hands and Feet, tho' from no other Part of the Body. We may learn from this the great Bounty of Nature, in ſo carefully ſupplying the Parts deſigned for Walking or Labour, with an additional Matter for their defence, which is not in any other Part of the Body.

6. Such are the Proximate Causes of Diseases. As to the Remote, the chief are these, 1. Intemperance in Meat or Drink, either with regard to the Quantity or Quality: 2. Want of Exercise, or Excess therein: 3. Immoderate Sleep or Watching: 4. Unwholesome Air: 5. The Diminution of some Natural Evacuation: 6. Irregular Passions. All or any of these affect the Temperature and Motion of the Blood and Spirits.

7. But it can scarce be conceived, after all that has been said and wrote on almost every Subject, how very little is known to this Day, concerning the Causes of Diseases. In most cases the most skilful Physicians acknowledge they have nothing but Conjectures to offer. We may give a Specimen with regard to *Fevers*, the most common of all Distempers. These are of various kinds: At present we will speak of *intermitting* Fevers only. Most of these agree in the following Symptoms. During the Approach of the Fit, Cold and Shivering seize the Body, with a small and slow Pulse. Heat succeeds, with a quick, strong, hard Pulse, followed by Sweat and a softer Pulse. These Fits return at stated Times.

It is supposed, that these Changes in the Blood arise, from some foreign Matter mixt with it, which it cannot readily assimilate, and which therefore must in some measure hinder its Motion: Perhaps because the Particles of it are too large, too long, or branching out. When the Circulation is hindered or retarded, *Chilness* naturally follows. And if these Particles sticking in the finer Passages, are prest on by the affluent Blood, this will occasion both a Shock and *Trembr* of the Muscles, and make the Pulse more *weak* and *slow*. But when they are at length broken and comminuted by the continued Afflux of the Blood, it will flow more violently, and of course occasion *Heat*, which driving the Blood to the Surface of the Body, many of its thinner Particles will burst thro' the Pores, in the form of *Sweat*. As to the Fevers returning at stated Times, it is supposed the peccant Matter, is generated from time to time, and mingled with the Blood afresh; whence the same Symptoms of course return, and that with more or less vio-

lence, as more or less of that Matter is generated. And as this is done more swiftly or slowly, the Fever returns in One, two or three Days. But all this is mere Conjecture. It may be so; and it may not. So that tho' we may *guess* much, we *know* nothing about it.

8. It is sufficient for us to know, How we may avoid Diseases, whether we can account for them, or not. To this End we should avoid whatever in Meat, Drink, Motion or Rest, is likely to produce any considerable Change in the Blood. The Body likewise should be as far as possible accustomed, to bear some Change of Food, Air and other Externals, that if we should at any time be constrained to make such a Change, no ill Consequence may insue. But no precise Rule can be laid down, which will suit all Constitutions. Every man must consult his own Reason and Experience, and carefully follow them.

9. As long as the Soul and Body are united, a man is said to be *alive*. But it is extremely difficult to determine, the precise time at which Life ceases, or what that is, which is absolutely necessary to the continuance of it. Is Respiration? But when this is entirely ceased, as is the Case in a person strangled, blow strongly into the Lungs, and they play again; which shews he was not *dead* before. Is the Beating of the Heart? But when this also is ceased, in the fore-mentioned Case, take the same Method, and when the Lungs begin to play, the Heart begins to beat anew. Is the Circulation of the Blood? But Persons drowned, who have been so long under Water, as to have no Pulse remaining in any Artery, and consequently no Circulation, have recovered by the use of proper Means, and lived many Years after. Is the Fluidity of the Blood? Nay, but it is a common thing in *Sweden*, to recover to Life one who has been twenty four Hours under Water; and who not only has no Pulse, but is as stiff all over, as any dead Corpse can be. What then is *Death*? Undoubtedly it is the Separation of the Soul and Body. But there are many Cases wherein none but God can tell the Moment wherein they separate.

But

But what is properly a *Natural Death*? From the very Birth every Veſſel in the Human Body, grows ſtiffer and ſtiffer, by the Adheſion of more and more earthly Particles to its inner Surface. Not only Solid Food ſupplies it with theſe, but every Fluid that circulates thro' it. Hereby more and more of the ſmall Veſſels are ſo filled up, as to be no longer pervious. In proportion, the Coats of the larger Veſſels grow harder, and their Cavities narrower. Hence the Dryneſs and Stiffneſs of all the Parts, which are obſervable in Old Age. By this means more and more of the Veſſels are deſtroyed, the finer Fluids ſecerned in leſs Quantity, the Concoctions weakened, and the Reparation of the decayed and injured Parts prevented. So that only the coarſer Juices continue to run ſlowly thro' the larger Veſſels, till theſe alſo not only become narrow, but ſtiff, bony and unelaſtic, till even the Great Artery having loſt its Spring, can propel the Blood no longer. And then follows Death by Old Age, which is a purely *Natural* Death. But this is a very rare Caſe: It is ſeldom Life is ſo long protracted: The Lamp of Life being eaſily blown out, when it burns with ſo feeble a Flame. So that the Age of Man ſeldom exceeds threeſcore Years and ten, before Duſt returns to duſt.

Indeed ſoon after the Creation, when the Earth was to be peopled by One Man and One Woman, the wiſe Providence of God prolonged the Life of Man to above 900 Years. After the Flood, when there were three Men to people the Earth, their Age was cut ſhorter. And none of theſe Patriarchs, except *Shem*, attained to five hundred Years. In the next Century none reached 240: In the third, none but *Terah* lived 200: Men being then ſo increaſed, that they built Cities, and divided into different Nations. As their number increaſed, the Length of their Lives diminiſhed, 'till about the Time of *Moſes*, it was reduced to 70 or 80 Years, where it ſtands at this Day. This is a good Medium, ſo that the Earth is neither over-ſtocked, nor kept too thin of Inhabitants. If Men were now to live to *Methuſelah*'s Age, of 969 Years, or only to *Abraham*'s

of 175, the Earth would be over-peopled. If on the contrary, the Age of Man was limited (like that of divers other Animals) to 10, 20 or 30 years, it would not be peopled enough. But at the present rate, the Balance is nearly even, and Life and Death keep on an equal pace.

This is highly remarkable, that wherever any Account has been taken, there is a certain Rate and Proportion in the Propagation of Mankind. Such a number marry, and so many are born, in proportion to the number of Persons in every Town or Nation. And as to Births, two things are very observable; One, the proportion of Males and Females, Fourteen Males, to thirteen Females, which is exactly agreeable to all the Bills of Mortality. And this Surplusage of Males allows One Man to one Woman, notwithstanding the Casualties to which Men are exposed above Women. The other is, that a few more are born, than appear to die in any place. This is an admirable Provision for extraordinary Emergences, to supply unhealthful Places, to make up the Ravages of Epidemic Distempers, and the Depredations of War; and to afford a sufficient number for Colonies, in the yet unpeopled Parts of the Earth. On the other hand, those extraordinary Expences, are not only a just Punishment of Sin, but also a wise Means, to keep the Balance of Mankind even. So one would be ready to conclude, by considering the *Asiatic*, and other more fertile Countries, where prodigious Multitudes are swept away by Wars and Plagues; and still they remain full of People.

As to the Length of Life, it has been an antient Opinion, that Men lived longer in Cold Countries than in hot. But the reverse is true. The Inhabitants of the *Caribbee* Islands, usually live an hundred and fifty Years. In the *Molucca* Islands, the ordinary Life of the Natives is an hundred and thirty Years. In *Sumatra*, *Iava*, and the neighbouring Islands, the Life of the Inhabitants, commonly extends to an hundred and forty Years; in the Realm of *Cassuby*, to 150. The *Brasilians* frequently live 160 Years, and many in *Florida* and *Iucatan* still longer.

Nor

Nor is this at all improbable. For there being no ſuch Inequality of Weather in thoſe Climates as in ours, the Body is not ſhocked by ſudden Changes, but kept in a more equal Temper. And ſickly Perſons with us, when fixt to their Beds, and kept in an equal Degree of Heat, are often found to hold out many Years, who would otherwiſe ſcarce have ſurvived One.

Before concluding this Head, we may obſerve one more eminent Inſtance of the Divine Wiſdom, in the great Variety throughout the World, of Men's Faces, Voices and Hand-writing. Had Men's Faces been caſt in the ſame Mould, their Organs of Speech given the ſame Sound; and had the ſame Structure of Muſcles and Nerves given the Hand the ſame Direction in Writing: What Confuſion, what numberleſs Inconveniences muſt we have been expoſed to? No Security could have been to our Perſons, no Certainty of our Poſſeſſions. Our Courts of Juſtice abundantly teſtify the Effects of miſtaking Men's Faces, or Hand-writing. But this the wiſe Creator has taken care to prevent from being a General Caſe. A Man's Face diſtinguiſhes him in the Light, as his Voice does in the dark: And his Hand-writing can ſpeak for him when abſent, and ſecure his Contracts to future Generations.

Lastly, How admirably has God ſecured the Execution of his Original Sentence, upon every Child of Man, *Duſt thou art, and unto duſt ſhalt thou return?* From the moment we live, we prepare for Death, by the Adheſion of Duſt, mixt with all our Aliments, to our native Duſt; ſo that whatever we eat or drink, to prolong Life, muſt ſap the Foundation of it. Thus in ſpite of all the Wiſdom of Man, and all the Precautions which can be uſed, every Morſel we take poiſons while it feeds, and brings us nearer to the Duſt from whence we came.

CHAP. IV.

Of the Soul, and of the Origin of Man.

1. EVERY one finds, there is something in himself, which *perceives* the Motions raised in his Body by outward Objects. For when we see, hear, taste, smell or feel, while the Objects affect our bodily Organs, we find also various Perceptions in our Mind, according to the Variety of those Objects.

2. WE observe likewise, that after the Objects are removed, those Perceptions often *continue*, yea and are variously mixt and compounded together, which we term *Imagination*. And a long time after, when those Objects are not only removed, but even cease to exist, those Perceptions *return* into our mind. And this we call *Memory*.

3. AND

3. And as we *perceive* these outward Objects, so we *know* that we do perceive them. The Mind can look inward upon itself, and *reflect* upon its own Perceptions. Over and above this, we seem to find in ourselves, a Knowledge of things *abstracted* from Matter. But the more we labour to penetrate into the Nature of this Divine Principle, the more it seems to retire and withdraw itself from our most studious Researches.

4. In like manner we find in ourselves various *Appetites* for Good things, and *Aversions* to evil things: Yea, the very Involuntary Motions of the Body tend to avoid the Evil, and attain the Good. And the things which are perceived by our Senses, or represented by our Imagination, so necessarily affect us, that we can by no means hinder ourselves from having an Appetite for some, and an Aversion to others.

5. Yet frequently a more hidden and *sublime Appetite* exerts itself in our minds: One that checks, controlls, and exercises Authority over all the rest. For if we are convinced, that the things which are pleasant, are nevertheless hurtful, the Appetite for them is over-ruled, and we find a Desire, not to enjoy, but to avoid them.

6. In order to explain these things, Philosophic men suppose, that all the *Involuntary Motions* of the Body, are performed in a mechanical Manner, by Matter so and so modified: And that such Effects spring of course from such Causes, according to the stated Laws of Motion.

7. As to the *Senses*, they suppose, that when the Organs of Sense are struck by any of the Bodies that surround us, and the Motion caused thereby continued thro' the Nerves to the Brain, the Soul residing there is suitably affected: God having so closely connected the Soul and the Body, that on certain Motions of the Body, (if conveyed to the Brain by means of the Nerves) certain Perceptions of the Mind always follow: As on the other hand, on certain Perceptions of the Mind, certain Bodily Motions follow.

8. They suppose, if these Motions, which are by the Nerves communicated to the Brain, continue there after

after the Objects are removed, the Perception of these is *Imagination:* Which, if it occurs after it has ceased, is then stiled *Memory.* Others suppose, That Imagination results from the Motion of the Animal Spirits, thro' those Traces which were made in the Brain, while the outward Objects were present: and Memory, from the Spirits moving thro' them afresh, after some Intermission.

9. ONCE more. They suppose there are two Faculties in the Soul, One that is Passive, the *Understanding*, by which it perceives all the Motions of the Body, and knows and reflects on its own Operations: The other Active, the *Will*, by which we incline to Good, and are averse to Evil. The *Affections* are only, the Will exerting itself variously on various Objects.

10. To speak freely upon the matter. I know the Body of Man is contrived with such exquisite Wisdom, that he is able, by means of the Organs of Sense, to *perceive* outward Objects, to *continue* those Perceptions, to *recall* them after they are gone, and by a *reflex* Act to know what passes in his Mind or Body. But I know not how to account for any of these things.

11. THAT the *Soul* is immaterial is clear from hence, that it is a *thinking* Substance. If it be said "GOD can endue Matter with a Faculty of Thinking:" We answer, no otherwise than He can endue a Spirit with Solidity and Extension; that is, He can change Spirit into Matter: And he can change Matter into Spirit. But even the Almighty cannot make it *think* while it remains *Matter*; because this implies a Contradiction.

12. THE *Union* of the Soul and Body is another of those things which human Understanding cannot comprehend. That Body and Spirit can't be implicated or twisted together like two Bodily Substances, we know. But how two Substances of so widely different Natures, can be joined at all, we know not. All we can tell is this; GOD has ordered that certain Perceptions in the Soul, should constantly follow certain Motions of the Body, and certain Motions of the Body, such Perceptions in the Soul.

13. How

13. How Mankind began is another point, which is too hard for our Reason to determine. That Men always existed is no way probable, were it only on this Account, the late Invention of Arts. For since it appears, at what times the most necessary Arts were invented, we cannot reasonably suppose, that Men began to exist long before that Period: Seeing if they had always existed, no Reason can be given, why these and many more Arts, were not invented long before. And yet the Accounts given of the Origin of Mankind, by the wisest of the Heathen Philosophers, are so above measure ridiculous, that they serve as a melancholy Proof of the Weakness of barely Natural Reason.

14. The Scriptural Account is this. God made the Body of Man out of the Earth, and breathed into him the *Breath of lives:* Not only an Animal Life, but a Spiritual Principle, created to live for ever. Even his Body was then perfect in its kind; neither liable to Death nor Pain. But what the Difference was between the Original and the present Body we cannot determine.

But to form it even as it is now, no less than a Divine Power was requisite. No less could mix Earth, Water, Air and Fire, in so exact a proportion, and then frame so many different Parts, of so various Figure, Texture and Magnitude. God alone was able to form the Original Fibres; to weave those Fibres into hollow Tubes; to dispose these Tubes filled with their several Humours and variously interwoven with each other into different Organs; and of those Organs connected together in a continued Series and due Situation, to finish so complicated and wonderful a Machine as the Human Body.

15. Nothing was wanting now, but that the immortal Spirit should be sent into its Habitation, to bear the Image of its Creator, and enjoy his Glory. But the Manner wherein this was done we cannot tell: This Knowledge is too wonderful for us. And it is of no use to indulge mere Conjecture, where Knowledge is unattainable.

16. Even

16. Even the preſent Production of the Body by *Generation* is what no man can fully explain. But this we know: The Female *Ovaries*, which hang on each ſide the Womb, contain abundance of ſmall Veſicles, filled with a tranſparent Liquor. It is ſuppoſed, that each of theſe contains in Miniature, all the Parts of an Human Body: That when one of them is penetrated by the Male Seed, it is rarified and expanded thereby 'till it breaks the membranous Shell, and by the *Fallopian Tube*, falls down into the Womb. Here being ſlightly faſtened to the Sides of the Womb, it receives Nouriſhment from the Mother, 'till the Heart is formed, and begins to propel the Blood to the Extremities of the ſtill increaſing Body. When it is come to its full Size, by rolling to and fro, it tears aſunder the incloſing Membranes, and having burſt as it were the Priſon-bars, emerges into light.

The firſt thing that appears of a Fœtus is the *Placenta*, like a little Cloud on one ſide of the outer Coat of the Egg. About the ſame time the *Spine* becomes viſible; and a little after, the *Brain* and *Cerebellum* appear like two ſmall Bladders. Next the *Eyes* ſtand prominent in the Head: then the *Punctum Saliens*, the Heart beating is plainly ſeen, and laſt of all, the Extremities. When formed, the Fœtus lying in the Womb, is almoſt of an oval Figure. For the Head hangs down with the Chin upon the Breaſt. Its back is round. With its Arms it embraces the Knees, which are drawn up to the Belly, and its Heels are cloſe to the Buttocks. Its Head is upward, and its Face toward the Mother's Belly. About the Ninth Month, the Head, which 'till then was lighter, becomes heavier than any other Part. In conſequence of this, the Head falls down in the Liquor that contains it; the feet get looſe, and the face turns toward the Mother's Back. But being now in an uneaſy Poſture, it ſtruggles and brings on the Mother's Throes. [x]

Some

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[x] Mr. *Dodart*, nicely obſerving an Embryo, one and twenty Days old, found the Placenta more than half of the whole; and

Some ſuppoſe, that Millions of Animalcula ſwim in the Seed of Male Animals, which are ſo many Embryos, for which a Receptacle only is provided in the Eggs of the Female. But all agree, that either the Male Seed or the Female Egg, contains all the Parts of the Body, ſo that Generation is no more than the Growth or unfolding of the Parts there delineated. But how thoſe Seeds, whether male or female, are elaborated and prepared, abundantly tranſcends the higheſt reach of Human Underſtanding. *y*

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thence concludes, the younger the Embryo is, the larger is the Placenta in proportion to it: A plain Reaſon, why Miſcarriages, tho' the Fœtus is leſs, are more dangerous than regular Deliveries. For tho' the Embryo in a Miſcarriage makes a way ſufficient for itſelf, it does not make a way for ſo large a Placenta as is to follow it.

The Embryo itſelf was only ſeven lines long, from the top of the Head to the bottom of the Spine where it terminated. The Thighs were not unfolded: they only appeared like two little Warts at the bottom of the Trunk. The Arms made the ſame Appearance on the Shoulders. The Head was one Third of the whole Length. On this were two ſmall black Points, which would have been Eyes. The Mouth was very big, a plain Indication that it fed thereby. There was no Eminence for the Noſe: but two little, almoſt imperceptible Pits for the Noſtrils. Always the younger the Embryo, the bigger the Head is, in proportion to the Body. The Parts nearer the Head are likewiſe bigger in proportion to the reſt.

It weighed leſs than Seven Grains, which is an extraordinary Lightneſs, for a Body ſeven lines long. It was ſo ſoft, that no Part of it could be touched, without making a Change in its Figure. Upon opening it, Mr. *Dodart* diſcovered the Heart and the Right Auricle. All the other Parts in the Thorax and lower Belly, were ſimple Outlines, (all Veſicular) Except a Part on the Left Side, probably the Spleen.

y If the Animalcula of which all Animals are formed are originally in the Male, yet they never can be formed into Animals, without the Egg of the Female.

That all Animals ſpring from Animalcula ſeems probable, from the following Conſiderations:

1. That ſomething may be obſerved in the *Tread* of an Egg even before Incubation, like the rudiments of an Animal, in form of a Tadpole:

2. That after Incubation, all the Parts of the Animal ſuddenly appear, the *Stamina*, which exiſted before being then expanded. After three Days Incubation, the Punctum Saliens of a Chick is diſcovered by the naked Eye. On the fifth Day, the Rudiments of the Head and Body appear, which were before diſcernible by Glaſſes.

Glasses. After thirty Hours, we see the Head, the Eyes, the Heart, and the Carina with the Vertebræ distinct. And by Glasses we see all those Parts after Forty Hours, which the naked Eye cannot discern 'till the fifth Day. Whence it is probable that even the first Discovery of them by the Microscope, is not the Discovery of parts newly formd, but of those that existed before Incubation, tho' not then dilated enough to be visible.

3. That there is a near Analogy between Animals and Plants. Now we know the Seeds of these are only little Plants, folded up in Membranes. Hence we may easily infer, that Animals proceed from Animalcula folded up, 'till they are gradually inlarged and unfolded.

And that these Animalcula are originally in the Seed of the Male is probable. For 1. Numberless Animalcula are observed in the Seed of Animals: 2. We observe the Rudiments of a Fœtus in Eggs fecundated by the Male, but not in others. 3. The Rudiments in the Egg, both before and after Incubation, exactly resemble the Animalcula in the Seed. 4. This gives a rational account of many Fœtus's at one Birth, especially that of the Countess of *Holland*. It accounts also for a whole Cluster of Eggs in an Hen, being fecundated at once: 5. This best suits the Analogy between Animals and Plants. Every Herb, and Tree bears its own Seed, a little Plant of the same kind, which being thrown into the Womb of the Earth, spreads forth its Root and receives its Nourishment from the Earth, but has its Form within itself

Yet that no Animal can be formd without the Egg of the Female, is evinced by the following Considerations.

1. No Animalcule can come forward, if it do not fall into a proper Nidus. So tho' a thousand should fall into one Egg, none of them would come forward, but that which was in the very Center of the *Cicatricula*, or Tread. And perhaps the Nidus necessary for their Formation is so proportioned to their Bulk, that it can hardly contain more than One Animalcule. This is certainly the case in *Oviparous* Kinds. And all the difference between the Viviparous and the Oviparous is, that in the former, the Egg is nothing but the Cicatricula with its Yolk. So that the Fœtus must draw its Nourishment from the Womb. Whereas in the Oviparous, the Egg itself is a kind of Womb, containing all that is needful for the Animal, 'till it is hatched.

2. It is acknowledged, that the Fœtus in the Womb, is not connected with it for a considerable Time after Conception: That it is wholly loose from it, and is only a little round Egg, with the Embryo in the midst, which sends forth its umbilical Vessels by degrees, and at last lays hold on the Womb. Hence it is plain, that the Cicatricula which nourishes the Animalcule, does not spring from the Womb, but only falls into it as a fit Soil, whence it may draw Nourishment for the Fœtus.

Yet there is a Difficulty which presses equally on those, who suppose the Animal to spring either from the Male or Female Parent. It is the Case of Monsters. In a Mule, for instance. The Body is of the Form of the Mare; whereas the Feet, the Tail and the

the Ears, reſemble thoſe of its Sire. If the Male ſupplied the Animalcula, one would imagine the Fætus ſhould always be of the ſame Species with the Male. If the Female, it ſhould be of her Kind: Whereas Monſters are of both: As if the main Part of the Animal lay in the Egg, and the Impregnation only conveyed or changed the Extremities.

Part the Second.

Of Brutes.

CHAP. I.

Of Beasts.

1. *The General Difference of Men and Beasts, as to the Structure and Posture of the Body:*
2. *Their Agreement:*
3. *Their Agreement and Disagreement, as to the Head and Brain;*
4. *The Heart and Lungs;*
5. *The Eyes,*
6. *The Ears, Nose, Teeth,*
7. *The Windpipe:*
8. *Of the Vegetative and Sensitive Motions in Brutes:*
9. *Of the Soul of Brutes:*
10. *Of some particular Sorts of Beasts:*
11. *Some General Reflections.*

1. NEXT to Man in the visible Creation are *Beasts*. And certainly, with regard to the Structure of the Body, the Difference is not extremely great, between Man and other Animals. Only in this, that the *Stature* of Man is erect, and his *Form* more elegant; that

that no Beaſt has the *Feet* of a Man, much leſs a *Hand* ſo admirably fitted for every purpoſe: And laſtly, that no other Animal has a *Brain*, ſo large in proportion to its Bulk as Man. Concerning the prone *Poſture* of their Body we may obſerve two things; the Parts miniſtering thereto, and the Uſe thereof.

I. As to the Parts, it is obſervable, That in all theſe Creatures, the Legs are made exactly conformable to their Poſture, as thoſe of Man are to his Poſture: and farther, That the Legs and Feet are always admirably ſuited to the Motion and Exerciſe of each Animal. In ſome they are made for Strength to ſupport a vaſt unwieldy Body: As in the Elephant, which being a Creature of ſuch prodigious Weight, has its Legs accordingly made like Pillars. In Others they are made for Agility and Swiftneſs. So Deers, Hares and ſeveral other Creatures, have their Legs very ſlender, but ſtrong withal, and every way adapted for quick Motion. In ſome they are formed only for Walking and Running; In others for Swimming too. Thus in the Feet of the Otter, the Toes are all conjoined with Membranes, as they are in Geeſe and Ducks. 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. [a] In others, as Moles, they are made for Walking and Digging: and in others, for Walking and Flying. [b] In ſome they are made more weak, for the plainer Lands; in others,

[a] The Structure of the *Beaver's* Feet is very extraordinary, and demonſtrates this Animal to have been deſignd to live in the Water as well as on Land. For the Hinder Feet are more proper for Swimming than Walking, being joined together by a Membrane like thoſe of a Gooſe. But the Fore-feet are made otherwiſe: the Toes of theſe are not joined together. Nor would it have been convenient: Seeing on many occaſions he uſes theſe like Hands.

[b] The Membranous Wings of a *Bat* are a prodigious Deviation from Natures ordinary Way. And ſo it is in the *Virginian* Flying Squirrel: Whoſe Skin is extended, in the Nature of Wings, between its Fore-legs and Body.

ſtiff and leſs flexible, [c] for traverſing Ice and dangerous Precipices. [d] In ſome they are ſhod with rough and hard Hoofs, in others with only a callous Skin. In the latter, the Feet are compoſed of Toes; ſome ſhort, barely for going; ſome long, to ſupply the place of an Hand; ſome armed with long and ſtrong Talons, to catch, hold and tear the Prey: and ſome fenced only with ſhort Nails, to confirm the ſteps in running and walking.

II. As the Poſture of Man's Body is the fitteſt for a rational Animal, ſo is the prone Poſture of Beaſts, the moſt uſeful to themſelves, and the moſt fit for the ſervice they perform to Man.

2. But there is a wonderful *Agreement* between the Bodies of Men and Beaſts, not only with regard to the Structure, but alſo the Uſe of the ſeveral Parts. How they differ, will be mentioned hereafter.

3 The *Brain* in Them is of nearly the ſame Structure and Conſiſtence as in Man, and undoubtedly performs the ſame Office, ſecreting the Animal Spirits (if ſuch there be) in order to Senſation and muſcular Motion in every Part of the Body. The *Cerebellum* is of near the ſame Shape in all. But the Shape of the Brain neceſſarily varies, according to that of the Head. [e]

4. The

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[c] The *Elk* has Legs ſo ſtiff and inflexible, that they run on Ice without ſlipping. And this is the Way they take in Winter, to ſave themſelves from the Wolves.

[d] The *Goat*, which generally dwells on Mountains and Rocks, and delights to walk on narrow Ridges, and to take great and ſeemingly dangerous Leaps, has the Joints of the Legs remarkably Stiff and ſtrong. Likewiſe the Hoof is hollow underneath, and its Edges ſharp.

[e] It is remarkable, that in Man the Head is of one ſingle Form: Whereas in the four-footed Race, it is as various as their Species. It is in ſome ſquare and large, ſuitable to their Food, Abode and ſlow Motion: in others, it is ſmall, ſlender and ſharp, agreeable to their ſwifter Motion, or to make way to their Food, or Habitation under the Ground. And as to the Brain contained therein, how ſmall is it in Beaſts, in proportion to what it is in Man? Another thing no leſs remarkable is, The *Situation* of the Brain and the Cerebellum. As God has given to Man a lofty Countenance, and has lodged in his Brain an immortal Soul, to behold and contemplate

4. THE *Heart* and *Lungs* in Beasts are of the same Structure, with the same Apparatus of Veins and Arteries as in Men. We cannot therefore doubt but the Blood circulates in Them, and Nutrition is performed as in Us. Their Food also being dissolved in the Stomach, [f] is conveyed by the Lacteals to the *Receptacle of the Chyle*. To the Fore-part of this (in Men, the Upper Part) joins the *Thoracic Duct*, which extending

heavenly things, so as his Face is erect, his Brain is set in an higher Place, above the Cerebellum and all the Sensories. But in Brutes, whose Face is prone to the Earth, and who are not capable of Speculation, the Cerebellum, which ministers merely to animal Life, is placed above the Brain. Also some of the Organs of sense are placed, if not above the Brain, at least on a level therewith.

ANOTHER very great Convenience in this Position of the Brain and Cerebellum is; In the Head of Man 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 Beasts, whose Heads hang down, the Base of the Skull makes a right Angle with the Horizon. By which means the Brain is beneath, and the Cerebell above. And lest the Cerebellum should hereby be liable to frequent Concussions, an admirable Provision is made, by that strong Membrane, the *Dura Mater* closely incompassing it. Beside this, it is guarded in some Species with a strong, bony Fence. In the Hare, the Coney, and several others, a Part of the Cerebell is on each Side within the Os Petrosum. So that its whole Mass is, by this double Stay, firmly contained within the Skull.

[f] BUT some Beasts have more Stomachs than One. And some have the peculiar Property of *chewing the cud*. The Food after it has been swallowed, is returned to the Mouth, where is is chewed over again at leisure.

NOT that this is altogether peculiar to Beasts. There have been Instances of Men who had this Property. Dr. *Slare* gives us a particular account of One whom he knew at *Bristol*. "He begins, says he, to chew his Meat over again, within a quarter of an hour after Meals. This Chewing, after a full Meal, lasts an Hour and an half. If he goes to bed soon after a Meal, he cannot sleep, 'till the usual Time of chewing be over. The Victuals returned taste more pleasantly than they did at first. Bread, Flesh, Cheese and Drink are of much such a Colour, as they would be, if mixt together in a Mortar. His Victuals lie heavy on his Stomach, 'till they have passed this second Chewing. He was thus ever since he can remember. His Father does the same, but in small Quantities. What a mercy is it, that we have not more such Instances? For how much of our precious time would it consume?

thro' the Length of the Thorax, ends in the Vein called in Beaſts *Cruralis Anterior*. The remaining Part of the Circulation, is performed in Them as in Men.

5. The Situation, Number and Conformation of the *Eyes* in various Animals, is wonderfully adapted to their various Circumſtances. In ſeveral the Eye looks chiefly forward, but ſo as to take in nearly the Hemiſphere before it. In others, the Eyes are ſo placed, as to take in nearly a whole Sphere. In ſome they are ſo fixt as to look chiefly behind, ſo that they ſee their Enemy following them. So in Rabbits and Hares: Whereas in Dogs they are more forward, to look after their Prey.

Generally the *Head* is moveable for the ſake of the Eyes, and the Eyes themſelves moveable every way. Where it is not ſo, other Expedients are found, to anſwer the ſame End. Thus in ſome Creatures the Eyes are ſet at a diſtance from the Head, to be moved this way or that: As in Snails, whoſe Eyes are fitted to the End of their Horns, or rather of the Optic Nerves which are ſheathed therein. In other Creatures whoſe Head and Eyes are immoveable, this is made up by the number of Eyes. So Spiders, which cannot move their Head, have four, ſix or eight Eyes, all placed in the Front of the Head, (which is round) like a Locket of Diamonds.

Many Animals have Muſcles to move the Eye and obvert it to the Object. Fiſhes have none; but for amends they have many little Protuberances finely ranged on their large, bulging Eyes, by which numberleſs Rays of Light are deflected from Objects above, beneath and on either Side. Yea, ſome hundreds of theſe Protuberances are curiouſly ranged on the convex Eye of a Fleſh-fly.

Scorpions have above an hundred Eyes; an Ephemeron-fly, full two Thouſand.

In other Creatures, which have only two Eyes, the Want of Motion therein is ſupplied, by their Eyes protuberating into Hemiſpheres, each being a vaſt number of Segments of a Sphere.

The

THE Eyes of a Cameleon reſemble a Convex Glaſs ſet in a round Socket, which he turns backward and forward without ſtirring the Head, and commonly One a contrary way to the other.

LASTLY, Moles, living under ground, have not ſo much need of Eyes as other Creatures. Yet they have Eyes, but exceeding ſmall, far in the Head, and covered with ſtrong Hair. When they are above ground they can put them forth beyond the Skin, and draw them back at pleaſure.

ANOTHER Circumſtance, relative to the Eye is highly remarkable. As we uſe various Apertures to our Optic Glaſſes, ſo Nature has made a far more compleat Proviſion, to admit enough, and not too much Light, into the Eyes of Animals, by the Dilation and Contraction of the Pupil. And this in divers Animals is of divers Forms, according to their peculiar Occaſions. In ſome it is round, particularly in Man, 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 Animals it is of a longiſh Form, in ſome tranſverſe, with its Aperture large, an admirable Proviſion for their ſeeing ſide ways, and thereby avoiding many Inconveniences, as well as an help for gathering their Food on the Ground, whether by day or night. In others, that Aperture is erect, and alſo capable of opening wide and ſhutting cloſe. The latter ſerves to exclude the bright light of the Day, the former to take in the faint Rays of the Night: Thereby enabling them to ſee and catch their Prey, when there is no Light diſcernible to Us.

THUS Cats can ſo cloſe their Pupil, as to admit but a ſingle Ray of Light. And again, by throwing all open, they can take in all the fainteſt Rays: Which is an incomparable Proviſion for Creatures that have occaſion to watch their Prey both by day and night.

BUT beſide this, in Cats and other nocturnal Animals, there is a ſort of Carpet at the bottom of the Eye, which gives a kind of Radiation on the Pupil, thereby enabling them to ſee in the Dark.

To

To preſerve this tender Organ, many Creatures have a Membrane, which is not commonly perceived, wherewith they can at pleaſure cover the Eye, without too much hindering the Sight, being both tranſparent and ſtrong, ſo that it is a kind of moveable Cornea.

PROVIDENCE is conſpicuous in furniſhing Frogs with this. For as they live in watry Places, which generally abound in Plants that have ſharp Edges or Points, and as the Frog goes on, not by Walking but by Leaping: If he were not ſo furniſhed, he muſt either ſhut his Eyes, and ſo leap blindfold, or run many riſques by leaving them open. But this Membrane guards the Eyes, without blinding him. And as ſoon as the occaſion for it is over, he draws it back into a little Cell. Many Birds alſo, as they muſt fly between trees and Buſhes, are provided with the ſame Membrane.

6. THE Comparative Anatomy of the *Ear*, yields abundant Inſtances of the Creator's Wiſdom. In Birds the Outward Ear is cloſe and covered, not protuberant, as that would obſtruct their Flight. In Beaſts, its Form is agreeable to the Poſture and Motion of the Body, but admirably varied in the ſeveral Species, according to their various Occaſions. In ſome, as the Hare, it is large, open and erect, by which means that timorous, helpleſs Creature, is warned of the leaſt Approach of Danger: In others it is covered, to keep out noxious Bodies. In thoſe which are forced to mine and dig for their Habitation, it is ſhort and lodged deep and backward in the Head. Thus Moles have no Auricle at all. but only a round Hole, between the Neck and Shoulder. And this is cloſed with a little Skin, which opens and ſhuts like an Eyelid. The Sea-calf alſo, as well as Lizards, and Serpents, have no Outward Ear. And the Tortoiſe, with moſt kind of Fiſhes, have the Paſſage quite covered over.

BUT among all the Varieties in the Structure of this Organ, none are more remarkable than thoſe of the *Paſſage* into the *Os Petroſum*. In an Owl, which perches upon a Tree or Beam, and hearkens after the

the Prey beneath her, it comes farther out above than below, for the better reception of Sounds from beneath. In a Fox, which ſcouts under the Prey at rooſt, it comes farther out below than above. In a Pole-cat, which hearkens ſtrait forward, it is produced behind, for the taking a forward Sound: Whereas a Hare, whoſe Enemy comes behind, is ſupplied with a bony Circle, directed backward: By means of which ſhe receives diſtinctly the ſmalleſt Sound which comes that way.

The more accurate the Senſe of *Smelling* is in any Creature, the longer are the Laminæ in the Noſtrils, and the more in number, folded up, and crouded together, to contain more nervous Filaments, and to detain the odoriferous Particles, in their Windings and Turnings. An admirable Proviſion this, for the Good of many Creatures, the chief Acts of whoſe Lives are performed by the Miniſtry of this Senſe. In Inſects and many other Creatures, it is of great Uſe, in helping them to proper Places for hatching their Eggs, and breeding up their Young. And moſt irrational Animals, Beaſts, Birds and Reptiles, do by their Smell find out their Food. With what Sagacity do ſome of them diſcover it, in the midſt of Mud and Dirt? How curiouſly do others pick and chuſe ſuch Plants as afford them wholeſome Food, (perhaps Medicine too) avoiding ſuch as tend to hurt or deſtroy them? And all this principally by the Smell, together, with its near Ally, the Taſte.

The various Form of the *Teeth* in various Creatures, is another Inſtance of the Divine Wiſdom. How curiouſly are they adapted to the peculiar Food and Occaſion of each Species? Thus in the Rapacious they are fitted to catch and hold their Prey; in the Herbaceous, to gather and chew Vegetables. In thoſe which have no Teeth, as Birds, the Bill ſupplies that Defect; together with their additional Stomach. And it is a remark which hardly fails, All ſuch Animals as have Four Stomachs, have no Teeth at all.

There are great Varieties in the Teeth of other Animals. Trout have Teeth upon their Tongues; Cod-

Cod-fish at the bottom of their Gullet. Crocodiles have three Rows of Teeth on the same Jaw, Sharks, four or five; Sea-devils, so called, have several Rows of moveable Teeth.

7. The Variation of the *Wind-pipe* in various Creatures is likewise observable, as it is necessary for that of the Voice. In an Hedge-hog, which has a very small Voice, it is hardly more than membranous. In a Pidgeon, which has a low, soft Note, it is partly membranous, partly cartilaginous. In an Owl, which has a good, audible Note, it is more cartilaginous. But that of a Jay (as of a Linnet) has Bones instead of Cartilages.

The Rings of the Windpipe likewise are fitted for the Modulation of the Voice. For in Dogs and Cats, which use a great many Notes, they are (as in Man) open and flexible; whereby all or any of them is more or less dilated or contracted, in order to a deeper or shriller Note. But they are One entire Ring in the *Jopan* Peacock, which uses one single Note.

8. As to the *Motions* of Brutes, it is not easy to conceive, that even those of the *Vegetative* kind, can be the mere mechanical Effects of Matter, however modified. Much less can we conceive this of their *Sensitive* Motion: For we have not the least Reason to doubt, but the same Impressions of External Objects, raise the same Perceptions in them, as in Us. No question they see, and hear, and smell, and taste, and feel in the same manner as Men.

9. We cannot therefore deny, that there is something in Brutes, which perceives the Impressions made by outward Objects; And that they perform a thousand Actions, which can never be explained by mere Mechanism: Those in particular which spring from what we call *Instinct*, as the feeding and tending their Young, the building their Nests and preparing their Habitation, upon or in the Earth.

It is true, some things in Brutes, as well as in Men, may be mechanically accounted for. But others cannot: So that we are constrained to own, there is in them

them alſo ſome ſuperior Principle, of what ever kind it be, which is endued with Senſe, Perception and various Appetites. For from their Outward Actions we may as eaſily learn, as we could from thoſe of a Man born deaf and dumb, that there are in this Principle or *Soul* two different Faculties: That of *perceiving* or *knowing*, anſwerable to our Underſtanding, and that of *deſiring* and *ſhunning*, anſwerable to our Will. That this Principle is immaterial appears, from this ſingle Conſideration, It has a Power of *Self-motion*; which no Matter can have, being wholly and eſſentially paſſive.

10. It is not my deſign, to enumerate the ſeveral Species of Beaſts. But it may illuſtrate the Wiſdom of the Great Creator, to give ſome account of a Few, ſeveral of which are not ſo commonly known.

The largeſt Land-Animal in the world is an *Elephant*. They are found only in the South of *Africk*, and in the *Eaſt-Indies*, and are generally of a dark colour. Their Eyes are like thoſe of a Hog. They bend their Fore-legs when they ſleep; but cannot bend their Necks or turn their Heads. Their Trunk reaches to the ground, which they can open and ſhut, and take up any thing, even a Pin or a grain of Muſtard-Seed. With this they feed themſelves, and in their Trunk their chief Force lies. At the Corners of their Mouth grow two large Teeth, ſix or ſeven foot long in the Male, but not above one in the Female. They feed on Graſs, Nuts and other Vegetables.

Some of them are twenty feet in compaſs, and near fourteen high. They ſeem to have more Senſe than any other Brute, and are capable of Fidelity and ſtrong Affection: Particularly to their Companion: So that neither the Male nor Female is ever known to make a Second Choice.

The Female goes Seventeen Months with her Young: They are fifty or ſixty Years before they have their full Strength, are in full vigour at much about an Hundred, and live two or three Hundred Years.

A *Rhinoceros*, next to the Elephant, is the moſt extraordinary Animal in the *Indies*. He is equal in height

height to a middling Horſe, but is ſhaped like a Wild boar: Only he is much larger, and has ſhorter Legs. His Skin is without Hair, but ſo thick and hard, as to be almoſt impenetrable. It is ſo full of Scratches and Scabs, that at a diſtance, they may well be taken for Scales. On his Noſe he has a Horn of a dark, brown Colour, which bends backward, and is often two foot long. He has another Horn a little above this, which never exceeds ſix inches. His Eyes are exceeding ſmall, and he only ſees ſtrait forward: Therefore he always runs in a ſtrait Line, tearing up whatever ſtands in his way. With his Horn he throws Stones over his head to a great diſtance, and even tears up trees by the roots. He grunts like an Hog; but when he purſues his Prey, he makes a terrible Noiſe. He feeds much on the Boughs of ſuch trees as are thick ſet with tough and ſtrong thorns. But he prefers the Fleſh of Animals, when they come in his way. He has a natural Antipathy to the Elephant, which places all his Safety in Flight. He ſeldom attacks a Man, unleſs he is dreſt in Red, a Colour to which he has a mortal Averſion. When he overtakes him, he lifts him by the twiſt on his Horn, and throws him over his Head with ſuch violence, as breaks all his bones, ſo that he never fails to find him dead when he comes to devour him. This he does by licking all the Fleſh from his Bones, with his Tongue (for he has no Teeth) which is like a File.

Another Native of the *Eaſt-Indies* is the *Camel*, one of the moſt ſerviceable Animals in the World. He kneels down to receive his Burden, and riſes when he hath his accuſtomed Load. If he feels himſelf over burdened, he will not riſe, but cry till part of it is taken off. One of them will carry a thouſand or twelve hundred weight, forty miles a day, for thirty or forty Days together. They have no Teeth in the upper Jaw. They will travel forty Hours, without either Meat or Drink: And nine Days without Drink: They have Two Stomachs admirably contrived for this Purpoſe. The Gentleman who diſſected One at *Paris*, found in his Second Stomach ſeveral Square Holes

Holes, which were the Orifices of about Twenty Cavities, made like Sacks, placed between the two Membranes which compose the Substance of the Stomach. And in these Reservoirs he contains Water enough, to serve him for so many Days.

The Bunch on his back is not Flesh, much less Bone, but mere Hair. And when this is prest close down, he is no more hunch-backed than a Swine. They subsist on very little, which enables them to travel thro' those vast and barren Deserts. How wise is He who caused these to be Natives of those Countries, where such Creatures are absolutely necessary? A farther Instance of this is, that the *African* Camel, which has still greater and more uncouth Journeys to take, is larger and stronger, and capable of carrying heavier burdens than those of *Asia*.

Another wonderful Property of Camels is, that of foreseeing the poisonous Winds, which kill in a moment. A little before those come, they run together and cry, and hide their Noses in the Earth. And as soon as they are past, they lift up their heads, and continue their Journey.

The *Dromedary* in most respects resembles the Camel: Only it is of a slighter make, and instead of one Bunch on its Back, has two, about six Inches in height. It goes frequently forty Leagues a day: So that altho' it cannot carry above Six Hundred weight, yet its Swiftness atones for its Weakness. Its Feet are soft as a Spunge, and are not hurt, either by Stones or Sand. And (what is an excellent Providence) they travel best, and have the greatest Spirits in the hottest Weather.

A creature no less remarkable, but in a quite different way, is the *Castor* or *Beaver*. This Creature is about 4 foot long, and 15 inches broad. He is covered with two Sorts of Hair, one long, the other a soft Down. The Down, an inch long, is properly his Cloathing, being extremely fine, and close laid upon the Skin. The long Hair is spread over all to preserve it from Dirt and Wet.

WHETHER Male or Female, it has two Bags under its Belly, which contain a liquid Subſtance, that congeals in Air, and affords an excellent Medicine, which we call *Caſtoreum*.

HE has ſtrong Teeth riveted faſt in his Jaws, to cut wood, as well as chew his Food. His Fore-feet are like thoſe of an Ape or Squirrel, to hold what he eats in his paws. And with theſe he digs, ſoftens and works the Clay or Loam for his Habitation. His hinder Feet are remarkably formed, more proper to ſwim than to walk with, the five Toes being joined together like thoſe of a Gooſe, by a ſtrong Membrane. His Tail is long, flattiſh, and covered with Scales, and conſtantly lubricated with Oil: becauſe being an Architect from his Birth, he uſes his Tail as a Hod, to carry his Clay or Mortar, and as a Trowel, to ſpread it into an Incruſtation. Meantime the Scales preſerve it from being hurt by the Burden; and the Oil which he ſqueezes from his Bags, and rubs on with his Snout, from the noxious Air and Water.

As they like to live together, they chuſe a Situation near ſome Rivulet. They firſt build a Cauſeway, in which the Water may riſe level with the firſt Story of their Habitation. This is built of wood and clay, 12 feet thick at the bottom, deſcending in a ſlope on the ſide next the water. The other ſide is perpendicular: the top of this is about two foot broad. They cut their wood, tho' as thick as one's thigh, into pieces, from 2 to 6 foot long, drive them into the earth with their teeth, and lace them together with Boughs, cloſing all the Openings within and without with a ſtrong Plaiſter made of Clay. If the Water increaſe upon them, they raiſe their Wall higher. Knowing their Meterials are more eaſily brought by Water than by Land, they watch its Increaſe, to ſwim with Mortar on their Tails, and Stakes between their teeth to the place where they build. When the Cauſeway is finiſhed, they begin their Apartments, which are oval, and divided into three Partitions, one above another. But the Walls of theſe are perpendicular,

cular, and only two foot thick. All the Wood that projects, they cut off with their teeth: and rough-caſt both the out and inſide of the Work, with a mixture of Clay and dry Graſs. The firſt Partition, being below the level of the Dyke, is full of Water: for they love to have their hinder Part hanging in the Water. The other two are above it, ſo that if the Water aſcend, they may aſcend proportionably.

At the bottom of their Building they ſtrike out two Openings to the Stream; One leads to the place where they bathe: the other to that where they eaſe nature.

They aſſociate, ten or twelve together; and proportion their houſe to their number. When all is finiſhed below, they vault the Top or Roof in an oval Form.

In Summer they feed on Fruits and Plants: In Winter, on Willow, Aſh or other Wood. This they collect and ſtore up in time. They cut Boughs from 3 to 6 foot long; the large pieces are brought to the Magazine by ſeveral Beavers, the ſmaller, by one alone; but they take different Ways, each having his Path aſſigned, to prevent the labour being interrupted. They build up their Pile with much Art, which is proportioned to their number. A Square Pile of thirty feet, about ten foot deep, ſerves for Ten Beavers. But the Wood is not piled up in one continued Heap: but the Pieces are laid acroſs one another, with Cavities between, for the Conveniency of drawing out what they want. They always uſe firſt the Parcel at bottom, which lies in the water. And when it is taken up for uſe, they cut this wood into ſmall pieces, and convey it to their Apartment, where the whole Family come and receive their ſhares.

Another Animal of a very peculiar kind is an *Ichneumon*. It is of the Weeſel kind, with a longer and narrower Body than a Cat, ſomething approaching to the Shape and Colour of a Badger. Its Noſe is black and ſharp, like that of a Ferret. Its Colour is a yelloviſh Grey. Its Legs are ſhort and each of its

Feet has five Toes. Its Tail is very long; its Teeth and Tongue much like those of a Cat. It is a very cleanly Animal, very brisk and nimble, and of great Courage. It will engage a Dog, and will destroy a Cat, by three Bites on the Throat. But it is quite inoffensive to Mankind, and is kept tame in *Egypt*, running about the House, destroying all Vermin, and playing tricks, like Spaniels.

When wild, he cannot overtake any nimble Animal. But he makes this up by Assiduity. His Legs being short, he is not much seen: but he has a way of concealing himself yet more, by crawling with his Belly close to the Ground, which he does all day long. But on the least Noise (for his Hearing is exceeding quick) he starts up erect on his hinder Legs. If the noise is made by any Reptile, Bird or small Beast, he observes where about it is, places his Nose directly in a line with it, and begins to move toward it. He is silent and slow, but constant in his Approach; often stopping, to hear, or look forward, and know exactly where the Creature is: When he is got within about five feet, he stops. Nature, which has denied him Speed, has given him Strength to leap, beyond most other Creatures. Having taken good Aim, he springs from the Place and falls directly on his Prey. Thus he deals with Beasts and Birds. But to Serpents he gives chase, and to avoid their Bite, always seizes them by the Neck.

Gesner tells, that the Ichneumon is not only an Enemy to Serpents themselves, but to their Eggs also; which he hunts after continually and destroys, tho' he does not feed upon them. How mercifully has God given this Animal in the Countries where those terrible Reptiles most abound! And which, without this Provision, would be so over-run with them, as to be uninhabitable.

The *Chimpanaze* is an Animal found in *Angola*, nearly approaching to the Human Figure; but of a fierce disposition, and remarkably mischievous. In the Year, 1738 one of these Creatures was brought over

over to *England*. It was about twenty Months old. (The Parent had it in her Arms when she was killed: She was five foot high.) It was of the Female Sex, naturally walked erect, was hairy on some Part of the Body and Limbs, and of a strong, muscular Make. It would eat any coarse Food, but was very fond of Tea, which it drank out of a Cup, with Milk and Sugar, as we do. It slept in the manner of the Human Species, and its Voice resembled the Human, when People speak very hastily; but without any articulate Sounds. The Males of this Species are very bold, and will fight a Man, tho' he is armed. It is said, they often assault and ravish the Negro Women, when they meet them in the Woods.

THERE is another strange Species of *Monkey* found in the *West-Indies*, of the Size of a Fox. Its Face is raised high, its Eyes black and shining, and its Ears small and round. His Hairs are so nicely disposed all over the Body, that he appears perfectly smooth: And they are much longer under the Chin, so that they form a kind of Beard there.

THESE are found in great Numbers in the Woods, and make a loud and frightful Noise. But it is very common for One only to make a Noise, and the rest to form a mute Assembly round him.

Margrave says, "I have frequently seen great Numbers of them, meeting about Noon: At which time they formed a large Circle, and One placing himself above the rest, began to make a loud Noise. When he had sung thus by himself for some time, the rest all remaining silent, he lifted up his Hand, and they all instantly joined in a sort of Chorus. This intolerable Yell continued, till the same Monkey who gave the Signal for their beginning, lifted up his Hand a second time. On this they were all silent again, and so finished the Business of the Assembly."

THE *Opossum* is about the Size of a Cat, only more corpulent, and its Legs more robust. It is of a kind of Chesnut Colour, very bright and glossy. Its Head is long, and terminates in a Snout, somewhat like a

Hog's. The Tail is long, and much reſembles that of a Rat, which it twiſts about with a ſurprizing Facility. The Legs being ſhort, the Body is carried at no great Diſtance from the Ground. On the Belly of the Female, a Bag is formed by the Skin being doubled. It is not very deep, the cloſed Part being toward the Upper Part of the Body, and the open Part toward the lower. This is covered with Fur, like the reſt of the Body, ſo that it is not very obvious to the ſight.

It is an harmleſs, but likewiſe a defenceleſs Animal: And the Young of no Creature, are produced ſo ſmall and tender, in reſpect of the Parent Animal. Therefore that Bag is extremely uſeful to them. They are cheriſhed there by the Warmth of the Parent's Body, 'till toward Noon: Then they go abroad, till at the firſt Warning by the Evening-Cold, they retire into their Lodging again. Nor is this all the Help which it affords them. For as the tender young of the Opoſſum are delicate Morſels, they would be expoſed to the Rage of many Animals both by Day and Night. But the Body of the Parent is a ſafe and ready Receptable for them. By day ſhe is as watchful over her Brood, as an Hen over her Chickens. She is alarmed at the ſlighteſt Appearance of Danger, and by a Noiſe, which they well underſtand, inſtantly calls them into her Bag. At Night ſhe conſtantly takes them in, and conſults for herſelf and them in a very uncommon manner. There are thoſe among the Devourers of her young, who will climb a Tree after her. Therefore when ſhe has climbed, to ſecure herſelf and her young ſtill farther, ſhe twiſts her Tail twice round ſome ſmall Bough, and then drops from it. There ſhe hangs with her Head downward: And whenever ſhe pleaſes ſhe recovers the Branch with her Feet by a Swing, and looſening her Tail, walks about as uſual.

To enable her thus to hang, there are *Spikes* or Hooks in the under ſide of the Vertebræ of the Tail. Indeed in the firſt three Vertebræ there are none; for there

there they would be of no use. But they are found in all the rest: They are placed just at the Articulation of each Joint, and in the middle from the Sides. Nothing could be more advantageously contrived. For when the Tail is twisted round a Bough, these Hooks easily sustain the Weight. And there is no more labour of the Muscles requised, than just to bow or crook the Tail.

I would mention only two Creatures more, very extraordinary, and yet but little known. *The Glutton* is frequent in the Forests of *Germany*. It is rarely seen twice of the same Figure. It is of the Weesel-kind, and is, in its middle State, about the Size of a turn-spit Dog. Its Body is long, its Legs short. Its Colour is Brown, with a tinge of reddish; but its Breast and Belly are white. The Tail is long and bushy; the Head small and sharp at the Nose. The Teeth are exceeding sharp, and the Claws sharper than almost in any Creature.

Thus

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§ It goes for current, that the *Jackal* discovers the Lion's Prey: that each of these retains one of them, and having satiated himself, lets his dependent feed on the offals of his repast.

But the truth is, there are great numbers of Jackals in some Woods, and when one of these sees a Stag or other large Beast, which is not a Beast of Prey, he sets up his Cry, which is like that of a Hound, and follows it. As he continues his Cry, the other Jackals that are within hearing follow likewise. And could the Creature outrun those that began the chase, there is a continual supply; so that it cannot escape. When they have run it down, they worry it at once, and it is devoured almost in an instant. After this the Jackals disperse, 'till another Cry invites them.

They hunt generally in the night, and in the parts of the East, where they are most frequent, there never is a night but they are heard, in one part or other of the Woods. The other Beasts of prey understand the Sound; and frequently profit by it. If a Lion, Tyger or Leopard happens to be near, he hears the Cry, and stands upon the watch. These large Animals are all very swift, but they are lazy, and never make long pursuits. If the Creature pursued be far off, and run another way, they never trouble themselves about it. But if it be near, or if it run toward the place where the Lion is, he will dart out upon it as it goes by. And the little Animals that hunted it down, must stand by, and be content with what their Master leaves.

This is the moſt hungry Animal in the world, but is ill provided for catching its Prey. Moſt Creatures can outrun it, and itſelf can ſcarce run away from any thing. But what he wants in Swiftneſs, he has in Climbing, which he performs to Admiration: Its ſharp Claws enabling it to run up a tree, as faſt as on the Ground. Its uſual Place is ſome large and ſpreading Oak, choſe both for Safety and for catching its Prey. He ſquats all day on ſome large Branch; and if nothing offers below, he preys in the Night on whatever Creatures he can find on the Tree above. Many Birds rooſt on ſuch Trees, which he climbs ſoftly to and ſeizes, and devours. But his favourite Food is larger Animals. He will lie many Days on a Slanting Bough; and when any which he likes comes underneath, he drops down upon them. Hares and Rabbits ſeldom eſcape him; but he chuſes rather a Goat, or any Creature of that Size. When one of theſe comes under the tree, he creeps from bough to bough, till he comes juſt over it, and then drops down. He always contrives to faſten on the Neck. In an inſtant, he fixes both his Teeth and Claws, lies acroſs the Neck, near the Shoulders. Here he is ſecure; and while the poor Creature runs with all its ſpeed, he is feeding on its fleſh. At length it drops, and he continues eating in the ſame ravenous manner, till from a mere Skeleton, his Back becomes round, and his Sides ſwelled out like a tun. Still he continues to eat, till he can eat no longer. He too drops down, and lies panting for Breath. He reſembles a dead Carcaſe, ſwelled and ready to burſt with lying in the Sun: and being unable to move for a long time, is frequently deſtroyed, and ſometimes periſhes without an Enemy.

The God of Nature ſeems to have formed the *Sloth*, to repreſent to us in a ſtrong Light, that odious and deſpicable Vice, from which it takes its Name. Its Body is ſhort, its Head ſmall, and it has ſcarce any Tail. Its Fur is long, thick, and of a greyiſh Green, ſo that when ſeen on the Bough of a tree, it appears only like an Excreſcence, or a Cluſter of Moſs. It is about the Size

of

of a Cat, but the Legs are ſhort, as is the Neck: and its long and thick Covering, renders it ſo Shapeleſs, that it ſeems only an irregular Lump of living Matter. Its little and remarkably ugly Head ſtands cloſe between the Shoulders. The Face has much of the Monkey-Aſpect. Its ſmall and heavy Eyes, are always half ſhut, and it has no Appearance at all of any Ears. Its Feet are flat, and very narrow, but armed with ſharp Claws, for laying hold on the Bark of a Tree, by ſtriking deep into it.

He rarely changes his place; and never, but when compelled by abſolute Neceſſity. As upon the Ground it would be a Prey to every other Animal, ſo its conſtant Reſidence is on a Tree. Here it is ſafe from all Animals but thoſe who climb theſe Trees, for the Birds that rooſt on them. The Leaves and tender Part of the tree are its Food, and ſerve it for Drink as well as Meat. It never moves to another Branch, till it has devoured all the Nouriſhment upon that where it is ſtationed: Nor from one Tree to another, till the firſt is wholly withered and waſted.

It is obſervable, the *Sloth* always aſcends to the top of a Tree, only baiting as he goes, before he begins his Deva ſtations. And this is doubtleſs from the Inſtinctive Guidance of Nature. For was it to begin eating upward, when it had devoured all, it would have to climb down from the top of a dead tree, and would be half ſtarved in the Journey. But this is not all. The Havock which one Sloth makes on the largeſt Tree is eaſily ſeen. For he eats not only the Leaves, but all the Buds and Bark, leaving only a dead Branch: So that unleſs the ſame thing might happen by accident, this would betray the Creature. It does ſo happen; and Trees then put on the ſame Form, as when they are left by the Sloth. But they always die at the Top firſt, and ſo gradually downward. This Animal therefore, wonderfully taught, begins its havock at the top. As it feeds, the tree decays; but its Decay is in the Courſe of Nature. The Decay ſpreads downward; and when he has eaten the laſt of his Proviſion, He is near the Ground,

Ground; and has only to walk away to another Tree. But if it is at any diſtance, his Motion is ſo ſlow, that he grows quite lean in the Expedition.

As the Sloth brings forth her Young in the hollow of a tree, ſo is ſhe led by the ſame wonderful Inſtinct, to conduct them to the topmoſt Branches, as ſoon as they crawl out. When ſhe is big with young, ſhe climbs ſome old, hollow tree; and having fixt on a convenient ſpot for her young, ſhe climbs to the very higheſt Bough, and there feeds faſter than uſual. When ſhe is full, ſhe deſcends with unaccuſtomed haſte, and brings forth One, two, or three young ones. It is well ſhe is full fed; for ſhe is to ſupport theſe with her Milk, till they can crawl out, without having any Supply herſelf. She is round and fleſhy when ſhe retires for this purpoſe, but a mere Skeleton when ſhe comes out. She crawls as well as ſhe can, to the Part where ſhe left off feeding, and her young follow her. Nor will ſhe touch any in the way, however both her Hunger and Lazineſs prompt her to it.

It is the moſt timerous of all Creatures. And with Reaſon; for it can neither fight nor fly. While it is journeying on the ground, the tread of an human Foot, ſhakes the Earth enough to put it into terrors. It trembles: The Head is turned about every way, and the Mouth is opened, to cry like a young kitten.

Insignificant as the Creature is, there is a ſpecial Providence in the Formation and Care of it. Not deſigned for Walking, its Claws enable it to climb, and then to hold faſt in its Station. Helpleſs as it is, the univerſal Provider has aſſigned it a Place of Safety, where it finds Plenty of Food; and as it cannot eaſily ſeek for Drink, it has no need of any. To render it the leſs obnoxious to Purſuit, its Colour ſecures it even from View: And its amazing Inſtinct of feeding from the top to the bottom, proves a *deſigning* and *directing* Hand.

Before I proceed to ſome General Reflections upon Beaſts, I beg leave to take notice of one Circumſtance, relating to ſeveral Species of them, which is very ſtrange, tho' very common. The *Horns* of many Animals fall off

off every Year, and new ones come in their place. Our Deer drop them in *March*, and the new Horns are full grown by the *July* following. We may very juſtly rank this, among the moſt wonderful Phænomena of Nature, which yields nothing analogous to the Growth of ſuch hard, ſolid Bodies, of ſo great a bulk, in ſo ſhort a time. Many idle Opinions have been maintained, concerning the Cauſe of their falling off. The truth ſeems to be this: They are a ſort of Vegetables, growing on Animals, as the Nails and Hair on Man. And there is ſome Analogy between the Growth of them, and that of Branches and Leaves in Trees. Trees commonly drop their Leaves in Autumn, becauſe the nouriſhing Juice flows into them no longer. And at certain Periods, theſe Parts of the Animal drop off, becauſe the Blood and Juices ceaſe to flow into them. At this time the hollow Part at the Root of the Horns grows hard, and the Pores, thro' which the Juices paſſed, grow up. And as no more Nouriſhment can then be carried to the Horn, it decays and falls off. 'Tis probable this Stoppage of the Pores happens, as ſoon as the Horns are at their full Growth. But they are ſo fixt to the Head that it takes a long time for them to looſen and fall. Whereas in Leaves, their Stalks are ſo tender, that when the Juice ceaſes to flow, they preſently wither and fall.

The Analogy between the falling off of Deer's Horn, and the falling of Leaves and ripe Fruit, from the Tree, will receive Light from obſerving the Proceſs of Nature, in the latter Caſe. If the Stalk from which a ripe Orange has fallen, be compared with that part of a Deer's Forehead, from which a Horn is juſt fallen, it will plainly appear, that Nature has operated by the ſame Laws in both. The young Horns while yet ſoft, are full of Blood Veſſels; and if cut off, eſpecially near the Head, bleed violently. By theſe Veſſels they are ſupplied with Nouriſhment for their Growth. But theſe dry up, when there is no farther occaſion for them. And hence it is, that no ill Symptoms attend the falling off of theſe Parts, when full grown.

So

So far we may give a probable Account. But who can account for this, That if a Stag be caſtrated while he is ſo young as not to have Horns, he will never have any: And if caſtrated afterward, while his Horns are on, he will never caſt them?

16. It remains only, to add a few Reflections. And firſt, What admirable Wiſdom is diſplayed, in the *Motion* of various Animals ſuited to their various Occaſions? In ſome their Motion is ſwift, in others, ſlow, and both diverſified a thouſand Ways.

And firſt, for ſwift or ſlow Motion. This is exactly proportioned to the Occaſions of each Animal. *Reptiles* whoſe Food, Habitation and Neſts lie in the next Clod, Plant, Tree or Hole, or which can bear long Hunger, need neither Legs, nor Wings, but their vermicular Motion anſwers all their Purpoſes.

Beaſts, whoſe Occaſions require a larger Room have accordingly a ſwifter Motion: And this in various Degrees, anſwerable to their Range for Food, and the Enemies they are to eſcape from.

But as for *Birds*, who are to traverſe vaſt Tracts of Land and Water, for their Food, Habitation, breeding their Young, and for Places of Retreat and Security, from various Inconveniences: they are endued with the Faculty of Flying; and that ſwiftly or ſlowly, a long or ſhort time, according to their Occaſions. In all this the Wiſdom of God appears, ordering all things well.

Again. How admirable in the Motion of all Creatures, is the neat, geometrical Performance of it! The moſt accurate Mathematician cannot preſcribe a nicer Motion than that they perform, to the Legs and Wings of thoſe that fly or walk, or to the Bodies of thoſe that creep. Neither can the Body be more compleatly poiſed, for the Motion it is to have in every Creature. From the largeſt Elephant to the ſmalleſt Mite, the Body is exactly ballanced. The Head is not too heavy, nor too light for the reſt of the Body, nor the reſt of the Body for It. The Bowels are not looſe, or ſo placed as to ſwag, over-balance, or overſet the

the Body: but well-braced, and accurately distributed, to maintain the Equipoise of it. The Motive Parts also are admirably well fixt, in respect to the Center of Gravity, placed in the very Point which best serves to support and convey the Body. Every Leg bears its true share of the Weight. And the Wings are so exactly placed, that even in the fluid Medium, the Air, the Body is as truly balanced, as we could have balanced it with the nicest Scales.

Yet again. What an admirable Provision is made for the Motion of some Creatures, by *Temporary Parts! Frogs*, for instance, have Tails in their Tadpole State, which fall off when their Legs are grown out. The *Water-Newt* also when young, has four Fins, two on a side, to poise and keep the Body upright. But as soon as the Legs are fully grown, these presently drop off.

Secondly, The *Bore* of the *Gullet* in all Creatures, is answerable to their Occasions. In a Fox, which feeds on Bones, (as in all ossivorous Beasts) it is very large. But in a Squirrel it is exceeding small, lest he should disgorge his Meat in his descending Leaps: And so in Rats and Mice, which often run along a Wall with their Heads downward.

Thirdly, In all Animals the Strength and Size of their *Stomach* are proportioned to their Food. Those whose Food is more tender and nutritive, have it smaller, thinner and weaker. Whereas it is large and strong, in those, whose Food is less Nutritive, and whose Bodies require large Supplies.

All carnivorous Beasts have the smallest Stomachs, as Flesh goes the fartherest. Those that feed on Fruits and Roots have them of a middle size. Sheep and Oxen which feed on Grass, have the greatest. Yet the Horse, Hare and Rabbet, tho'. graminivorous, have comparatively small ones. For 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 Diaphragm is requisite. But this could not be, did the Stomach lie big and cumbersome upon it, as it does in Sheep and Oxen.

ANOTHER very remarkable Circumſtance is, that thoſe Animals which have Teeth on both Jaws, have but one Stomach; whereas moſt of thoſe which have no *Upper-Teeth*, or no Teeth at all, have three Stomachs. For the Meat which is firſt chewed, is eaſily digeſted; but that which is ſwallowed whole, requires a ſtronger concoctive Power.

FOURTHLY, All the Parts of the ſame Animal are adapted one to the other. So, for inſtance, the Length of the Neck is always proportioned to that of the Legs: Only the *Elephant* has a ſhort Neck: For the Weight of his Head and Teeth, would to a long Neck have been unſupportable. But then he is provided with a Trunk, which abundantly ſupplies the Defect. In other Beaſts and Birds, the Neck is always commenſurate to the Legs: So that they which have long Legs have long Necks, and they that have ſhort Legs ſhort ones: As may be obſerved in Lizards of all kinds, and the King of them, the Crocodile. And Creatures that have no Legs, as they want no Necks, ſo they have none, as Fiſhes. This Equality between the Length of the Neck and Legs, is peculiarly ſeen in Beaſts that feed on Graſs. Their Legs and Necks are very near equal. Very near, I ſay, becauſe the Neck muſt neceſſarily have ſome Advantage; for it can't hang perpendicular, but muſt incline a little.

MOREOVER, as theſe Creatures muſt hold their heads down, for a conſiderable time together, which would be very laborious and painful for the Muſcles, therefore on each ſide of the Neck, Nature has placed a thick and ſtrong Ligament, capable of ſtretching and ſhrinking again as need requires: This, which is vulgarly called *Whit-Leather*, extends from the Head (to which, and the next Vertebra of the Neck it is faſtened at that End) to the middle Vertebra of the Back, to which it is knit at the other. And by the Aſſiſtance of this, they are able to hold the Head in that poſture all day long.

FIFTHLY, The Parts of all Animals are exactly fitted to their manner of living. A notable Inſtance of this is in the Swine. His natural Food being chiefly

chiefly the Roots of Plants, he is provided with a long and ſtrong Snout; long, that he may thruſt it to a convenient Depth in the Ground, without offence to his Eyes; ſtrong, and conveniently formed, for rooting and turning up the Ground. And beſides, he has an extremely quick Scent, for finding out ſuch Roots as are fit for him. Hence in *Italy*, the uſual way of finding Truffles, or Subterraneous Muſhrooms, is by tying a cord to the hind-leg of a Pig, and driving him before them into their Paſtures. They then obſerve, where he ſtops and begins to root: and digging there, they are ſure to find a Truffle. So in Paſtures where there are Earth-nuts, tho' the Roots are deep in the Ground, and the Leaves are quite gone, the Swine will find them by their Scent, and root only in the places where they grow.

ANOTHER Inſtance of like Nature we have in the *Porpes*, (antiently wrote *Porc-peſce*, that is, *Swine-fiſh*) which reſembles the Hog, both in the Strength of his Snout, and in the manner of getting his Food. For the Stomach of one of theſe when diſſected, was found full of Sand-Eels, which lie deep in the Sand, and cannot be gotten but by rooting or digging there.

THAT very Action, for which we look upon Swine as unclean Creatures, namely, wallowing in the Mire, is deſigned by Nature for a good End; Not only to cool their Bodies, (which fair Water would do as well) but alſo to ſuffocate and deſtroy Fleas, Lice, and other Inſects, which are troubleſome and hurtful to them. For the ſame reaſon, Poultry and divers other Birds baſk themſelves in the Duſt, in hot Summer Weather.

A FARTHER Inſtance of the Fitneſs of Animals for their manner of Living, we ſee in the *Ant-Bear*: which has not only a ſharp Head and Snout, but alſo a narrow, and toothleſs Mouth. Their Tongue is as big as a Gooſe-quill, round, and in ſome, above two foot long. Therefore it lies doubled in a Channel, between the lower Parts of the Cheeks. This when hungry they thruſt out, being well moiſtened, and lay upon the Trunks of Trees: And when it is covered with

Ants, suddenly draw it back into their Mouths. If the Ants lie deep, they dig up the Earth with their long and strong Claws, with which their Fore-feet are armed. So are they fitted for this Diet and no other!

CHAP. II.

Of Birds.

1. *Of their Motion:*
2. *Brain:*
3. *Organs of Sense:*
4. *Lungs:*
5. *Stomach and Bladder:*
6. *Generation.*
7. *Of some particular Sorts of Birds:*
8. *Some General Reflections.*

1. THE Species of Birds are exceeding numerous. These have *Feathers*, which they expand in order to fly; the fine Branches of which lie so close together, that little Air can insinuate itself between them. Now when the Column of Air on which a Body rests is specifically heavier than the Body, it remains suspended in the Air; if it be lighter, the Body sinks. Hence the larger Space a Body circumscribes, the more easily does the Air sustain it. Consequently the same Bird which sinks when the Wings are closed, is sustained when they are expanded. To this also the Motion of the Wings contributes: (As a Body while moving swiftly, will swim in Water, which immediately sinks, if that Motion ceases.) And so do the Feathers, with which their Bodies are clothed, which increase their Bulk, but not their Weight in the same proportion.

THE Parts of Birds chiefly concerned in Flying, are the Wings and the Tail. By the first, the Bird sustains and wafts himself along. By the second he is enabled, to keep his Body steady and upright, particularly

cularly in aſcending and deſcending. It is by the Largeneſs and Strength of the Pectoral Muſcles, that they are qualified for Flying. In Men theſe are ſcarce a Seventeenth Part of the Muſcles of the Body. In Birds they conſiderably outweigh all the other Muſcles together. And this Circumſtance alone, the Want of ſuitable Muſcles, makes all Human Attempts to fly, void and vain.

In Flying, the Bird firſt bends his Legs and leaps from the Ground; then opens the Joints of his Wings, ſo as to make a right Line, perpendicular to the Sides of his Body. Being now raiſed and ſtrongly vibrating his Wings, the Air re-acts, as much as it is acted upon, and ſo protrudes his whole Body. But in recovering his Wing for freſh Strokes, it has a great Reſiſtence to overcome. To elude this, the bony Part of the Wing, into which the Feathers are inſerted, moves ſideways with its ſharp End foremoſt, and the Feathers follow it like a Flag.

All Birds have near their Tail a little Bag, which contains Oil, to moiſten their Feathers. Geeſe have two Glands for the Secretion of this: Other Birds only One. In this are divers little Cells, ending in two or three large ones, lying under the nipple of the Oil-bag. This *Nipple* is perforated, and being preſt by the Bird's Bill, emits its Oil.

In all Birds that fly much, the Wings are placed in the very beſt manner, to balance their Bodies in the Air, and to give as ſwift a Progreſſion, as they are ſeverally capable of. Otherwiſe they would reel and fly unſteadily; as we ſee they do, if we deſtroy the Equipoiſe, by cutting one of their Wings.

And what Nicety may we obſerve, in a Part no more conſiderable, than the *Vanes* of the Flag-feathers of the Wing! 1. The Edges of the exterior or narrow Vanes bend downward, but the interior, wider Vanes upward. By this Means they catch hold and lie cloſe to each other, when the Wing is ſpread; that not one Feather may miſs its full Force and Impulſe upon the Air. 2. Equal Nicety is obſerved in the very ſloping the Tips of the Flag-feathers: The interior

Vanes are neatly sloped away to a Point, toward the outward Part of the Wing. The Exterior (at least in many Birds) are sloped toward the Body. And in the middle of the Wing, the Vanes being equal are but little sloped. So that the Wing, whether open or shut is as neatly sloped, as if constantly trimmed with a pair of Scissars.

The *Vane* consists not of one continued Membrane, because if once broke, it would not easily be repaired: But of many Laminæ, which are thin, stiff, and something resembling a thin Quill. Toward the Shaft of the Feather (especially in the Flag-feathers of the Wing) these Laminæ are broad and of a semicircular Form, which serves for Strength, and for Shutting them close together, when Impulses are made on the Air. Toward the Outward Part of the Vane, they grow slender and taper. On their under-side they are thin and smooth; but their upper-outer Edge is parted into two hairy Edges.

As curiously made are the Feathers in the Wing, and no less curiously placed, exactly according to their several Lengths and Strength; And these again are lined, faced and guarded with *Covers* and *Secondary Feathers*, to keep the Air from passing thro' and so eluding the Impulse.

Lastly, How admirably wrought are the *Bones* of the Wing, very strong, but light withall: The *Joints*, which open, shut, and move every way, as occasion is; and the various *Muscles*, all suited to the Motions which they minister to.

Next to the Parts for Flight, let us view the *Legs* and *Feet*, which minister to their other Motions; both made light, for their easier Passage thro' the Air, and the latter, some with Membranes for Swimming, some without, for steady Going, for perching, for catching and holding their Prey, or for hanging by the Heels, to gather their Food: The Legs, all curved, for their easy Perching or Roosting, as also to help them upon their Wings, in taking their Flight. In some they are long, for wading and searching the Waters; in others,

others, if need be, remarkably short. And how wisely are they placed! In all somewhat out of the Center of the Body's Gravity. But in such as swim, more than in others, for the better rowing their Bodies, as also to help them in Diving.

Geese and *Ducks*, their Bodies being made for Swimming, have their Wings too placed out of the Center of Gravity, nearer the Head: But the extending the Neck and Head in Flight, ballances the Body upon the Wings: Which is another excellent Use (beside searching for Food) of the long Necks of these Birds.

But in the *Heron*, whose Head and long Neck (altho' tucked up in Flight) overbalances the hinder Part of the Body; the long Legs are extended, both to counterpoise the Body, and to supply what is wanting in the Tail.

It has been supposed, that the Flying of Birds is analogous to the Rowing of Vessels. But it is a Motion of quite another Kind: Oars are struck toward the Stern: Whereas Birds do not vibrate their Wings toward the Tail, but waft them downward. Nor does the Tail cut the Air (as the Rudder does the Water) at Right Angles, but horizontally. It likewise keeps the same Situation, which way soever the Bird turns.

It is not therefore by the Tail, that most Birds turn to the right hand or the left, but by the Wings. They turn to the right, by beating the Air with the Left Wing alone toward the Tail: To the left, by beating it with the Right Wing. Thus Pigeons changing their course toward the left, labour with the Right Wing, scarce stirring the other. [a]

Birds

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[a] It is a remarkable Use which is made of Pigeons, in the Eastern Countries. They are trained up in *Turky* and *Persia* to carry Expresses: being first used to short Flights, afterwards to longer, 'till at length they will return from the farthest Part of the Kingdom. Yea, if they are brought hoodwinked twenty or thirty Miles, nay sixty or an hundred, they will find their way in a very little time, to the place where they were bred. Every Bashaw has a Basket of these Pigeons, bred at the Seraglio; one of which he dispatches thitherward on any emergent Occasion, with Letters braced under her Wings. This proves a more speedy Method, as well as

Birds with long Necks have another way of altering their Courſe, by only inclining their Head and Neck this or that way.

Birds rarely fly up or down perpendicularly, but rather in a crooked Line. In aſcending directly, the Natural and Artificial Tendency would counter-act each other. In deſcending directly both would concur, and endanger too precipitate a Motion.

Only the Hawk ſtoops directly to ſeize its Prey: Whereas other Birds in deſcending, retard the Motion by keeping their Wings expanded, and at the ſame time ſtretching out their Feet and Legs.

There is no flying Animal, but has Feet as well as Wings; becauſe there is not Food, or at leaſt not Food ſufficient for them, to be had always in the Air. But if there were, yet ſuch Birds could take no reſt; for having no Feet, they could not perch upon Trees. And if they alighted on the Ground, they could not raiſe themſelves again, which Birds that have ſhort Feet can hardly do. Beſide, they would want Means of Breeding, having no way to lay their Eggs, to ſit, hatch or brood their Young. As for the Story of the *Manucodiata* or *Bird of Paradiſe*, ſaid to have no Legs it is now diſcovered to be a Fable.

This Bird is a native of *Arabia*, It is one of the lighteſt Birds that is known; and its feathers are ſo diſpoſed, that with a ſmall Motion of its Wings, it can float upon the Air. And indeed it lives moſtly there, ſeldom ſtanding on its feet, except to ſleep. Hence many have ſuppoſed, that it lives wholly in the Air, and was ſuſtained without Food. Thoſe who brought them into *Europe*, finding this increaſed their price, tore their Legs off, and pretended they never had any.

It is indeed much on the wing, like the ſwallow, and like this, feeds on flying Inſects as it flies. And the *Arabian* Inſects being larger and ſtronger than ours, its

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ſafer, than any other. For one of theſe Birds will carry a Letter from *Babylon* to *Aleppo*, which is thirty Days Journey, in forty eight Hours.

its Beak is proportionably ſtronger, than that of the Swallow.

It is not ſtrange, that a Bird ſo light, and having very long Feathers, ſhould lie upon the Air, almoſt without moving. But the ſtrength of its Legs, and the Sharpneſs of its Claws, ſhews it is deſigned both for ſtanding and tearing its Prey.

Before we conclude this Head, it may be obſerved, that all the Parts of Birds are fitted for their uſe of Flying. Firſt, As the Muſcles of the Wings are peculiarly ſtrong, ſo the under Side of them is made concave, and the upper convex, that they may be the more eaſily lifted up, and the more ſtrongly ſtrike the Air. Then the Trunk of their Body ſomewhat reſembles the Hull of a Ship, the Head, the Prow; which is generally ſmall, that it may the more readily cut the Air, and make way for the Body. Add to this, that the Bodies of Birds are ſmall in compariſon of Beaſts, that they may be more eaſily ſupported by the Air. And they are not only ſmall, but of a broad Figure, that they may be buoyed up the better. They are alſo hollow and light: Yea, their very Bones are light. For even thoſe of the Legs and Wings have ample Cavities: By this means alſo they become rigid and ſtiff: It being demonſtrable, that a hollow Body is more ſtiff and inflexible, than a Solid one of equal Subſtance. The ſhafts alſo of their Feathers are either empty, or filled with a light and ſpungy Matter. And their Webs conſiſt of two Rows of contiguous Filaments furniſhed all along with Hooks on each ſide, whereby catching hold of one another, they ſtick faſt together.

As to their Tails, altho' it is true, as was obſerved, that all Birds whoſe Tails are pointed and end in a right line, turn themſelves by their Wings and not their Tails, yet in thoſe that have forked Tails it is otherwiſe. Thus it is manifeſt to ſight, that the forked-Tail'd Kite, by turning her Train ſideways, raiſing one horn, and depreſſing the other, turns her whole Body. And doubtleſs the Tail has the ſame Uſe in Swallows, who have all forked Tails, and make more ſudden turns in the Air than any other Bird.

But

But Feathers muſt in time wear out. Therefore Nature has provided for the renewing them yearly. To lighten Birds ſtill farther, they have large Membranes extending to the bottom of their Bellies, into which the Air is received, where, by the Heat of the Body it is expanded into twice or thrice the Dimenſions of the External Air. And this they can either compreſs by the Muſcles of the Abdomen, or expire, more or leſs, in order to their deſcending ſwifter or ſlower, in what degree they pleaſe.

2. As to the *Brain* of Birds, whereas in Men the *Cortical* Part of the Brain is outermoſt, in Birds it is innermoſt, and the Membrane that covers the Upper Ventricle is *Medullary*. The Ventricles likewiſe are ſituated above, near the upper Part of the Skull.

Perhaps before we proceed, it may be well to premiſe one General Obſervation, That the Structure of Birds is in many reſpects different from thoſe both of Man and Beaſts; having ſeveral Parts which theſe want, and wanting others which they have. Beſides, there are great Variations in the Contrivance of Parts which are common to both: All wiſely adapted to their different Conditions and manner of Life.

Parts peculiar to Birds are 1. The *Bill*; 2. The *Membrane* to draw over the Eyes, 3. *Feathers* and *Wings*. The Parts wanting in Birds, are 1. *Teeth* and *Lips*, 2. *Kidneys* and *Bladder*, which they do not need, as they drink no more than juſt to moiſten their Food. Variations in the Parts of Birds from thoſe of Men and Beaſts are 1. In the *Ear*, which is of a very peculiar Make, 2. In the Diviſion of the *Aorta*, 3. In the *Spinal-Marrow*, which is divided into two in the middle of the Back, 4. In the *Bones*, which are all hollow, 5. In the *Heart*, which has a fleſhy Valve at the Mouth of the Vena Cava, 6. In the *Lungs* which are ſtrongly joined to the Back, for the greater conveniency of Flight, 7. In the *Stomach*. Birds have two or more, to ſupply the Want of Chewing, 8. In the *Legs* and *Feet*, 9. In their *Tails*, 10. In their *Pectoral Muſcles*, which are the ſtrongeſt of all, whereas in Man the Crural Muſcles are the ſtrongeſt, 11. In the *Brain*, as

as was before obſerved, 12. In the *Bronchiæ*, which extend to the very bottom of the Abdomen, ſo as to contain a large Quantity of Air, 13. In the *Ovaries*, which in Birds are ſingle, and faſtened to their Back.

THE *Ears* of Birds differ much from thoſe both of Men and Beaſts. There is almoſt a direct paſſage from Ear to Ear: So that if the Drum be pricked in either Ear, Water poured in at one Ear, will run out at the other. And what is ſtill more remarkable is, they have a ſmall winding Paſſage, that opens into a large Cavity, running betwixt Two Skulls, and paſſes all round the Head. The Upper of theſe Skulls is ſupported, by many Hundreds of ſmall, thread-like Pillars: Which have another Uſe alſo, to break their Sound, and hinder its making a confuſed Echo.

THIS Paſſage between the two Skulls is much larger in Singing-Birds than in others. So that a perſon who has been ſhewn this, may hereby know them from all others.

THE other Organs of Senſe are nearly the ſame in Birds as in other Animals. Only there is a difference in the Organ of *Smell*. The Noſtrils lie on each Side of the Beak in the inner Part whereof, beſide the Tube which reaches to the Lungs, there are little Tubes, continued from the Membranes and Subſtance of the Brain. And theſe ſeem to be the Organ of Smell. Only two Nerves paſs thro' the *Os Cribroſum* to the Beak: Leſt if there were more Perforations, as in other Animals, too much Air might flow into the Brain.

3. THE *Bill* of Birds is peculiarly remarkable. In the firſt place, it is neatly ſhaped for piercing the Air. In the next, it is hard and horny, to ſupply the Want of Teeth, and alſo in ſome meaſure, of an Hand. Its hooked Form is of great uſe to Rapacious Birds, in catching and holding their Prey; and to Others, in Climbing, and in taking and comminuting their Food.[b]

Its

[b] *Parrots* have their Bills nicely adapted to theſe Services, being hooked, for climbing and reaching what they want, and the lower

Its extraordinary Length and Slenderneſs is of uſe to ſome, to ſearch for their Food in Mooriſh Places : [c] As its Length and Breadth is to others, to hunt and ſearch in muddy Places. [d] The contrary Form, a thick, ſhort and ſharp-edged Bill is as uſeful to all other Birds, who muſt huſk the Grains they ſwallow. But it would be endleſs to reckon up all the Shapes, and commodious Mechaniſm of all: The Sharpneſs and Strength of thoſe that have occaſion to perforate Wood and Shells; [e] the Slenderneſs and Neatneſs of ſuch, as pick up ſmall Inſects: The Croſs Form of ſuch as break up Fruits; [f] the compreſſed [g] Form of others, with many other curious Forms, all ſuited to the Occaſions of the ſeveral Species.

In

Jaw ſo exactly fitted to the Hook of the Upper, that it will break the Food, as other Creatures do with their Teeth.

c As to *Woodcocks* and *Snipes*, who hunt for Worms in Mooriſh Ground, and likewiſe ſuck the unctuous Humour out of the Earth. So alſo the Bills of *Curlews*, and other Sea-fowl are very long, to enable them to hunt for Worms, &c. in the Sands.

d *Ducks*, *Geeſe*, and divers other Species of Birds, have Bills both long and broad, whereby they are enabled to quaffer in the Water or Mud, 'till they find their Food.

e THE *Green Woodſpite*, and all *Woodpeckers* have ſtrong and ſharp Bills, curiouſly made for digging Wood. An even Ridge runs along the top of the Green Woodpecker's Bill; as if an Artiſt had deſigned it at once for Strength and Neatneſs.

WOODPECKERS have alſo a Tongue, ending in a ſharp, bony Rib, dented on each ſide, which they can at Pleaſure ſhoot out to a great length, and thruſt into the Holes, Clefts and Crannies of Trees. They ſtrike them likewiſe into Ant-hills, and fetch out the Ants and their Eggs. Moreover they have ſhort, but ſtrong Legs, and their Toes ſtand two forward, two backward: a Diſpoſition which is particularly convenient, for the climbing of Trees. In this they are likewiſe aſſiſted by the uncommon Stiffneſs of the Feathers of their Tails, and by their bending downward, whereby they are fitted to ſerve them as Props to lean on.

f THE *Croſs-Bill*, whoſe Bill is thick and ſtrong, with the Tips croſſing each other, readily breaks open Fir-cones and other Fruits, to come at and feed on the Kernels. And undoubtedly the croſſing of the Bill was deſigned for this very Service.

g THE *Sea-pye* has a long, ſharp, narrow Bill, compreſſed ſideways, and every way adapted, to the raiſing Limpets from the Rocks, which are its chief, if not only, Food.

In the *flat-billed Birds*, as *Ducks*, there are three pair of Nerves, which come down between the Eyes into the Upper Bill, whereby they are enabled to ſmell and find out their Food, in the Mire or Water. The like have been obſerved in ſeveral round-billed Birds, but ſo ſmall as to be ſcarce diſcernible. Only in the *Rook* they are diſcernible enough: And it is remarkable that theſe, more than any other round-billed Birds, grope for their Meat in Cow-dung and the like.

Concerning *Birds of Prey*, it is obſerved, 1. They commonly fly ſingle, but not always; Vultures fly in Troops, after an Army, fifty or ſixty together. 2. That the Females are both larger, ſtronger, and of more Courage than the Males: Nature ſo ordering, becauſe they muſt procure Food, not only for themſelves, but alſo for their Young.

4. Of their *Lungs* it is obſervable, that they are not only larger in proportion than thoſe of Beaſts, but that they admit the Air, both above and beneath, by which means they become far lighter. [h]

[h] A *Duck* is furniſhed with a peculiar Structure of Veſſels, which enables it to live ſome time under Water. Yet ſhe cannot live without Air. One that was put into the Air-pump, and the Air exhauſted, ſeemed to bear it better for a few Moments, than any other Fowl. But in leſs than two Minutes her Head fell down, and ſhe appeared dying, 'till revived by letting in the Air.

A young, callow Duck being tried in the ſame manner, was near Death in leſs than two Minutes. It is obſervable both of them ſwelled extremely, on pumping out the Air. It not being intended, that Water-fowl ſhould live in an exceeding rarefied Air, but only continue under water, they are qualified for this, but not at all for the other.

Yet that Ducks can live almoſt any where, we may learn from the blind Ducks of the *Zerchintzer* Lake in *Carniola*. This communicates with another Lake under ground in the Mountain *Savornick*, and fills or empties itſelf according to the fulneſs or emptineſs of That. The Waters of the Upper Lake, when it empties, run off by large Holes in the bottom. The Ducks which are very plentiful in the Water, are often carried down with it into the ſubterraneous Lake. In this many of them undoubtedly periſh; yet ſome remain alive. But they loſe their Sight and their Feathers: And at the next filling of the Lake, both they and vaſt Numbers of Fiſh are thrown up with the Water. They make a ſtrange Appearance

It is likewiſe remarkable, that whereas in other Animals the Lungs are looſe and have much Play, in all Birds they adhere to the Thorax, and have little Play. This 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 ſerve for Braces to the Viſcera, as well as to contain Air. Toward the upper Part, each Lobe of the Lungs is perforated in two places with large Perforations: whereof one is toward the Outer, the other toward the Inner Part of the Lobe.

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in their naked State; and for want of Sight are eaſily caught. In about a Fortnight they recover their Sight and their Feathers, and are then as big as common Wild-ducks. At their firſt coming up, their Stomachs are full of ſmall Fiſhes, and ſomething reſembling Weeds. It ſeems therefore, they were not quite blind, when in their dark Habitation, but could ſee by that ſmall Quantity of Light, to ſearch for and find their Food.

Nor is it in this Lake only, that theſe Ducks are found. They are frequently thrown up, after great Rains, at a Hole in a Mountain, near the Town of *Laos*. The Water then guſhing out with great violence, brings theſe blind and bald Creatures with it. And their Frequency and Cheapneſs, from the vaſt Quantities which are thrown out, makes them eſteemed no Variety.

The Bodies of *Duckers* or *Loons* are admirably fitted for Diving: Being covered with a thick Plumage, and the Surface of it ſo ſmooth, that the Water cannot penetrate it. Hereby their Bodies are defended from the Cold, the Water being kept at a Diſtance; and are ſo poiſed, that by a light Impulſe, they eaſily aſcend in it. Again, their Feet are ſituate in the hindmoſt Part of their Body, ſo that ſhooting them backward and ſtriking the Water upwards, they plunge themſelves down with great Eaſe, and move forward therein. Their Legs alſo are made flat and broad, and their Feet cloven into Toes, with appendent Membranes on each ſide. By this Configuration they eaſily cut the Water, and are drawn forward, to take their Stroke backward: And by this, their Feet being moved to the Right or Left, ſerve them as a Rudder to turn under Water. How they riſe above Water is not determined: Whether by their natural Lightneſs, or by ſtriking againſt the bottom, in the manner of a Leap, or by ſome peculiar Motion of their Legs. That they dive to the bottom is undeniable. For in the Stomachs both of the Greater and Leſſer kind, we find much Graſs and other Weeds; And in the leſſer kind, little elſe. Yet both prey upon Fiſh; and their Bills are ſtreight and ſharp, for the eaſier ſtriking their prey.

Lobe. Thro' these Perforations the Air has a Passage into the fore-mentioned Bladders; so that by blowing into the Windpipe, the Lungs are raised, and the whole Belly blown up. This doubtless is a means to make them more or less buoyant, as they take in more or less Air: And so answers the Design of the Air-bladder in Fishes.

In general we may observe, whatever is peculiar in the Wings, Bills, and every other Part of Birds, on a close Inspection will be found exactly suited to their Wants. They are set of Implements nicely proportioned to their Manner of Life. To instance in a few. *Sparrows* and most small Birds are supported by the little Grains they find up and down. They have no effort to make, to obtain their Food, or break it in pieces, and therefore have a small Bill, as well as short Necks and Legs, which are sufficient for their purposes. But the *Woodcock*, *Snipe*, *Curlew*, and many other Birds, seek their Food deep in the Earth or Slime. Therefore they are provided with a long Neck and Bill, and with these they dig and search and want for nothing. The *Woodpecker*, who lives in a quite different manner, is as differently formed. His Bill is very long, solid and strong: his tongue is sharp, and extremely long; beside which, it is armed with little points, and covered with Glue toward the Extremity. He has short Legs, two Talons before, two behind, and all very crooked. All this Equipage suits his manner of Living. His Food is Worms or Insects, that live in the Heart of Branches of Trees, or under the Bark of old Wood, Frequently they are sunk very deep, under the Bark of large Billets. The Woodpecker wants hooked Claws, to grasp these Branches; and a strong, and pointed Bill, to find out by darting it up and down, what Parts of them are rotten. When he has found out these, he with his Bill, shatters the Bark and Wood. He then sends forth a loud, whistling Cry, into the Cavity, to alarm the Insects and put them in motion. Next he darts in his Tongue, and by the small points which rise out of it, and the Glue that covers it, draws out whatever lodged there.

The *Heron*, on the contrary, mounts aloft. His Legs and Thighs are very long, and bare of Feathers. He has a great Length of Neck, and an enormous Bill, very ſharp and jagged at the End. What reaſon can be aſſigned for a Figure, which at firſt ſight ſeems ſo extravagant? He feeds on Frogs and ſmall Shell-fiſh, as well as other fiſh which he finds in fens, or bogs, or near the Shores of Rivers. He wants no Feathers on his thighs, to walk thro' Water and Slime; but he needs very long Legs, to run in the Water, along the Shores, whither the Fiſhes reſort for their Food. A long Neck and Bill qualify him for purſuing and ſeizing his Prey at ſome diſtance: And the jaggs of his Bill enable him to hold the Fiſh, which would otherwiſe ſlide away. In fine, his large Wings, which ſeem incommodious to a Bird of ſo ſmall a Body, are abſolutely needful for his making ſo great Movements in the Air, and conveying ſuch Burdens to his Neſt, which is frequently two or three Leagues diſtant from the place where he fiſhes.

The Imperfections therefore which we imagine we diſcover, in this, (as in many other Animals,) in reality belong only to our own Underſtanding: And all our Cenſures of the Works of Nature, are in truth, only ſo many Indications of our own Ignorance.

5. The *Stomach* (eſpecially of granivorous) Birds, is of a peculiar Structure. Firſt, there is a glandulous Receptacle, wherein the Grains are kept for ſome time. They are then received into another Stomach, conſiſting of Two Muſcles, and a callous Membrane. One of theſe moves obliquely downward, and the other upward. Hereby the Shell of the Grain is broke, and the Meal expreſſed and mixt with proper Juices. The Aliments thus prepared fall into the bottom of the Stomach, where they are purged again from the Refuſe: to which end that Part is a little raiſed, that the Corn may not paſs out too ſoon. There is alſo a Partition, which divides what is already digeſted from the reſt.

As Birds have no Bladder, in the room of Urine, a whitiſh Excrement is diſcharged from the Kidneys into the Rectum.

6. The

6. The *Generation* of Birds is now well known. In the *Ovary*, placed between the Liver and the Backbone, a great Number of Yolks are contained; one of which when impregnated, passes thro' the *Oviduct* into the Womb, where it receives the *White* and the *Shell*, and remains 'till it comes to its full Size. The Parent then broods over it, 'till the Young being gradually formed, perfected and quickened, bursts the Shell.

Under the Shell of an Egg lies the *Common-Membrane*, adhering closely to it, except at the bigger End, where a little Space is left between them. This Membrane contains two Whites, each inclosed in its own Membrane. In the middle of the Inner White is the Yolk, inclosed likewise in a separate Cover. The Outer White is Oval, the Inner Round, (as is the Yolk) and of a more viscid Substance.

At each End is a *Chalaza*, a white, dense Body, consisting of three little Globules, like Grains of *Hail*, (so the Word signifies) all joined together. These serve both to knit the several Membranes together, and to keep the Liquors in their proper Places and Position.

About the middle of the small End of the Yolk, is a little yellowish Bladder, like a Vetch, called the *Cicatricula* or *Eye* of the Egg. This contains an Humour, in and out of which the young Bird is generated. The White serves it for food, 'till it becomes big; then the Yolk, and likewise after it is hatched. For even then a good Part of the Yolk is lodged in its Belly, as in a storehouse, and being conveyed thence by the *Intestinal Duct* into the Bowels, serves it instead of Milk.

An Egg, *improperly* so called, is that, of the whole whereof the Animal is formed. Such are the Eggs of Flies. *Proper* Eggs, when excluded, need no external Nutriment. Of proper Eggs, some are *perfect*, that is, have all the Parts above described, while in the Ovary or Womb: Some *imperfect*, which have them not, 'till after they are excluded: As those of Fishes, which assume a White in the Water.

An Egg not impregnated by the Male, will never breed Young, but always putrify. One impregnated contains the Rudiments of the Bird, even before Incuba-

tion. By the Microscope we see the plain Carina or Spine of it swimming in the middle of the Cicatricula, consisting of fine, white Threads, which Incubation gradually perfects.

The *Air-Bag* is very small in a new-laid Egg, but becomes larger, when the Egg is kept. The Yolk is specifically heavier than the White. Hence its smaller End is always uppermost, in all Positions of the Egg.

After Incubation the Air-bag gradually extends, till near the Hatching, it takes up a Third of the Egg. By Incubation the White becomes thinner and more turbid, especially near the Air-bag, where it is first consumed. Then it lessens towards the sharp End of the Egg, till nothing is left but a white, chalky Substance. The White of an Impregnated Egg is as sweet all the time of Incubation as that of a new-laid Egg. They are only unimpregnated Eggs, vulgarly called *Wind-Eggs*, which putrify and stink.

The Yolk also remains fresh and uncorrupted, all the Time of the Incubation. It is depress in the middle, as the Chick grows, and is soon brought into a Form, not much unlike that of a Horse-shoe, in the middle of which the Chick lies.

Not long before the Chick is hatched, the whole Yolk is taken into the Abdomen.

The Eye or Tread, in which the Chick lies, is soon inlarged by Incubation, and rises to the upper Part of the Egg. The Heart and Umbilical Vessels, are some of the first Parts, which we are able to distinguish.

The Embryo is seen at first like a small Worm. Then its Carina or Spine appears, with the large Prominences that afterward shew themselves, to be the Brain and Eyes. The other Bowels seem hanging from the Spine. Then the Chasm of the Mouth is discovered. The Extremities sprout out. The Bowels are gradually coverd with the Teguments. At last the Beak, Nails and Feathers are seen. When all its Parts are formed, the Chick is always found lying on its Side, with its Neck bent forward, the Head covered with the Upper Wing, and the Beak placed between the Thighs.

The

THE Birds which nouriſh their Young, have commonly very few. On the contrary, thoſe whoſe Young feed themſelves when they firſt ſee the day, have ſometimes eighteen or twenty at a Brood. This Prudence could only ſpring from Him, who regulates all Things to the beſt advantage. Were thoſe who provide for their Young to have ſo numerous a Brood, both the Parents would be Slaves, and yet the Young but ill accommodated. Whereas the Mother, who only marches at their head, without nouriſhing them, can conduct Twenty as well as Four.

BUT when they firſt make their Appearance, what Care do the Parents take, till their young can ſubſiſt without them? Of thoſe that feed their Young, the Linnet and the Nightingale then labour like the reſt. Sometimes one Parent goes in queſt of Proviſions, ſometimes the other, and ſometimes both. They are up before the Sun. And the Food they have procured, they diſtribute with great equality, giving each a portion in its turn, before ever they feed one bird twice.

AND this Tenderneſs for their Offspring is ſo ſtrong, as even to change their Natural Diſpoſition. Follow the Hen when ſhe is the Parent of a Family, and ſhe is no longer the ſame Creature. She is no longer ravenous and inſatiable. If ſhe finds but a grain of Corn or crumb of Bread, ſhe never touches it herſelf, but calls her troop, by a note they well underſtand, and divides it among them. She is no longer timorous, but at the head of her Young, will ſpring even at the ſtouteſt Dog.

WHEN the Turkey-hen appears at the head of her Young, ſhe ſometimes utters a mournful Cry, and they immediately run under buſhes, furz or whatever preſents itſelf. She looks upward, and repeats her Cry: which is occaſioned by her ſeeing a Bird of Prey, tho' ſo diſtant, that he appears to Us, only as a dark point under the Clouds. But he no ſooner diſappears, than ſhe utters another Cry, which revives all her Brood. They run to her, flutter their wings, and ſhew all the Tokens of Joy. Now who apprizes her of an Enemy, that never yet committed any Act of Hoſtility in the Country? And how is ſhe able to diſcover him, when at ſo great

great a distance? How are her Family instructed, to understand her different Cries, and regulate their Behaviour accordingly? What Wonders are these which are daily obvious to our view, tho' we treat them with inattention?

When almost all Birds produce their Young by Incubation, yet the Scripture gives us one Exception. *The Ostrich leaveth her eggs in the earth, and forgetteth that the foot may crush them—because GOD hath deprived her of wisdom, neither hath he imparted to her understanding. Job.* xxxix. 14 &c. In which words we may observe, 1. This anomalous Way of Incubation, by the Heat of the Sun, 2. The singular Care of the Creator, supplying the Parent's Want of Care, so that the young are fed and bred up notwithstanding, even in those large and barren Deserts: 3. The Instinct of Irrational Animals, is expressly ascribed to God. *She forgetteth, because GOD hath deprived her of wisdom, and not imparted unto her understanding:* That understanding, that natural Instinct, which most other Creatures are endued with.

7. An amazing degree of natural Instinct or Understanding, God has imparted to *Birds of Passage*. They fly in Troops, often in the form of a Wedge, with the Point foremost. They steer their course thro' unknown Regions, without either Guide or Compass. And they are peculiarly accommodated for their Flight, by the Structure of their Parts.

In the Act of Migration, it is highly remarkable, 1. That they *know* (as the Scripture speaks) *their appointed Times*, when to come, when to go. *Appointed* by whom? Surely by the Great Creator, who has imprinted on their Nature an Inclination, at such a Time to fly from a Place that would obstruct their Generation, or not afford Food for them and their Young, and betake themselves to another Place, which will afford all that is wanting.

It is highly remarkable, 2. That they know whither to go, and which way to steer their Course! That they should be directed yearly to the same Place, perhaps to a little Island, as the *Basse* in *Edinburgh-Frith*. How come Land-birds to venture over a vast Ocean,

of

of which they can see no End? And how do they steer their Course aright to their several Quarters, which before the Compass was invented, Man himself was not able to do? They could not possibly see them at that distance. Or if they could, what should teach or persuade them, That that Land is more proper for their purpose than this? That *Britain*, for instance, should afford them better Accommodations, than *Egypt*, than the *Canaries*, than *Spain*, or any other of the intermediate Places?

But it has been commonly supposed, that several Birds are of this Number, because they disappear in Winter, which really are not: Cuckoos, for instance, and Swallows: For neither of these ever cross the Seas. Cuckoos lodge all the Winter in hollow Trees, or other warm and convenient Cavities. And Swallows have been found in vast Quantities, clung together in a Lump, like Swarms of Bees, but utterly cold and senseless, even in Ponds that have been cleaned out, hanging under the Water.

7. The largest of Birds is the *Condor* of Peru. The Body is as big as that of a Sheep. Its Wings extended are fifteen or 16 Feet from point to point. It is never seen in Forests, because it would not have Room to fly, but frequents the Sea-shore and the banks of Rivers. Nature to allay their Fierceness has denied them the Talons given to Eagles, tho' they are of the Eagle-kind. However their beak is strong enough to tear off the Hide, and rip up the Bowels of an Ox.

What a blessing is it to Mankind, that there are but few (just enough to keep up the Species) of this Monster in the feathered Creation! And into what can we resolve this, but the wise and over-ruling Care of an adorable Providence?

The smallest of all birds is the *Humming-bird*, but of the most beautiful, lively Colours of any. It flies very swiftly, and in flying makes a Noise like the Humming Bee. It can sustain itself a long time on the Wing, and in that posture, thrusts its little Beak into the Flowers, the Juices of which it sucks and feeds on. As it has no Food but this, there is no keeping it alive, but all die that are taken.

They are naturally very gentle; but when they neſtle they are very fierce, and will chaſe the largeſt Birds that come near their Neſts. This they can eaſily do as their ſwift Flight enables them, to attack their Adverſary in any Part, and yet fly on, but they generally attack the Eyes, and other tender Parts. They fly to and fro, backward and forward, in an inſtant, often with their Bodies perpendicular. And frequently ſo ſwift that you cannot obſerve them, nor know what Courſe they take, but by the noiſe they make in cutting the Air.

Their Egg is of the ſize of a Pea. They make their Neſt chiefly of Cotton, or the Down of Plants intermixt with a few hairs, and a little fine Moſs. And theſe they commonly faſten to the branch of an Orange or Lemon-tree, where they are well covered by the foliage, and the larger Branches.

The *Indians* make Pictures with the Feathers of theſe Birds, which are ſo brightly coloured, as to vie with the fineſt Paint, and ſo thin, that they look like Colours on Canvas.

The *Stork* is a Bird of Paſſage, and goes away toward Winter to the Southern Countries. It has a very long Beak, and long red Legs. It feeds on Serpents, Frogs and Inſects. As it ſeeks for theſe in watry Places Nature has provided it with long Legs. And as it flies to the Neſt with its Prey, its Bill is ſtrong and jagged, to hold faſt what it has taken. She likewiſe digs with her Bill into the Earth for Snakes or Adders, which ſhe carries to her Young. Moſt of her Feathers are white. She lays but four Eggs, and ſits for thirty Days.

But what renders this Bird moſt remarkable is, its ſteady Love to its Parents. It never forſakes them when they are old, but tenderly feeds and defends them, as long as they live.

The following Adventure of a tame Stork ſome Years ago in the Univerſity of *Tubingen*, ſeems to ſhew a degree of underſtanding, which one would ſcarce expect in the Brute-Creation. This Bird lived quietly in the Court Yard, till Count *Victor Gravenitz*, then a Student

Student there, ſhot at a Stork's Neſt, adjacent to the College, and probably wounded the Stork then in it. This happened in Autumn, when foreign Storks uſually leave *Germany*. The next Spring a Stork was obſerved on the Roof of the College, which after a time came down to the upper Gallery, the next day, ſomething lower, and at laſt, by degrees, quite into the Court. The tame Stork went to meet him with a ſoft chearful Note, when the other fell upon him with the utmoſt Fury. The Spectators drove him away; but he came again the next day, and during the whole Summer, there were continually Skirmiſhes between them. The Spring following, inſtead of one Stork, came four, and attacked him all at once. A ſurprizing Event followed. All the Turkies, Ducks and Geeſe, that were brought up in the Court, ran together, and formed a kind of Rampart round him, againſt ſo unequal a Combat. This ſecured him for the preſent. But in the beginning of the third Spring, above twenty Storks ſuddenly alighted in the Court and before the poor Storks Life-guards could form themſelves, or the People come to his Aſſiſtance, they left him dead on the Spot: Which none could impute to any thing but the Shot fired by Count *Victor* at the ſtrange Stork's Neſt.

The *Pelican* ſomewhat reſembles a Swan. The Body is as large, the Neck nearly as long, the Legs are ſhort, and the feet are black, broad and webbed in the ſame manner. It is alſo of a whitiſh Colour, only the tips of ſome of its Feathers are black It is much in the Waters. It has a moſt horrid Voice, like that of a man grievouſly lamenting.

Its Beak is above a foot in length, and the point is very ſharp. The upper Part is formed as in other Birds; but the Lower is unlike every thing in Nature. It is made of two long, flat Ribs, with a tough Membrane connected to One and the other. This reaches alſo to the Throat, and is very broad and looſe, ſo that it can contain a vaſt Quantity of Proviſion.

It frequents both freſh and ſalt Waters, and feeds on Fiſh. Yet its favourite Reſidence is in wild, remote Foreſts, where it may remain undiſturbed; and it eaſily flies, having

having ſtrong Wings, backward and forward. Here it builds and breeds its Young: And hence it is ſtiled "The Pelican of the Wilderneſs." Hither ſhe is to bring food for a numerous Brood; and for this End the Bag at her Throat is provided. In this ſhe ſtores what ſhe has caught and flying away to her Neſt, feeds her Young out of her Storehouſe. And hence aroſe the Tale, ſo commonly believed, of her feeding them with her own Blood.

In the Year 1745 a Pelican brought from the Cape of *Good Hope*, was ſhewn in *London*. The Pouch at its throat was ſo large, that the Keeper put his Head into it.

THAT which in *Iceland* they call the *Down-bird*, is very remarkable. It is a Species of Duck, but covered with fine, ſoft, downy Feathers. The Drake is full as large as a Gooſe, but the Duck conſiderably ſmaller. They abound all over *Iceland*, but particularly the Weſtern Part, on account of the Iſlands off the coaſt, where chiefly they build their Neſts. They build them with the Down they pull from their breaſt: They lay four green Eggs, as large as a Gooſe. The Inhabitants then take away both the Eggs and the Neſt. The Ducks go to work again, pull more Down from their Breaſts, and lay four Eggs more, which are again taken away by the Inhabitants. This does not however diſcourage the Duck. She builds a third Neſt, and lays four more Eggs: But the Drake is now obliged to Supply the Down, the Duck having none left. They now let her hatch her Young: for if they diſturb her the third time, ſhe builds no more that Year, nor ever returns to the ſame place. When the Young have left the Neſt, they take it a third time, and ſo have two ſets of Eggs, and three Parcels of Down from the ſame Neſt.

THE *Bat* ſeems a Medium between Bird and Beaſt. But it comes nearer to the Latter. They lay themſelves up and ſleep for the Winter-Months, in the dryeſt Parts of Caves. There fixing their Talons in the Roof, they cover their Bodies with their Wings, and hang perpendicularly in great Numbers, but ſo as not to touch each other.

8. I HAVE now only to add a few Reflections.

AND

And, 1. That Birds ſhould all lay Eggs, and not bring forth live Young, is a clear Argument of Divine Providence, deſigning their Preſervation thereby. For if they had been Viviparous, had they brought any number at a time, the Burden of their Womb muſt have been ſo great and heavy, that their Wings would have failed, and they become an eaſy Prey to their Enemies. And had they borne but one at a time, they would have been bearing all the year.

2. Since it would have been many ways inconvenient to Birds to give ſuck, and yet inconvenient, if not deſtructive to the new-born Chick, to paſs ſuddenly from liquid to hard Food, before the Stomach was ſtrengthened and able to digeſt it, and before the Bird was accuſtomed to uſe its Bill and gather it up, which it does at firſt very ſlowly and imperfectly: Therefore Nature has provided in every Egg a large Yolk, which ſerves the Chicken a conſiderable time inſtead of Milk. Meantime it feeds by the Mouth a little at a time, and that more and more, till the Stomach is ſtrengthened to digeſt it.

3. Birds that feed their Young in the Neſt, tho' they bring but one Morſel at a time, and have perhaps Seven or Eight, which all at once, with equal Greedineſs, hold up their Heads and gape; yet never miſtake, never omit One, but feed them all by turns.

4. Tho' Birds cannot number, yet are they able to diſtinguiſh many from few. And when they have laid as many Eggs as they can cover, they give over, and begin to ſit. Yet they are not determined to ſuch a number: they can go on and lay more at their pleaſure. Hens, for inſtance, if you let their Eggs alone, lay fourteen or 15, and give over. But if you withdraw their Eggs daily, they will go on, to lay five times that number. This holds not only in Domeſtic Birds, but alſo in the Wild. A Swallow, when her Eggs were withdrawn daily, proceeded to lay Nineteen.

5. It is remarkable, that Birds, and ſuch other oviparous Creatures as are long-lived, have Eggs enough conceived in them at firſt, to ſerve laying for many Years, allowing ſuch a proportion for every Year, as will ſuffice for one or two Incubations. Whereas Inſects,

which are to breed but once, lay all their Eggs at once, be they ever so many.

6. How exceeding speedy is the Growth of Birds that are fed by the Old ones in the Nest! Most of them come to near their full Bigness, within the short term of a Fortnight: An admirable Provision, that they may not lie long, in that helpless Condition, exposed to the Ravine of any Vermin, and utterly unable to shift for themselves.

7. What amazing Care do the Parents take, for the hatching and rearing of their Young? First they seek out a secret and quiet place, where they may be undisturbed in their Incubation. Then they make their Nests, every one after his kind, that their Eggs and Young may be soft and warm: And those so elegant and artificial, as no Art of Man can imitate.

"I have seen, says Mr. *Ray*, the Nests of an Indian Bird, composed of the Fibres of some Roots curiously platted together, which they hang on the End of the Twigs of Trees over the Water, to secure their Eggs from Apes, Monkeys and other Beasts." After they have laid their Eggs, how diligently do they sit upon them, scarce giving themselves time to go off, to get them Meat? When the Young are hatched, how diligently do they brood over them, lest the Cold should hurt them? All the while labouring hard to get them Food, and almost starving themselves, lest they should want. Moreover, with what Courage are they inspired, so as to venture their own Lives in defence of them? The most timorous, as Hens and Geese, daring then even to fly in the face of a Man. And all these pains are bestowed upon those that will render them no thanks for it! And they are bestowed just so long as is necessary. For when the Young is able to shift for itself, the Old retains no such Affection for it, but will beat it indifferently with others.

8. It is another Proof of a superintending Providence, that all Animals are produced, at the most convenient time of the Year, just when there is Food and Entertainment ready for them. So Lambs, Kids and many other living Creatures, are brought into the World in the Spring, when tender Grass and nutritive Plants are provided for their Food. The like may be observed concerning Silkworms,

worms, whose Eggs are hatched just when the Leaves of the Mulberry-tree appear: The Ailment being soft and tender, while the Worms themselves are so, and growing more strong and substantial, as the Insects increase in Bulk and Vigour.

9. A STILL farther Proof hereof we have in the various *Instincts* of Animals, directed to Ends which they know not, As 1. All Creatures know how to defend themselves, and offend their Enemies. All know what their natural Weapons are, and how to make use of them. A Boar knows the Use of his Tushes, a Horse of his Hoofs, a Cock of his Spurs, a Bee of her Sting. Yea a Calf will make a Push with his Head, even before any Horns appear. 2. Those Creatures which have not strength to fight, are usually swift of foot or wing, and are naturally inclined to make use of that Swiftness, and save themselves by Flight. 3. Every Creature knows and shuns its natural Enemy, as a Lamb does the Wolf, and Partridge or Poultry, Birds of Prey. And they make use of a peculiar Note, to warn their Young of their Approach, who thereupon immediately run to shelter. 4. As soon as ever it is brought forth, every Animal knows its Food. Such as are nourished with Milk immediately find their way to the Paps and suck Whereas those which are designed for other Nourishment never make any such Attempt. 5. Birds that are fin-toed, or whole-footed are naturally directed to go into the Water. So Ducklings, tho' hatched and led by a Hen if she brings them to the brink of a River or Pond, presently leave her and go in, tho' they never saw any such thing before; and tho' the Hen clucks and calls, and does all she can to keep them out. 6. Birds of the same kinds make their Nests of the same Materials, laid in the same Order, and exactly of the same Figure, so that by the Sight of the Nest one may certainly know what Bird it belongs to. And this, tho' living in distant Countries, and tho' they never saw any Nest made; that is, altho' they were taken out of the Nest and brought up by hand. Nor were any of the same kind ever known to make a different Nest, either for Matter or Fashion.

I WOULD add a little farther Improvement of ſome Particulars mentioned before.

WHAT Maſter has taught Birds, that they have any need of *Neſts?* Who has warned them, to prepare them in time, and not to ſuffer themſelves, to be prevented by Neceſſity? Who hath ſhewn them how to build? What Mathematician has given the Figure of them? What Architect has taught them to chuſe a firm Place, and to build on a ſolid Foundation? What tender Mother has adviſed them to cover the bottom with a ſoft and delicate Subſtance, ſuch as Cotton or Down, and when theſe fail, who has ſuggeſted to them that ingenious Charity, to pluck off as many Feathers from their own Breaſt, as will prepare a ſoft Cradle for their young.

AGAIN. What Wiſdom has pointed out to each Kind a *peculiar Manner* of building? Who has commanded the Swallow, to inſtance in One, to draw near to Man, and make choice of his Houſe for the Building her Neſt, within his view, without Fear of his knowing it, but ſeeming rather to invite him, to a Conſideration of her Labour? Nor does ſhe build like other Birds, with bits of Sticks and Stubble, but employs Cement and Mortar: And that in ſo firm a manner, that it requires ſome Pains to demoliſh her Work. And yet in all this, it has no other Inſtrument to make uſe of but a little Beak!

YET again. Who has made the Birds comprehend that they muſt hatch their Eggs by ſitting upon them? That this Neceſſity is indiſpenſable: that the Father and Mother could not leave them at the ſame time; and that if One went abroad to ſeek for Food, the Other muſt wait till it returns? Who has told them the preciſe number of Days, this painful Diligence is to Coſt? Who has taught them, to aſſiſt the Young in coming out of the Egg, by breaking the Shell for them? Yea, and advertiſed them of the very Moment, before which they never come?

WHO has taught ſeveral of the Birds that marvellous Induſtry, of retaining Food or Water in their Gullet, without ſwallowing either, and preſerving them for their Young, to whom this Preparation ſerves inſtead of Milk?

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Is it for the Birds, O LORD, who have no Knowledge thereof, that thou haſt joined together ſo many Miracles? Is it for the Men who give no Attention to them? Is it for thoſe who admire them, without thinking of Thee? Rather is it not thy Deſign, by all theſe Wonders, to call us to Thyſelf? To make us ſenſible of thy Wiſdom, and fill us with Confidence in thy Bounty, who watcheſt ſo carefully over thoſe inconſiderable Creatures, two of which *are ſold for a farthing?*

BUT paſs we from the Induſtry of Birds, to harken for a moment to their Muſick: the firſt Song of thankſgiving which was offered on Earth, before Man was formed. All their Sounds are different, but all harmonious, and all together compoſe a Choir which we cannot imitate. One Voice however more ſtrong and melodious I diſtinguiſh above the reſt. On inquiry I find it comes from a very ſmall Bird. This leads me to conſider the reſt of the Singing Birds. They likewiſe are all ſmall: The great ones having an harſh and diſagreeable Voice. Such an amends is made to theſe weak, little Creatures, for their Defect of Strength!

SOME of theſe little Birds are extremely beautiful, nor can any thing be more rich or variegated than their Feathers. But it muſt be owned, that all Ornament muſt give place to the Finery of the *Peacock*; upon which GOD has plentifully beſtowed all the Riches which ſet off the reſt, and laviſhed upon it with Gold and Azure, all the Shades of every other Colour. This Bird ſeems ſenſible of its Advantage, and looks as if it deſigned to diſplay all its Beauties to our eyes, when it Stalks along, and expands that ſplendid Circumference, which ſets them all in open view.

BUT this pompous Bird has of all others that are kept tame, the moſt diſagreeable Cry, and is a Proof, that there may be a ſhining Outſide, when there is little Subſtance within.

IN examining the Feathers of the reſt, I find one more Circumſtance very obſervable. The Feathers of Swans and other Water-fowl, are proof againſt the Water. And accordingly they continue dry, tho' the Creature ſwim or dive ever ſo long. And yet neither our Eyes

not all our Art can discover, wherein they differ from others.

I know not how to conclude this Chapter, without adding a few more Reflections.

All the Universe is repleniſhed with Life: and every Part of it, with its proper Animals. But would one expect to see them in the Air? Nothing ſeems more Natural to our Eyes: but nothing is more aſtoniſhing to our Reaſon. The Fact is certain, and yet might ſeem to be altogether impoſſible. A Bird in flight, is a Maſs raiſed aloft, in ſpite of the Gravity of the Air, and the Tendency of all Bodies to the Earth. This Maſs is raiſed, not by any foreign Force, but by a movement ſuited to the purpoſe of the Creature, and which ſuſtains it in the Air, for a conſiderable time, with a peaceful Vigour.

Again. In the whole Kingdom of Birds, none have more than Two Wings, and yet they all fly in a different manner. Some launch away by repeated Springs; others glide thro' the Air with an even Motion. Theſe always ſkim over the Earth; thoſe ſoar up to the Clouds. Some know to diverſify their Flight, by a ſtreight, oblique or circular motion: To ſuſpend their Bodies, and continue motionleſs in an Element lighter than themſelves: After this, to ſtart into an horizontal Motion, and then dart either to the right or left, wheel into a contrary tract, remount, and then precipitate themſelves like a deſcending Stone: In a word, they tranſport themſelves, without oppoſition, or hazard, wherever their Neceſſities or Pleaſures call them.

The Structure of their Neſts, the Care with which they attend their Eggs, the Mechaniſm of the Egg itſelf, and the Birth and Education of their young, are equally aſtoniſhing. See the perfect Similitude that appears in all the Neſts of Birds of the ſame Species, the conſtant Difference between the Neſts of one Species and another! Together with the Neatneſs and Precautions which all of them obſerve. One Species builds its Neſt on the top of Trees; another on the Ground, under a Canopy of Graſs: But always with a Shelter, either of Herbs, or a Branch, or a double Roof of Lea-

Leaves, down which the Rain slides, without entering the Opening, which lies concealed below. The outward Part of the Nest is made of solid Materials, Thorns, Reeds, Clay, or compact Mass: The inner of softer Materials, closely interwoven, so as to keep out both Winds and Insects. But each Species have a peculiar Taste. When the Building is completed, some hang the Inside with a Tapestry of Feathers, or quilt it with Wool or Silk.

How amiably does this display the Wisdom of Him who furnished Man with Reason, which extends to every thing around him, and inspired Animals with an imitation of it, limited indeed to a few points, but admirable in that limitation? For who informed the Bird, that she should lay Eggs, and want a Nest to lodge and nourish them with genial Heat? That this Heat would not be concentered round the Eggs, if the Nest were too large? And that were it smaller, it would not be capable of containing all the Young? Who has taught her not to miscalculate the Time, or lay her Eggs, before she has completed her Nest?

The same Wisdom will more fully appear, if we observe what the Egg contains, with the manner how the young is there formed, and how it issues from its Confinement.

The Yolk lies in the Heart of the Egg, inclosed in the First Membrane, which is surrounded by the Second. Near the Center of the Egg are the Ligaments that sustain the Yolk, which is contained in a peculiar Membrane. A second Membrane incloses the first White; a third and fourth encompasses the whole. The Shell is formed last of all, out of the Salts evacuated from all the Humours of the Body, which the Heat gradually fixes and consolidates, to serve a double purpose, first that it may be excluded without crushing the Contents; Secondly, to defend the tender Young, 'till it is throughly formed, and ready to forsake the Egg.

Under the Membrane which surrounds the Yolk, is a white Speck, which is the seed of the Chick, in Miniature. If the smallest portion of the vital Spirit be infused into it from the Male, by a process of which we have

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no idea, in the inſtant the Chick receives Life, and the whole Subſtance is in motion. If it is not infuſed, the Egg may indeed be laid, but it never comes to a living Creature.

The Pulſation of the Heart bears ſome analogy to the Pendulum of a Clock, from whoſe Vibrations the whole Machine derives all its Motions. The moment the Heart begins to beat, the Animal is alive, and receives by the umbilic Duct, the nouriſhment which it tranſmits to the other Veſſels, whoſe Branches diſtribute it to the whole Body. All thoſe little Canals, which were flat before, are now ſwelled and inlarged. The whole Subſtance imbibes a proper Aliment, and the Chick begins to grow.

In this Situation of the Speck out of which it is formed, one Circumſtance is highly remarkable. This minute Particle which is lodged on the Film that includes the Yolk, is always near the Center of the Egg, and toward the Body of the Dam, in order to be impregnated with a neceſſary Warmth. But in how admirable a manner is this effected? The Yolk is ſuſtained by two Ligaments, which faſten it on each ſide to the common Membrane, that is glued on the Shell. A Line drawn from one Ligament to the other, would not paſs thro' the middle of the Yolk, but above the Center, and cut the Yolk into two unequal Parts, ſo that the ſmaller Part, which contains the Seed, is of neceſſity raiſed toward the Belly of Birds that ſit: The other Part as neceſſarily ſubſides, ſo that let the Egg turn as it will, the Young receives no Hurt, but ſtill enjoys a Warmth, that puts all about it in motion. So it feeds at eaſe, firſt on the White, which is more thin and delicate, and afterwards on the Yolk, which affords a more ſubſtantial Nouriſhment. When his Bill is hardened, and he grows uneaſy at his Confinement, he pecks and breaks the Shell and iſſues out, fully repleniſhed with the Yolk, which nouriſhes him a little longer, till he is ſtrong enough to raiſe himſelf upon his feet, and can march about to look for Proviſions.

CHAP.

CHAP. III.

Of Fishes.

1. *Of Fishes: their Conformation:*
2. *Their Brain:*
3. *Organs of Sense:*
4. *Gills or Lungs:*
5. *Heart:*
6. *Of Shell-fish:*
7. *Of the Generation of Fish:*
8. *Of some particular Sorts of Fish:*
9. *Some General Reflections.*

1. THE Variety of Fishes is abundantly greater than even that of Birds. A world of Wisdom appears in the Structure of them, and their conformation to the Element they are to reside in. Their Bodies are either thin, or long and slender, for their more easy swimming and dividing the Water. They are cloathed suitable to their respective Circumstances, the Dangers they are exposed to, and the Motions they are to perform. The Center of Gravity is placed, in the fittest Part of the Body, which is smooth, sharper before and tapered off, in order to make its Way the more commodiously. They have *Fins* made of grisly Spokes, firmly connected by Membranes, which they are able to contract or dilate, like a Woman's Fan. These are furnished with Muscles for Motion; but their chief use, is to balance and keep the Body upright; as appears, in that when they are cut off it wavers to and fro. Their *Air-bladder*, which they can either dilate and fill with Air, or contract and empty at their will, enables them to rise or sink, or sustain themselves at any Height in the Water at their pleasure. The great Strength by which they dart themselves forward, like an Arrow out of a bow, lies in their *Tails*; their Fins meantime, lest they should retard their Motion, being held close to their Bodies. And therefore almost all the Muscular Flesh they have, is bestowed upon the Tail and Back. Their Eyes are peculiarly formed to correspond with all the Convergencies and Divergencies of Rays, which the Variations of the watry Medium, and the Reflections thereof may occasion.

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2. It is obſervable in all, That tho' their Heads are much larger in proportion to their Bodies, yet their *Brain*, is conſiderably leſs, than that of other Animals. It conſiſts of only two ſmall Ventricles, placed in the Forepart of the Head.

3. Their *Organs of Senſe* do not much differ from thoſe of other Animals. But in their *Eyes* this is peculiar, That they are quite Spherical, and that the Optic Nerves in coming from the Brain, croſs each other: Whereas in other Animals, they incline a little to each other, but do not meet. [1] It was formerly believed, they did not *hear* at all. But from later Experiments, there is reaſon to believe, that ſeveral Species of them do hear, tho' but in a low Degree. Over the two Holes in their Head which ſerve for *Smelling*, a fine Membrane is ſpread, by which means they can open and ſhut them at pleaſure; a Contrivance highly neceſſary for Creatures that live in the Water.

4. Some Fiſhes have *Lungs*. But in the greater Part the place of them is ſupplied by *Gills*. As we take in and throw out the Air by our Lungs, ſo they take in the Air, mixt with the Water by their Mouth, and throw it out by their Gills.

There is always much Air incloſed in Water. This the Gills ſeparate from it, and preſent to the Blood, as it is preſented in the Lungs of other Animals. Each Gill contains a great number of bony Laminæ, conſiſting of an infinity of bony Fibres, that ſuſtain the innumerable Ramifications of the Veins and Arteries, which preſent the Blood extremely ſubdivided, and as it were, each Globule by itſelf to the Water: Between theſe Laminæ, thro' the whole Contexture of the Gills, are an infinity of very narrow Paſſages, which receive and divide the Water taken in by the Mouth, into minute Partieles. Then the Air, its Priſon-doors being in ſome meaſure

[1] A protuberant Eye would have been inconvenient for Fiſhes, by hindering their Motion in ſo denſe a Medium. And their continually bruſhing thro' the Water, would have been apt to wear their Eyes. Therefore their Cornea is flat. But To make amends for this, and for the Refraction of Water, different from that of Air, the wiſe Creator has made their Chryſtalline Spherical, which in other Animals is more flat.

measure opened, escapes and joins the Blood of all the little Arteries.

The Gills have an alternate Motion of Dilatation and Compression. When they dilate, the Water is taken in; when they contract, it is driven out. It seems, that in the Instant of Contraction, the Air expresst from the Water is forced into the Blood-vessels. It is the same, as to our Lungs. The Air enters them at the Time of Inspiration, but is received into the Blood at the time of Expiration only. So that the Water which is taken in by the Mouth of Fishes, when stript of its Air, is carried off by the Gills. Meantime the Air which thus gained, is distributed first to those fine Ramifications of the Arteries, which are expanded upon the Gill throughout, and then to the Veins inosculated therewith. And Fishes can no more live without a constant Supply of this, than Land-Animals can.

The Gills in all Fishes are Eight, Four on each side. The lower Gill is always smaller than the rest. The other three on each side are gradually larger to the top-one, which is always the largest. Each of these is formed of a bony Substance, bent into the Shape either of a Semicircle, or a Bow. On the convex Side of this, there is a sort of Plumes or Leaves, each of which consists of a double Row of bony Lamellæ, formed like so many Sickles, and fixt to the convex Side of the Bow by means of the Membrane wherewith it is covered.

These Lamellæ have one Part convex, the other concave. The convex side is covered with numerous Hairs. The Concave Part of each Lamella is applied to the convex Part of the next opposite Lamella. Every Lamella is invested with a fine Membrane, which receives the Ramifications of the Blood vessels. Every Gill has an Artery, a Vein and a Nerve. The Gills receive the Blood which is thrown from the Heart into the Aorta, and derive it to the utmost Parts of the Lamellæ, from whence it returns by Veins which distribute it throughout the Body.

5. In most Fishes the *Heart* is like that in other Animals. But in some it has only one Ventricle; which necessarily occasions a Difference in the manner, wherein the Blood circulates. In some also the Blood is not red but clear

clear and transparent. In others, especially Shell-fish, besides the Arteries and Veins, there are open Tubes, which convey the Water to the farthest Part of them: Probably that they may find no Want of Water, when they continue some time on shore.

6. It has long been supposed that all Shells, as well as the Animals in them, arose wholly from the Egg. But it is now found by various Experiments, That the Shells of Snails (and probably of all other Animals) are formed of a Matter which perspires from their Bodies, and then condenses round them.

'Tis certain, all Animals perspire and are encompast with an Atmosphere which exhales from them. Snails have nothing peculiar in this respect; unless that their Atmosphere condenses and hardens about them, and forms a visible Cover for the Body, while that of other Animals evaporates. This Difference may arise from the different Substance perspired, that from Snails being viscous and stony. This is no Supposition, but a Matter of Fact, proved by numerous Experiments.

Tho' therefore the Shell serves for an universal Bone, yet it does not grow like other Bones, by a Juice circulating within itself, but by an external Addition of Parts, laid over one another.

But the *Re-production* of the Shells of some Fish, yea, and of the Parts contained therein, is far more strange and unaccountable, than their First Production. This is particularly observed in Crabs and Lobsters. Lobsters cast their Shell yearly, sometime after Midsummer. In the room of the old, a new, thin Shell is immediately prepared by Nature, which in less than Eight Days, acquires almost the same Degree of Hardness as the other.

The Legs of a Lobster consist of five Articulations. When any of these Legs break, which frequently happens, the Fracture is always near the Fourth Joint, and what they lose is precisely re-produced in some time after: Four Joints shooting out, the first whereof has two Claws, as before.

If a Leg be broken off purposely at the fourth or fifth Joint, it is constantly re-produced: But very rarely, if at the first, second or third Joint. What is still more surprizing is, That upon visiting the Lobster, which was maimed

maimed in these barren Articulations, at the end of two or three days, all the other Joints are found broken off at the Fourth, which he has undoubtedly done himself.

The Part re-produced is perfectly like that broke off, and in a certain time grows equal to it. Hence it is, that Lobsters have often their two big Legs unequal. This shews the smaller Leg to be a New one. If a Part thus re-produced is broken off, there is a second Re-production. The Summer, which is the only Time when Lobsters eat, is the most favourable Time for this. It is then performed in four or five days; Otherwise it takes eight or nine Months.

The common Crab-fish has its abode from twenty to forty Fathom Water. They herd together in distinct Tribes, and have their separate Haunts for feeding and breeding, and will not associate with their Neighbours. This has been tried, by marking a Crab, carrying it two or three Miles, and leaving it among other Crabs. This Crab has afterward found its way home, and been caught in its old Abode.

This Creature too can break off its own Limbs. If when it is laid on its back, one of the outer Joints of a small Leg be bruised, he shews uneasiness, by moving it about. Afterward he holds it quite still, in a direct and natural Position, without touching any Part of the Body, or of the other Legs with it. Then on a sudden with a gentle Crack, the wounded Part of the Leg drops off. If an Hole be pierced in the Great Leg, the Effect will be the same; and the large Limb is thrown off in the same manner, only with greater Violence. A Mucus then overspreads the Wound, which presently stops the Bleeding; and a small Leg is by degrees produced, which gradually attains the size of the former. Nature has given this singular Power to these Creatures, for the Preservation of their Lives in their frequent Quarrels. In these, one Crab lays hold of the Claw of another, and crushes it in such a manner, that it would bleed to Death, had it not the Power, of giving up the Limb and healing the Wound.

One of the most extraordinary kinds of Shell-fish is the *Animal-Flower* in *Barbadoes*. In the Parish of St.

Lucy, on the North Side of the Iſland, there is a high rocky Cliff fronting the Sea, near the bottom of which is a large Cave. This opens into another Cave, the bottom of which is a baſon of Water. In the midſt of this Baſon is a rock, always covered with water: On the ſides of which, a few inches below the Water, are ſeen at all times of the Year, iſſuing out of little holes, what have the appearance of finely-radiated Flowers, in ſize, colour and ſhape greatly reſembling a common Marygold.

If you attempt to pluck one of theſe, as ſoon as your fingers come within two or three inches of it, it contracts, cloſes up its Border, and ſhrinks back into the hole of the Rock. But if left undiſturbed for a few Minutes, it iſſues again, and ſoon appears in full bloom. This might induce one to believe, that it was no other than an aquatic Senſitive Plant.

But on a nearer Inſpection we may diſcern four dark-coloured Filaments, riſing from the Center, moving with a quick and ſpontaneous Motion, and frequently cloſing, to ſeize its Prey, much like the Claws of a Lobſter. So that the ſeeming Flower is really an Animal; And its Body, which appeared to be the Stalk of the Flower, is black, about as big as a Raven's Quill.

It ſeems the vivid, yellow colour of its Feelers, is abſolutely neceſſary to procure its Food. The Water in the Cave having no Motion, cannot bring any food to them. Therefore the Creator has endued this Creature with a Quality which may allure its Prey. For bright Colours invite many aquatic Animals, as the Flame of a Candle does Flies.

7. As to the *Generation* of Fiſhes, ſome of them are Viviparous, others Oviparous. The Womb and Ovaries of moſt Fiſhes, are not unlike thoſe of Birds. The Female caſt out innumerable Eggs, in the Sea, in Lakes, in Rivers. Great Part of theſe are devoured by the Males. The reſt are hatched by the Warmth of the Sun, and the young ones immediately Swim away, without any help from the Parent.

Sea-tortoiſes lay their *Eggs* on the Sea-ſhore, and cover them with the Sand. It is not uncommon to ſee a great number

number of young Tortoiſes riſe out of the Sand, and without any Guide or Inſtructions, march with a gentle pace toward the water. But the Waves uſually throw them back upon the Shore, and then the Birds deſtroy the moſt of them. So that out of two or three hundred of them it is ſeldom that Ten eſcape.

It ſeems at firſt view, that Nature, in this inſtance, charges herſelf with unneſſary Expence. But a little reflection ſhews the contrary. We do not complain of the fertility of an Hen, which frequently lays above Two Hundred Eggs in one Year: Altho' it may be, that not one Chick is hatched out of all theſe. The Deſign of the Author of Nature is plain; not barely to preſerve the Species, but at the ſame time, to provide Man and other Animals with an excellent Food. So his Intention in the Fertility of a Tortoiſe, is, not barely to continue that Species, but to accommodate a number of other Animals with Food convenient for them.

But whence could ariſe the common Opinion, concerning the Generation of *Soles*? Namely, that they are produced from a kind of *Shrimps* or *Prawns*? A *French* Gentleman being determined to try, put a large Quantity of Prawns, into a tub about three feet wide, filled with Sea-water. At the end of twelve or thirteen days, he ſaw there eight or ten little Soles, which grew by degrees. He repeated the Experiment ſeveral times, and always found little Soles. Afterwards he put ſome Soles and Prawns together in one Tub, and in another Soles alone. In both the Soles ſpawned; but there were no little Soles, only in the tub where the Prawns were.

But how can Prawns be of uſe toward producing Soles? Farther Obſervation cleared up this. When Shrimps or Prawns are juſt taken out of the Sea, you may diſcern between their feet many little Bladders, which are ſtrongly faſtened to their Stomach, by a kind of Glue. If you open theſe bladders gently, you ſee a ſort of Embryo's, which viewed with a Miſcroſcope, have all the Appearance of Soles.

Now here lies the Myſtery. Theſe are the Eggs or Spawn of Soles, which in order to hatch, are faſtened

to the Shrimps or Prawns: Like many Plants and Animals, which do not grow or receive Nourishment, but upon other Plants and Animals. The Prawns therefore are the Foster-mothers of Soles, during their First Infancy. And this has occasioned many to imagine, they were their real Mothers.

The coming of certain kinds of Fish in Shoals to certain Coasts, at a certain time of the Year, is of great Advantage to Mankind. But the Reason of it has been little understood. Yet Observation may clear it up. There is a small Insect common in many Seas, particularly on the coast of *Normandy*, in June, July, and August. They then cover the whole Surface of the Water as a Scum. And this is the Season when the Herrings come also in such prodigious Quantities. The Fishermen destroy much of these Vermin; yet to these alone their Fisheries are owing. For it is evident the Herrings feed on these, by the Quantities found in all their Stomachs. And doubtless, the very Reason of their Coming is to feed upon them. Probably the case is the same in all other Places, where the Herrings come in the same Plenty.

The numberless Swarms of Herrings, Cod and other Fish, that come forth yearly from their Shelter, under the Ice adjoining to the north Pole, divide themselves into three Bodies. One Part direct their Course Southward, toward the *British* Islands: Another Part Westward, toward *Newfound-land*, and other places in *North-America*: And the third Part along the Coast of *Norway*, and then thro' the *Sound* into the *Baltic*.

The Water, tho' quite still before, curls up in Waves wherever they come. They crowd together in such numbers, that they may be taken up by Pail-fulls.

A large Shoal of Herrings, reaches (according to the Fishermens Account) an hundred, or two hundred fathom deep. They extend also to a considerable Circumference. Were they all to be caught, the greatest Part would be lost. For it would be impossible to get hands, tubs, salt, and other Necessaries to cure them.

them. Several Hundred Ship-loads are ſent every year from *Bergen* alone to foreign Parts: Beſide the Quantities that the Peaſants at home conſume, who make them their daily Proviſion.

Mackrels come in the ſame Numbers at certain times of the Year; and for the ſame Reaſon. They are particularly fond of a Sea-plant, the *narrow-leaved, purple Sea-wick*, which abounds on the Coaſts of *England*; and is in its greateſt perfection, in the beginning of Summer: Tho' at ſometimes later than other, according to the Severity or Mildneſs of the Winter.

The chief Occaſion of their coming is to feed on this Plant. And thoſe who attend to its growing up, would know when to expect the Mackrel, better than thoſe who liſten for Thunder. [1]

[1] But this is not the ſole occaſion of their coming. The real truth is this. The Sea near the Pole is the native Country of all *Fiſh of Paſſage*. The Ice which continually covers that Sea, affords them a ſafe retreat. Large, voracious Fiſh, want a free Air for Perſpiration, and cannot purſue the ſmaller ſort into their Sanctuaries, where they multiply ſo prodigiouſly, that at length for want of ſubſiſtence, they are forced to quit their Retreat. The large Fiſh wait for them at the Extremity of the Ice. They devour all they can catch, drive them cloſe into the Coaſts, while the Birds of Prey pour down upon them from all quarters. In conſequence of this Perſecution their March is always in Columns, which are commonly as thick as they are broad. With regard to the *Herrings*, they quit the Ice in the beginning of the Year. But the prodigious Column which they form, ſoon divides into two Wings. The Right moves weſtward, ſo as to be near *Iceland*, in the Month of March. The Left bends its courſe eaſterly, and comes down the North Sea to a certain Latitude, where it divides into two other Wings, the Eaſternmoſt of which coaſts along *Norway*. Hence it ſends off one Diviſion, by the Strait of the *Sound*, into the *Baltic*, another toward the Country of *Holſtein*, *Bremen*, &c. and thence into the *Zuderzee*. The Weſtern Wing, which is the largeſt, falls directly upon the Iſles of *Shetland* and the *Orkneys*. And thither the *Dutch* go, to wait their coming. All that eſcape theſe dextrous Fiſhers, go on toward *Scotland*, and dividing again into two Columns, one paſſes to the Eaſt of that Kingdom, and goes round *England*, detaching numerous Diviſions to the Coaſts of *Frieſland*, *Holland*, *Zeeland*, *Flanders* and *France*, while the other moves to the weſtward of *Scotland* and *Ireland*. The remains of the whole Weſtern Wing, which have eſcaped the nets of the Fiſhers, and the voracity of other Fiſh and Fowl, having at length rallied in the Channel, the Column is

The *Tunnies* come in equal Shoals at certain Seasons, to the Coasts of *Provence* and *Languedoc*. But it is on another occasion. The Fish called by the *French* the *Emperor*, is the great Enemy of these Fish. He is in summer so plentiful in those Seas, that they cannot escape him but by flying to the shallow Waters.

The *Pilchards* catched on the Coast of *Bretany*, are still a stronger Proof, of the Natural Means that bring fish in Shoals to certain Places. The People of *Bretany* purchase from *Norway*, the Offals and Entrails of all the large Fish caught there. These they cut in pieces, and straw in vast Quantities on the Sea along their Coasts. This always brings thither Shoals of Pilchards, enough to supply all the maritime Places in the Neighbourhood.

The *Salmon* (bred both in the Sea, and in Rivers) is another Fish, which comes in Shoals at certain times. But this is on another occasion. The Female Salmon chiefly ejects her Roe at the Mouth of Rivers, in Shallow Water. The Male comes presently after, keeps other Fish from devouring it, and casts his Sperm upon the Roe. They are in great Plenty from the middle of April till the middle of July; at which time also they come in Shoals into the Rivers, partly to refresh themselves in fresh Water, and partly to rub or wash off in the strong Currents, a greenish Vermin, called *Salmon-lice*; Insects wisely designed by the Creator, to drive this rich and valuable Fish, into the Hands of Men.

The Salmon when they are going up the Rivers out of the Sea, always swim as near the bottom as they can. And on the contrary, when they are going down them

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formed anew; and then issues into the Ocean: From which (without shewing itself again on the Coasts) it regains, like the Remains of the first Western Wing, which had not travelled so far, the Polar Ice, at the Approach of Winter. And under the protection of this, the loss is repaired, which the Species had suffered since they left it.

Thus does the Divine Wisdom supply many thousands of men with food, as well as numberless other Animals: And yet prevent any Decay of that necessary Provision, which is continually consumed and as constantly recruited!

them into the Sea, they always swim near the Surface. The Reason is, in going up, they swim against the Current, which always runs swifteſt at the Surface. When they are going down on the Surface, the Current alone is ſufficient to carry them.

8. One particular Inſtance of the Divine Care, is obſervable in the *Turbot*. Having no Air-bladder, he is not well able to ſwim, eſpecially in ſtormy Weather. He muſt then keep at the bottom, and lick in the Sand. And for that reaſon, he is provided, with a Skin or Membrane which draws over his Eyes, to keep the Sand out of them.

In Fiſhes of the *Whale-kind*, the Tail has a different Poſition from what it has in all other Fiſhes. For whereas in theſe it is erected perpendicular to the Horizon, in Them it lies parallel thereto; Partly to ſupply the Uſe of the Hinder Pair of Fins, which theſe Creatures have not, and partly that they may be able to raiſe or depreſs their Body at pleaſure. For it being neceſſary they ſhould frequently come to the Top of the Water, to take in, or let out the Air, they are provided with an Organ to facilitate their Aſcent and Deſcent as they have occaſion. And as for turning their Bodies in the Water, they perform that as Birds do; by ſtrongly moving one of their Fins, while the other is quieſcent.

8. The *Norway Whale* is frequently Sixty or Seventy foot long. His Shape pretty much reſembles that of a Cod: He has a large Head, and ſmall Eyes in proportion. On the top of the Head are two Openings, thro' which he ſpouts out the Water (which he takes in, as he breathes) like a large Fountain, which makes a violent Noiſe.

His Skin is ſmooth and not very thick. The Colour of his Back is dark and marbled. His Belly is white. His Throat is very narrow, in proportion to his Size. Under his Backbone lies a long Bladder, which he dilates or contracts, as he pleaſes. He rows himſelf with his Tail. They copulate after the manner of Land-Animals.

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THE Female brings forth but one or two at a Birth, at which time they are nine or ten foot long. They ſuck for ſome time: When they are tired with Swimming, ſhe carries them between her great Fins. Under the Skin lies the *Blubber* or Fat. Its uſual Thickneſs is about ſix Inches: But about the under Lip it is found two or three feet thick. Out of this the Oil is extracted. One Whale ordinarily yields 40 or 50, ſometimes 80 or 90 hundred weight.

THE Uſe of Blubber ſeems to be, partly to poiſe the Body and make it equiponderant to the Water; partly to keep the Water at a diſtance from the Blood, leſt it ſhould be chilled by its immediate Contact; and partly to keep the Fiſh warm, by reflecting the hot Steams of the Body, and ſo redoubling the Heat.

UNDER the Fat is the Fleſh, of a reddiſh Colour. Their general Food, is certain ſmall Inſects, which float upon the Water in great Heaps, and are no larger than Flies. But they likewiſe eat various Sorts of ſmall Fiſh, particularly Herrings, which they drive together in large Shoals, and then ſwallow vaſt Quantities at a time. The Whale commonly goes under the Shoal; then opens his Mouth and ſucks in all he can. Sometime he ſwallows ſo many, that he is ready to burſt, and ſets up an hideous Roar.

BUT he is far more troubled by a ſlender Fiſh about four feet long, which tears great Pieces of fleſh out of him. The Whale then not only makes a frightful Noiſe, but often leaps a conſiderable Height. In theſe Leaps he ſometimes raiſes himſelf perpendicular, above the Surface of the Water, and then plunges himſelf down with ſuch violence, that if his Head ſtrikes againſt any of the hidden Rocks that are in the Shallows, he fractures his Skull, and comes inſtantly floating up dead. So there is no Creature in the World ſo great or ſtrong as to be exempt from Calamities!

IT may not be unacceptable or unprofitable to thoſe who ſee GOD even in his loweſt Works, to add a ſhort Account of a few more Inhabitants of the Waters.

Flying-Fiſh are very rarely a foot long. They have a pretty large, tho' thin and light Head. The Mouth

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is generally open; the Body small, roundish and tapering toward the Tail: Beside the usual Fins, they have under their Necks, three broad and pretty long ones, of a more Subtle Structure, nearly as thin as a Fly's Wing, but strengthened with Rows of Bones. On the back Part of their Neck they have also a flying Fin, about six inches long, quite erect. And lower down the Back, there is another shorter, but broader. These Wings they use to escape the Pursuit of Creatures too powerful for them. They rise several Feet above the Water, and fly the length of two or three Musket shot. Then they drop, because their Wings are dry, which serve them no longer than they are moist.

The *Ink-Fish*, as some call it, has a still more extraordinary Way of escaping its Pursuers. "I have lately," says the Author of the Natural History of Norway, "procured a dryed one, which is two foot long. The Body is almost round, resembling a small bag, and is blunt at both Ends. But the Head is the most remarkable Part. It has two large Eyes and a Mouth like a Birds Beak. Above this stand eight Horns, like a Star. Each Horn is octangular, and covered with many small, round Balls, something larger than a pin's head. On each side of the Body there are two skinny Membranes, with which he can cover himself all over. The Fore-part of the Body is quite filled with a black Fluid. When it is pursued, it discharges this which colours the Water all around, and renders it invisible. This is a wonderful Gift of Nature, for the preservation of an Animal, otherwise utterly helpless.

The *Arborescent Star-fish* is another of the Curiosities of Nature. It is upwards of a foot in Diameter, having its Mouth in the middle. The Figure of the Trunk, is pentangular, and from the five Angles arise as many Branches, which subdivide into several others, and those again into others that are less, till the last are scarce thicker than Horse-hairs, and in number above a thousand. In swimming he spreads all these Branches like a Net; and when he perceives any Prey within them, draws

draws them in again, and so takes it with all the Dexterity of a Fisherman.

Full as surprizing a Creature is the *Torpedo*, a flat Fish, much like a Thorn-back. It is common on the Coasts of *Provence*, and is eaten without any ill Effect. But upon touching it with the Finger, the Person commonly (tho' not always) feels an unusual, painful Numbness, which suddenly seizes him up to the Elbow, and sometimes up to the Shoulder. It resembles, but far exceeds, the Pain felt by striking the Elbow violently against an hard Body. But it lasts only a few moments, and gradually wears away. If a Man touch it even with a Stick, he feels a little of it. If he presses his Hand strongly against it, the Numbness is the less. But it is so uneasy as to oblige him, very speedily to let it go. Many have attempted to account for this: But should we not rather, honestly own our Ignorance?

The *Sea-nettle*, so called, is another strange Production of Nature, common, I suppose, in all the Northern Seas. It generally swims on the top of the Water, and is throughout soft, smooth and transparent. It appears to be a lump of Slime or Jelly. But it co-heres firmly together, being marked in the middle with a Cross somewhat like a Flower-de-luce.

These Creatures are blue, white or red, and some of them have many Branches underneath. These are usually something larger than the common Sort, and are of a dark red. They all abound with a corrosive Poison, which if it drop on any Part of the Body, will cause a Smart and an Inflammation, much like that produced by Nettles. Hence it has its Name. However it is no Vegetable, but is evidently a living Creature. For it has Sensation: It grows, moves to and fro, contracts and extends itself. It often picks up and devours small Fish, and is itself devoured by others.

The Care of the Creator is observable, even in so inconsiderable a Creature as a *Limpet*, a small Shell-fish, which so fastens itself to the Rock, that scarce any thing can unloose its hold.

The Fact has long been known. But the Manner of its fastning itself, was not understood till very lately.

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Its Shell approaches to the Figure of a Cone; the Baſe of which is occupied by a large Muſcle, which alone has nearly as much Fleſh in it, as the whole Body of the Fiſh. This is not covered by the Shell, but ſerves the Creature equally to move forward or to fix itſelf to the Rock. When it is in a State of Reſt, which is the common Caſe, it applies this Muſcle every way round to the Surface of ſome Stone, and thereby holds itſelf fixt to it ſo firmly, that it is impoſſible to take it off with the hands. Thoſe who would remove them are obliged to make uſe of a Knife for that purpoſe. And even then it is not eaſy: For on whatever ſide the Blade of the Knife attempts to enter, the Fiſh immediately fixes its Muſcle with double Force to the Stone.

The true Cauſe of this Adheſion is a viſcous Juice, a kind of Glue, thrown out by this Muſcle, which tho' it is not perceptible to the Eye, yet is eaſily perceived by the Touch. For if immediately after the removing a Limpet from the Stone, the Finger be applied to the place, it is faſtened very ſtrongly to it, by means of the Glue left there. But if any Wet have come upon the Stone, ſince the Fiſh has been removed, no Viſcoſity can be perceived on it, the whole Subſtance of the Glue being immediately diſſolved. This Conſideration may lead us to obſerve the great Care of Nature over all her Works. How eminently is it manifeſted in this little Fiſh? It was abſolutely neceſſary for its Preſervation, that it ſhould have a Power of fixing itſelf to the Stone, or it would have been waſhed away by every Wave. And this Power is given it, by means of that Glue which fixes it ſo firmly. But when it is fixt, how ſhall it be looſed? This is equally neceſſary. For if there be not ſome Power in the Animal itſelf, to diſſolve this Glue, it muſt needs periſh for want of Food, when once fixt to a barren Spot. Water is the proper Diſſolvent of this Glue. But it cannot be the external Water. This is kept at a diſtance, by the cloſe Adheſion of the outer Rim of the great, circular Muſcle. And 'tis needful it ſhould: Elſe it would always diſſolve the Glue, as ſoon as it was diſcharged. But the under Surface of the Body of the Animal is covered all over with ſmall Tubercles, moſt of which

which contain Water. When therefore it would move, it has only to discharge a small Quantity of this Water, and the Cement immediately dissolves and sets it at liberty. The other Tubercles doubtless contain the viscous Matter. So that when the Animal would fix itself, it needs only to squeeze one set of its Tubercles, and when it would loose itself, the other.

One can hardly tell whether to rank the *River-horse* among Land or Water-Animals. He sleeps on Land, but passes all the rest of his time under Water. But in one respect he is different from all other Creatures, that live partly on Land and partly in the Water. All other Sorts of amphibious Animals have the Faculty of swimming; but this has not. He has to feed under Water, yet is the most unwieldy of all Creatures, and cannot swim at all. He comes out of the Water in an Evening to sleep: And when he goes in again, he walks very deliberately in overhead, and pursues his Course along the bottom, as easy and unconcerned as if it were in the open Air. The Rivers he most frequents are very deep, and where they are clear, this affords an astonishing Sight.

The River-horse is as tall as the tallest Horse; its Body much larger, and his Legs thicker and shorter. His Skin is quite naked, without Hair, and is black and very coarse. The Head is exceeding large, and his Mouth (which he has a way of opening very frequently, and of tossing up his Head at the same time) is the most terrible that can be imagined. His Teeth are blunt, but very thick and long, and are harder than any other Animal Substance. The Tail is short; and the Feet are not solid, like those of an Horse, but divided each into Four Toes.

An Animal of this Size and make, must be one of the strongest in the World. It therefore required from Nature no Swiftness, either to avoid Pursuit, or to overtake its Prey, as it was designed to feed on Vegetables. The Manner of its feeding is this. When he walks into a River, he seldom looks about till he is near the middle. Here he seeks for the larger Water-herbs, particularly for the root of a large Water-lilly. People from a Boat

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on the Surface frequently see this. He roots up these with his Nose, like an Hog, and his Mouth and Throat being very wide, swallows them in vast Morsels half chewed.

But he has frequently occasion to breathe; in order to which, when feeding at his Ease, his Custom is, every Ten Minutes, to rise to the Surface of the Water. This he does, by a Spring from the bottom, made with all his feet at once. Having taken a little fresh Air, and looked about him, he drops to the bottom again.

Another amphibious Animal, no less unwieldy than the River-horse, is the *Tortoise*. In several Countries they are small; but in the *East-Indies* they are five or six feet long. Having small and weak feet, they are exceeding slow in their Motions. They have neither Tongue, nor Teeth, nor any offensive Weapon. How then can they either take, how can they chew, or in any degree, comminute their Food? This is well provided for: they break not only Shells, but sometimes even Stones with their Lips: Which by their excessive Hardness effectually supply the Want of Teeth. But how can they defend themselves? Abundant Provision is made for this also. Their Shells more than cover the whole Body, and are of so firm a Texture, that a loaded Waggon may go over them, without any Injury either to the Shell or the Creature within it.

9. Upon the whole, how natural are the Reflections, which a late Writer makes on the Inhabitants of the Waters?

What an Abundance of Fish do the Waters produce? In these I seem to discern nothing but a Head and a Tail. They have neither Feet nor Hands. Nor have they any Neck: so that their Head cannot be turned at all, any otherwise than by turning the whole Body. Were I to consider their Figure only, I should think they were destitute of all that was necessary for the Preservation of their Life. But with these few outward Organs they are more nimble and dextrous, than if they had several Hands and Feet. And by the Use they make of their Tails and Fins, they are carried along like Arrows.

But as almoſt all Fiſhes prey upon each other, and cannot ſuſtain their own Lives, any otherwiſe than by continually deſtroying thoſe of their own Species, How can the Inhabitants of the Waters ſubſiſt? How can many Species eſcape utter Deſtruction? God has guarded againſt this, by multiplying them in ſo prodigious a manner. More than Three hundred thouſand Eggs have been counted, in the Roe of a ſingle Salmon. By this means, let them be deſtroyed ever ſo faſt, ſtill their Increaſe is equal to their Conſumption.

But who can explain, how the Inhabitants of the Sea enjoy their perfect Health, in the midſt of Water ſo loaded with Salt? And by what Art is it, that they preſerve even there, a Fleſh that has not the leaſt Taſte of it?

Why do thoſe which are fitteſt for the Uſe of Man, come and offer themſelves on our Coaſts? While ſo many that would be uſeleſs, if not pernicious, affect Remoteneſs from us.

Why do ſeveral of them, in their ſtated Seaſons, run up into our Rivers, and communicate the Advantages of the Sea, to ſuch Countries as are far diſtant from it? What Hand conducts them with ſo much Care and Goodneſs, but thine, O thou Preſerver of Men?

CHAP.

CHAP. IV.

Of Reptiles.

1. *Of their Motion:*
2. *Of Serpents:*
3. *Of their Brain, Stomach, Generation:*
4. *Venom:*
5. *Of some Particular Sorts of Reptiles.*

1 NOT far removed from Fiſhes are *Reptiles*, ſo named from their creeping, or advancing on the Belly. Many Species of them have Legs and Feet; but very ſmall in proportion to the Body. There is a world of contrivance in their Motion. The whole Body of the Earth-worm, for inſtance, is a Chain of annular Muſcles, or rather, One continued Spiral Muſcle, the orbicular Fibres whereof being contracted, make each Ring narrower and longer, by which means it is enabled, like the Worm of an Augre, to bore its Paſſage into the Earth. Its creeping may be explained by a Wire wound on a Cylinder. If this is taken off, and one End extended and held faſt, it will bring the other near it. So the Worm having ſhot out its Body, which is Spiral, takes hold by its ſmall Feet, and ſo brings on the hinder Part. Its feet are placed in a four-fold Row, the whole length of the Worm. With theſe, as ſo many Hooks, it faſtens to the Earth or whatever it creeps over, ſometimes this, ſometimes that Part of the Body, and ſtretches out or draws after it another.

2. THE moſt eminent Species of *Reptiles* are *Serpents*, which we may therefore particularly conſider. Their Bodies are of a very peculiar Make, having a Compages of Bones articulated together. Here Part of the Body is applied to the Ground, and the other Part ſhot forward, which being applied to the Ground in

its turn, brings the other after it. The Spine of their Back variously writhed, helps their leaping, (as the Joints of the Feet in other Animals.) They make their Leaps by means of the Muscles that extend the folds thereof.

3. Their *Brain* little differs from that of Fishes: But their *Stomach*, very much. It is like a loose Gut, which runs along, from the Jaws quite to the Tail. They have likewise solid Ribs and Vertebræ, at small Distances, from the Neck to the End of the Tail. Hereby they are enabled, to raise themselves up, to support, to writhe themselves into Rings, to spring forward, and to suck or swallow any things with surprizing Force. And their whole Flesh is of so close and firm a Texture, that they will live for some time, even after they are cut in pieces.

There is a great deal of Geometrical Nicety in the sinuous Motion of Serpents. For the assisting herein, the annular Scales under their Body are very remarkable, lying cross the Belly, contrary to those in the Back and the rest of the Body. Also the Edges of the foremost Scales lie over the Edges of the following Scales from Head to Tail. So that when each Scale is drawn back, or set a little upright by its Muscle, the outer Edge of it is raised a little from the Body, to lay hold on the Earth, and so promote the Serpent's Motion. But there is another admirable Piece of Mechanism, that every Scale has a distinct Muscle, one End of which is fixt to the middle of its Scale, the other to the upper Edge of the next Scale. There is nothing peculiar in the *Generation* of Serpents, most of which are oviparous.

4. *Vipers* and many other Serpents have small Bags near the Root of their Teeth, which contain the Poison. When they bite, this is squeezed out, by the Compression of those Bags. If they are taken out of a Viper, the Liquid they contain mixt with the Blood of an Animal, causes Death. But if taken in by the Mouth, it does no Harm, losing its Efficacy by mixing with other Liquids.

A Viper

A VIPER has the biggeſt and fatteſt Head of all the Serpent kind. It is uſually half an Ell long and an inch thick, with a Snout not unlike that of an Hog. It has ſixteen ſmall Teeth in one Row; beſide two large, ſharp, hooked, hollow, tranſparent Teeth, placed at each ſide of the lower Jaw. Theſe convey the Poiſon into the Wound, thro' a long Slit. They are flexible, and then only raiſed, when the Viper is going to bite. The Roots of them are incompaſt with a little Bladder, containing a large drop of a yellow, inſipid Juice. The Slit is a little below the Point of the Teeth, which are not hollow to the top. Hence ariſe all thoſe dreadful Symptoms, which frequently end in Death. But they are all prevented or removed, by rubbing Oil upon the Wound.

VIPERS creep but ſlowly, and never leap or bite, unleſs provoked. They are of a yellowiſh Colour, ſpeckled with longiſh, brown Spots. The Belly is of the colour of well-poliſhed Steel. Other Serpents lay Eggs; the Female Viper only brings forth her Young alive, wrapt up in Skins, which break on the third Day, and ſet them at liberty.

THE Poiſon of a *Rattle-ſnake* is equally fatal and more ſwift in its Operation. For it frequently kills within an Hour. The Snake is from ten to fifteen feet long. But whenever it moves in order to bite, the Tail begins to rattle: And that conſiderably loud: So that a man if he has preſence of Mind, may eaſily get out of his way. When he bites an Hare, he is obſerved to lick her all over before he takes her into his Mouth: Probably, that having moiſtened and ſmoothed her Skin, he may the more eaſily ſwallow her.

IT is very remarkable, that he frequently ſtays under a tree on which a Bird or Squirrel is hopping about, with his Mouth wide open. And the Event conſtantly is, the Creature in a while drops into it. Sir *Hans Sloane* thinks, he has wounded it firſt: And that he then waits under the tree, till the Poiſon works and the Animal drops down into the mouth of its Executioner.

But this is not the caſe, as plainly appears, from what many have been Witneſſes of. A ſwallow, purſuing his Prey in the Air, if he caſts his Eye on a Snake beneath him, waiting with his Mouth wide open, alters his Courſe, and flutters over him in the utmoſt Conſternation, till ſinking gradually lower and lower, he at laſt drops into his Mouth.

To the ſame purpoſe is the famous Experiment of Dr. *Sprenger*, mentioned in the *Hamburgh*-Magazine. He let looſe a Mouſe on the ground, at a little diſtance from a common Snake. It made a few turns, and ſqueaked a little, and then ran directly, into the Mouth of the Snake, which all the while lay ſtill, and without Motion. [1]

5. It is a wonderful Proviſion which is made for thoſe Snakes, who are Inhabitants of the Waters. A *Water-*

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[1] The *Rattle-Snake* being leſs nimble than others, would find difficulty in getting its prey, were it not for the ſingular Proviſion made, by the Rattle in his Tail. When he ſees a Squirrel or Bird on a tree, he gets to the bottom, and ſhakes this Inſtrument. The Creature looking down, ſees the terrible Eye of the Snake bent full upon it. It trembles, and never attempts to eſcape, but keeps its Eye upon the Deſtroyer, till tired with hopping from bough to bough, it falls down and is devoured. Indeed the ſame Power is in the Viper. The Field-Mice, and other Animals, which are its natural Food, if they have once ſeen his Eyes, never eſcape, but either ſtand ſtill, or run into its mouth.

But Vipers in general will not eat, after they are under Confinement. The Viper-catchers throw them together into great Bins, where they live many Months, tho' they eat nothing. It is only a Female Viper, when big with young, that will eat during its Confinement. If a Mouſe be thrown into the Bin, at the bottom of which 40 or 50 Vipers are crawling, among which One is with Young, ſhe alone will meddle with it, and ſhe not immediately. The reſt paſs it by, without any regard, tho' it be their natural Food. But the Female, after ſhe has done this ſeveral times, will at length begin to eye it. Yet ſhe paſſes by it again, but ſoon after ſtops ſhort, and holding her Head facing that of the Mouſe, ſeems ready to dart at it, which however ſhe never does, but opens her mouth, and brandiſhes her Tongue. Her Eyes having now met thoſe of the Mouſe, ſhe never looſes ſight of it more; but they face one another, till the Viper advances with her open mouth, nearer and nearer, till without making any leap, ſhe takes in the Head, and afterward the whole Body.

A *Water-ſnake* has no Air-bladder like Fiſhes: But to make amends for this Want, it has a large membranous Air-bag on its Back, which it empties or fills with Air at pleaſure, by an Aperture which it can ſhut ſo cloſe, that the leaſt Globule of Water cannot enter. By this means it can inlarge or leſſen the Bulk of its Body, and inhabit any Depth of Water.

As for the *Serpent of the Waters*, of which an Account is gravely given, by the Writer of the Natural Hiſtory of *Norway*, which he talks of, as being five or 600 Yards long, and as rearing his Head higher than the Main-maſt of a Man of War, I preſume it is very nearly related, to the *Craken* of the ſame Author: A ſea-Monſter, to which a Whale is but a Shrimp, larger than twenty Men of War put together. And this our Writers of Magazines and Reviews, ſwallow without any Difficulty! Is it from the juſt Judgment of GOD, that men who do not believe the Bible, will believe any thing?

THE King of all Reptiles which are known with any certainty, is the *Crocodile*. The *American* Crocodile or Alligator, is only fifteen or ſixteen feet long. But thoſe bred in *Afric* or the *Eaſt*-Indies, are ſaid to be between five and twenty and thirty. It may well be ſaid of Him (which cannot of the Whale) that *his Scales are his pride:* For on his Back, as well as his Head, they are impenetrable as Steel. Contrary to almoſt all other Creatures, he moves only the Upper Jaw. No Creature dares withſtand him. *He is the king of all the children of pride.* And as every Female Crocodile lays ſome hundreds of Eggs at once, they would utterly diſpeople the Waters, were it not that the Male devours all he can find of them. And ſo diligent is he in his Search, that ſcarce One out of an Hundred eſcapes him. It is another Inſtance of Divine Mercy, that he cannot bite under Water. By this Circumſtance, Creatures that are able to dive, generally eſcape his ravenous Jaws.

THE *Chameleon* (as well as the Alligator) is of the Lizard kind. Some in *Egypt* are twelve inches long; but the *Arabian* ſeldom exceeds Six. He has four Feet

Feet and a long, flat Tail, whereby he hangs on Trees, as well as by his Feet. His Snout is long, his Back ſharp, and grained, like Shagreen. He has no Ears, neither does he make or receive any Sound. The Tongue is half the length of the Animal, round to the Tip, which is flat and hollow, ſomewhat like an Elephant's Trunk. And this he darts out, and draws back with ſurprizing Swiftneſs. The great Uſe of this is, To catch Flies, (which are its proper Food, not the Air, as is vulgarly thought) by darting it out upon them. Its Colour is not always the ſame. One at *Paris*, when it was in the Shade, and at reſt, was of a bluiſh Grey. In the Sunſhine this changed to a darker Grey, and its leſs illumined Parts to various Colours. When handled or ſtirred, it appeared ſpeckled with dark Spots bordering upon Green. If it was wrapt up a few Minutes in a linen Cloth, it was ſometimes taken out whitiſh. But it did not take the Colour of any other Cloth or Subſtance that incloſed it. So that its aſſuming all the Colours it comes near, is a groundleſs Imagination.

THE Chameleon at *London* was of ſeveral Colours, like a mottled Coat. The moſt diſcernible were, a Green, a ſandy yellow, and a liver Colour. When ſtirred or warmed it was ſuddenly full of black Spots, as big as a large Pin's head. But when it was quiet, they gradually diſappeared.

THERE are four Species of Chameleons. 1. The *Arabian* about the Size of the green Lizard. This is of a whitiſh Colour, variegated with reddiſh and yellowiſh Spots. 2. The *Egyptian* which is of a middle Hue, between a whitiſh and a fair Green. 3. The *Mexican*, and 4. A kind which has been frequently ſhewn in *Europe*, and differs from all the reſt. His Head is large; but he alters his Body at pleaſure, inflating it more or leſs: And not only his Body, but his Legs and Tail. This is peculiar to him. The Body thus puffed up, will remain ſo two Hours. But it is inſenſibly ſinking all the time. It can continue a long time in either of theſe States: but it is generally uninflated. It then looks miſerably lank and lean: Its Backbone

may

may be seen perfectly; its Ribs counted; and even the Tendons of the Feet distinctly seen thro' the Skin.

Its Mouth is furnished with continued, denticulated Bones: But it does not appear what Use they are of, since it preys on Flies and swallows them whole, unless for holding a Stick in its Mouth cross-ways: Which, according to *Ælian*, he frequently does, to prevent being swallowed by Serpents.

The *Structure* and *Motion* of his Eyes are surprizing. They appear to be large Spheres, of which one half stands out of the Head, and is covered with a thick Skin, perforated with a small Hole at top. Thro' this is seen a very vivid and bright Pupil, surrounded with a yellow Iris. This Hole is a longitudinal Slit, which he opens more or less at pleasure. The *Motion* of his Eyes is not less singular. It can turn them, so as to see either forward, backward, or on either side, without moving the head at all, which is fixt to the Shoulders. And he can give one Eye all these Motions, while the other is perfectly still. Each Foot has five Toes, all of one side, two behind and three before. He moves very slowly on the Ground, but on Trees more easily. Its Tail is then its Safety, as it twists it round the Branches, when in any Danger of falling. [m]

Another uncommon Creature of the Lizard kind is a *Salamander*. This is supposed to live in Fire: but without any ground. It is indeed generally found in the Chinks of Glass-houses, or near Furnaces, where the Heat is so great, that no other Animal could endure it, without being destroyed in a few Minutes. But some years ago, the Trial was made by several Gentlemen, whether it could really live in Fire. Some Charcoal

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[m] But how can so slow a Creature, catch the most nimble sort of Insects? What Nature has denied it in Agility, is abundantly supplied by other means. Its slow, and easy Motion renders it but little suspected at a distance. And when it comes within a proper space of its Object, it stretches out its Tail, poises its Body, and fixes itself, so as seldom to meet with a disappointment. When all is ready, it uncoils its long, slender Tongue, and darts it so swift as scarce ever to miss its Prey.

Charcoal was kindled, and the Animal laid upon the burning Coals. Immediately it emitted a blackish Liquor, which entirely quenched them. They lighted more Coals, and laid it upon them. It quenched them a second time in the same manner. But being presently lain on a fresh Fire, it was in a short time burnt to Ashes.

That *Earth-worms* feed upon Earth, will be put beyond dispute, if any one is at the pains to examine, the little, curled Heaps of Dung, which are ejected out of their Holes. But it is in all probability, not pure Earth, but such as is made of Leaves, Roots, and Plants, when gradually rotted and mouldered away. And what makes this the more probable, is that they are observed to drag the Leaves of Trees into their Holes.

One more Reptile we may examine a little more minutely, in which the Wisdom of God is not a little displayed. It is a common *Leech*. When this is at rest, its upper Lip forms a regular Semicircle. When he moves, this Semicircle becomes two oblique Lines, the Junction of which makes an Angle, which he applies to whatever he would fix himself to. The two Lips then make a sort of Hollow. Both these and its Mouth are made of so Supple Fibres, that they take the Figure of the Part they are applied to, and fix perfectly close to it.

The Wounds it makes are not Punctures, but Three Cuts, made like three Rays, which uniting in a Center make equal Angles with each other. They appear as if made by a fine Lancet. They are indeed made by three Rows of fine and sharp Teeth, which the Microscope shews to be placed along the middle of a strong Muscle. When the Mouth has seized on any Part, the Muscle exerts its Action, and strikes in all the Teeth at once.

Between the Mouth and the Stomach, there is a small Space, in which are two different Arrangements of Fibres. The One Set are flat and plain, the others are circular. The former contracting in length, enlarge the Capacity of the Throat; and the Circular ones determine the Blood toward the Stomach, by contracting

contracting it, when the Blood is received. Hence it passes into a kind of membranous Sack, which serves the Animal both for Stomach and Intestines. This takes up the greatest Part of its Body. On each side of this long Canal, there is a number of little Bags. These being filled with Blood, swell out the Body of the Animal to a great Size. Here it remains for many Months, and serves the Creature for Nourishment. If any thing is excreted, it can be only by insensible Perspiration, since the Creature has no Anus, nor any Aperture which can supply the Place of one.

CHAP. V.

Of Insects.

1. THERE remains only the lowest Order of Animals, usually termed *Insects*, because they have an Incision, as it were, which in a manner cuts them into two Parts. Of these I would speak the more largely, because generally they are little known. Rather

Rather they are despised and purpofely paſſed over, as unworthy of our Conſideration. And yet it is certain, the Wiſdom of the Great Creator, does moſt conſpicuouſly ſhine in them.

As to the *Shape* of their Bodies, tho' it be ſomewhat different from that of Birds, being for the moſt Part not ſo ſharp before, to cut and make way thro' the Air, yet it is better adapted to their Manner of Life. For conſidering they have little need of long Flights, and that the Strength and Activity of their Wings, far ſurpaſs the Reſiſtence they meet with from the Air, there was no occaſion for their Bodies to be ſo ſharpened. But the Nature of their Food, the Manner of gathering it, and the great Neceſſity they had of accurate Viſion, and large Eyes in order thereto, required the Largeneſs of the Head, and its Amplitude before. The reſt of the Body is all well-made, and nicely poiſed for their Flight and other Occaſions.

The Make of their Bodies is no leſs admirable: Not built throughout with Bones, covered over with Fleſh, and then with Skin, as in moſt other Animals: But cloathed with a curious Mail of a middle Nature, ſerving both as a Skin and Bone too. As it were on purpoſe to ſhew, that the Great Contriver of Nature is not bound up to one way only.

How admirably are the Legs and Wings fitted for their intended Service? Not to overload the Body, nor to retard it, but give it the moſt proper and convenient Motion. What, for example, can be better contrived 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 adorned with beautiful Feathers: [n] And many of them provided with the fineſt Articulations, and Foldings, in order to be laid up in their Caſes, when they do not uſe them; and yet always ready, to be extended for Flight.

2. The

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[n] It is eaſily ſeen, by the Microſcope, that the elegant Colours of Moths and Butterflies, are owing to neat and well-made Feathers, ſet in Rows with great Curioſity and Exactneſs.

2. The Structure of the *Eye* is in all Creatures an admirable Piece of Mechaniſm. But this is peculiarly obſervable in that of an Inſect. Its Hardneſs is an excellent Guard, againſt external Injuries. And its outer Coat is all over beſet with curious, tranſparent Inlets, enabling it to ſee every way, without any Loſs of time, or trouble to move the Eyes.

And their *Feelers*, beſides their Uſe in cleaning the Eyes, are a good Guard to them in their Walk or Flight, enabling them by the Senſe of Feeling to diſcover Annoyances, which by their Nearneſs might eſcape the Sight.

The Eye of a Fly is in truth an Aſſemblage of multitudes, often, many thouſands of ſmall Eyes. Nature has given each Fly two large *reticular* Eyes (that is, covered with a kind of Net-work.) And as each contains ſuch a multitude of ſmaller Eyes, one would imagine, this might ſuffice. Yet ſome Flies have four reticular Eyes; the two ſmaller are placed as uſual, the two larger are behind the other, on the upper Part of the Head.

In different Species the reticular Eyes are of different Colours. Some are brown, ſome yellow, green, red, and this in all the different Shades of theſe Colours. And ſome have the Gloſs of Metals highly poliſhed.

But beſide theſe, many Species of Flies have a ſort of Eyes, which are not reticular, but of a perfectly ſmooth and even Surface, and far ſmaller than the reticular. Three of theſe are on the back of the Head of vaſt Numbers, which are triangularly placed. Some have more, and ſome have leſs then Three. Gnats have none of them. Their Heads are in a manner covered with their reticular Eyes, ſo as to leave no room or occaſion for *ſmooth* ones.

Nor are theſe ſmooth Eyes peculiar to Flies. Other Inſects alſo have them: The Graſs-hopper in particular has Two, which are placed near the Noſe.

3. The Species of Inſects are almoſt innumerable. All of theſe ſome ſuppoſe to have no *Heart*, as they have no ſenſible Heat, none that can be perceived either by the Touch, or by any other Experiment.

But this is a miſtake. Many indeed have not ſuch an Heart as other Animals have: But all have ſomething analogous to it, ſomething that anſwers the ſame purpoſe.

Some likewiſe have thought, That Inſects have no *Reſpiration*. But later Experiments ſhew, that there is no Species of them which has not *Lungs*, and thoſe larger in proportion than other Animals. In moſt of them they lie on, or near the Surface of the Body. And hence it is, that if Flies are beſmeared with Oil, or any other unctuous Matter, they die in a ſhort time, their Reſpiration being ſtopt, ſo that they are properly ſuffocated.

4. Some alſo have imagined, That Inſects were *generated* out of mere Putrefaction, becauſe they obſerved Worms come out of putrefied Fleſh, which afterward turned to Flies. But it is certain, if putrefying Fleſh be ſhut up cloſe, no Worms are ever generated from it. Hence we learn, that Flies lay their Eggs in Fleſh, which hatch when it putrefies: So that the Animal juſt comes to Life, when its Food is ready for it. All Inſects lay their Eggs, where there is Heat enough to hatch them, and proper food as ſoon as they are hatched. Thoſe whoſe Food is in the Water, lay their Eggs in the Water: thoſe to whom Fleſh is a proper Food, in Fleſh. Thoſe to whom the Fruits or Leaves of Vegetables are Food, are depoſited on the proper Fruits or Leaves. And conſtantly the ſame kind is found on the ſame Fruit or Plant. Thoſe that require more Warmth are lodged by the Parent, in or near the Body of ſome Animal. And as for thoſe to whom none of theſe Methods are proper, the Parents make them Neſts by Perforations in the Earth, in Wood, in Combs: Carrying in and ſealing up Proviſions, that ſerve both to produce the Young, and to feed them when produced.

The Eggs of all Inſects become Worms, commonly called *Nymphæ*. They are next changed into *Aureliæ*, ſo called, incloſed in a Caſe: And theſe dying, a Fly or Butterfly ſucceeds.

To

To trace these wonderful Changes a little, in one kind of Insect. A *Silk-worm*, from a small Egg, becomes a Worm of the Catterpillar kind, and feeds on Mulberry-leaves, till it comes to Maturity. Then it winds itself up into a silken Case, about the size and shape of a Pigeon's Egg, and is metamorphosed into an *Aurelia*, in which State it has no Motion or Sign of Life: till at length it awakes, breaks thro' its silken Sepulcher, and appears a Butterfly.

As soon as the Silkworm has Strength, he makes his Webb, a slight Tissue, which is the ground of his admirable Work. This is his first Days Employ. On the second, he covers himself almost over with Silk. The third, he is quite hid. The following Days he employs in thickening his Ball, always working from one single End so fine a Thread, that those who have examined it, affirm it would reach six Miles.

THE *Silk-spider* makes a Thread, every whit as strong, glossy and beautiful as the Silkworm. It spins from seven Nipples. These, as so many wire-drawing Irons, draw out a viscous Liquor, which gradually dries in the Air, and becomes Silk. °

EACH of these Nipples contains many smaller Nipples, invisible to the naked Eye; thro' the several Perforations whereof, numberless finer Threads are drawn. Before the Spiders begin to spin, they apply more or fewer of the large Nipples to the Body whence the Webb is begun. And as they apply them more or less strongly, more or fewer of the small Nipples come to touch: And accordingly the whole Thread will be compounded of more or fewer single Threads. One compound thread frequently consists of fifteen or sixteen single ones.

THEIR Threads are of two kinds: One serves only for the Webb with which they catch Flies. The other is much thicker and stronger, in which they

° All boneless Insects are Hermaphrodites, as are Snails, Leeches, and many Sorts of Worms. But such Worms as become Flies are not, being indeed of no Sex.

wrap up their Eggs, in order to shelter them from the Cold, as well as from devouring Insects. These Threads they wind loosely round, resembling the Balls of Silk-worms that have been loosened for the Distaff.

The Balls are grey at first, but turn blackish, when long exposed to the Air. From these Balls a Silk is made, nothing inferior to the common Silk. It takes all kind of Dyes, and may be made into all kind of Stuffs. Only there is a difficulty in keeping the Spiders: for they are so extremely quarrelsome, that if an hundred of them be put together, in a few Hours scarce twenty will be left alive.

5. Amazing Wisdom is displayed in the make of the *Common-Spider*. She has Six Teats, each furnished with innumerable Holes. The Tip of each Teat is divided into numberless little Prominences, which serve to keep the Threads apart at their first Exit, 'till they are hardened by the Air. In every Teat, Threads may come out at above a thousand holes. But they are formed at a considerable Distance, each of them having a little Sheath in which it is brought to the Hole. In the Belly are two little soft Bodies, which are the first Source of the Silk. In shape and transparency they resemble Glass Beads, and the Tip of each goes winding toward the Teat. From the Root of each Bead proceeds another Branch much thicker, which also winds toward the same Part. In these Beads and their Branches is contained the Matter of which the Silk is formed, the Body of the Bead being a kind of Reservoir; the two Branches, Canals proceeding from it.

It was before observed, that the tip of each Teat may give Passage to above a thousand Threads. And yet the size of the Teat in the largest Spider, does not exceed a small pin's head. But the smallest Spiders no sooner quit their Eggs, than they begin to spin. Indeed their Threads can scarce be perceived, but the Web formed thereof is as thick and close as any. And no wonder, as 4 or 500 little Spiders often concur in the same Work. How minute are their Teats! When perhaps

perhaps the whole Spider is leſs than the Teat of its Parent. Each Parent lays 4 or 500 Eggs, all wrapt up in a Bag. And as ſoon as the young ones have broken thro' the Bag they begin to ſpin.

And even this is not the utmoſt which Nature does. There are ſome kinds of Spiders ſo ſmall, as not to be diſcerned without a Microſcope. And yet there are Webs found under them! What muſt be the Fineneſs of theſe Threads? To one of theſe the fineſt Hair is as a Cart-Rope.

There are ſeveral Species of Spiders that fly: and that to a ſurprizing Height. "The laſt October, ſays an eminent Writer, 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 of the Spiders that fell upon the Pinnacles I took, and found them to be of a kind, which ſeldom or never enter Houſes, and can't be ſuppoſed to have taken their flight from the Steeple." P

P There are divers Animals, as well as Spiders, that have ſome way of Conveyance, utterly unknown to us. Thus the Animals on the ſtanding Waters, ſo numerous as often to diſcolour them, and tinge them red, yellow, or green. That theſe have ſome way of Conveyance is certain, becauſe not only moſt ſtagnating Waters are ſtocked with them, yea, not only new Pits and Ponds, but even Holes and Gutters on the top of Houſes, Churches and Steeples. That they have not Legs for travelling ſo far, is manifeſt: It is therefore probable, either that they dart out Webs, and can make themſelves Buoyant, and lighter than the Air: Or that their Bodies are naturally lighter than Air, and ſo they can ſwim from place to place. It is highly probable, the Eggs of ſuch as are oviparous, may be light enough to float therein.

To trace this matter farther: Every one muſt have obſerved Threads floating in the Air: But few conſider what End they ſerve. They are the Works of Spiders. Their uſual Method is, to let down a Thread, and then draw it after them. But in the midſt of this work they ſometimes deſiſt; and turning their tail according to the wind, emit a thread with as great violence, as a Jet of Water diſcharged from a Cock. Thus they continue darting it out, which the Wind carries forward, till it is many yards long. Soon after, the Spider throws herſelf off from her Web, and truſting herſelf to the Air, with this long tail, will aſcend ſwift, and to a great height with

6. A *Tarantula* is a kind of Spider, chiefly found near the City of *Tarentum* in *Apulia*. It is about the size of an Acorn and has eight Eyes and eight Feet. Its Skin is hairy: From its Mouth rise two Trunks, a little crooked and exceeding sharp. Thro' these it conveys its Poison: they seem likewise to be a kind of moveable Nostrils; being in continual Motion, especially when it is seeking its Food. It is found in other Parts of *Italy*, but is dangerous only in *Apulia*. And there it does little Hurt in the Mountains (which are cooler) but chiefly on the Plains. Indeed it is not venomous, but in the Heat of Summer, particularly in the Dog-days. It is then so inraged, as to fly upon any that come within its reach. THE

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it. These Lines, which the Spiders attached to them (tho' unobserved) make these Air-threads, that waft them along the Air, and enable them to prey on many Insects, which they could not reach by any other means.

ALL Spiders that spin, young as well as old, cast out these threads, and sail thereby in the Air. And the Threads themselves shew the Use thereof, being usually hung with the fragments of devoured Animals.

WHEN the threads are newly spun, they are alway single, and are generally seen ascending higher and higher. But when they are seen coming down, they are sometimes composed of three or four, and either without any Spider or with several. 'Tis plain this happens from the threads meeting and intangling in the Air, which of course brings them down.

IT is common to see a Spider mount to the topmost Branch of a Bush, and from thence dart out several threads one after another, trying, as it were how she likes them. When she has darted one several yards, she will of a sudden draw it up again, and wind it into a link with her fore-feet, but more frequently break it off and let it go. A Spider will sometimes dart out and break off many threads, before it Spins one that it will trust to. But at length she Spins one to her liking, and commits herself to the Air upon it.

THE Business of Feeding is not all the Use of these threads: but they evidently sport and entertain themselves by means of them, floating to and fro in the Air, and changing their height at pleasure.

THESE Air-threads are not only found in Autumn, but even in the the Depth of Winter. The serene Days at Christmas bring out many: But they are only short and slender, being the work of young Spiders, hatched in Autumn, and are thrown out, as it seems only in sport. The thicker ones of Autumn are the only ones intended to support the old Spiders, when there is plenty of small flies in the Air which make it worth their while to sail among them.

The Bite causes a Pain, like that by the stinging of a Bee. In a few Hours the Patient feels a Numbness, and the Part is marked with a small livid Circle, which soon rises into a painful Tumour. A little after, he falls into a deep Sadness, breathes with much Difficulty, his Pulse grows feeble and his Senses dull. At length he loses all Sense and Motion, and dies, unless speedily relieved. An Aversion to Blue and Black, and an Affection for White, Red and Green, are other unaccountable Symptoms of this Disorder.

There is no Remedy but One. While he lies senseless and motionless, a Musician plays several Tunes. When he hits on the right, the Patient immediately begins to make a faint Motion. His Fingers first move in Cadence, then his Feet: Then his Legs, and by degrees his whole Body. At length he rises on his feet, and begins to dance, which some will do for six Hours without intermission. After this he is put to bed, and when his Strength is recruited, is called up by the same Tune to a Second Dance. This is continued for six or seven Days at least, till he is so weak he can dance no longer. This is the Sign of his being cured; for if the Poison acted still, he would dance till he dropt down dead. When he is throughly tired he awakes as out of Sleep, without remembring any thing that is past. And sometimes he is totally cured: but if not, he finds a melancholy Gloom, shuns Men, seeks Water, and if not carefully watched, often leaps into a River. In some the Disorder returns that time twelve-month, perhaps for 20 or 30 Years. And each time it is removed as at first. Can even Dr. *Mead* account for this? ¶

7. Mention

¶ Equally unaccountable are the two Relations published some years since, by a Physician of undoubted Credit. The first is: A Gentleman was seized with a violent Fever, attended with a Delirium. On the third Day he begged to hear a little Concert in his Chamber. It was with great Difficulty the Physician consented. From the first tune, his Face assumed a serene Air, his Eyes were no longer wild, and the Convulsions ceased. He was free from the Fever during the Concert; but when That was ended, it returned. The Remedy was repeated, and both the Delirium and Fever always

7. MENTION was made of the extreme Smallneſs of ſome Spiders. But how much ſmaller are thoſe *Animalcula*, diſcerned by the *Microſcope?* Theſe are in almoſt all Water. Even in that wherein the beſt Glaſſes can diſcover no Particle of animated Matter, after a few Grains of Pepper, or a ſmall Fragment of a Plant of almoſt any kind has been ſome time in it, Animals full of Life are produced and ſo numerous as to equal the Fluid itſelf in Quantity.

A SMALL Quantity of Water taken from any Ditch in Summer, is found to abound in juſt ſuch Creatures, only larger. Nay any Water, ſet in open Veſſels in the Summer Months, will after a few Days yield Multitudes of them.

THESE we know by their future Changes are the Fly-worms of Gnats, and ſeveral other ſorts of Flies. And we eaſily judge, they owe their Origin to the Eggs of the Parent-fly there depoſited. No doubt then but the Air abounds with other Animalcula, as minute as the Worms in theſe Fluids. And theſe are the Fly-worms of thoſe Animalcula, which after a proper time ſpent in that State, will become Flies like thoſe to them they owe their Origin.

THE Waters in which different Liquors are infuſed afford a proper Matter for the Worms of different Species of Flies. And ſome of theſe doubtleſs are viviparous, others oviparous. This may occaſion the different time taken up for producing Inſects in different Fluids.

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ceaſed during the Concerts. In Ten Days, Muſic wrought an entire Cure, and he relapſed no more.

THE other Caſe is that of a Dancing-Maſter, who, thro' fatigue, fell into a violent Fever. On the fourth or fifth Day he was ſeized with a Lethargy, which after ſome time changed into a furious Delirium. He threatened all that were preſent, and obſtinately refuſed all the Medicines that were offered him. One of them ſaying, that perhaps Muſic might a little compoſe his imagination, a Friend of his took up his Violin, and began to play on it. The Patient ſtarted up in his bed, like one agreeably ſurprized, and ſhewed by his Head (his Arms being held) the pleaſure that he felt. Thoſe who held his arms, finding the Effects of the Violin, looſened their hold, and let him move them, according to the Tunes. In about a quarter of an hour, he fell into a deep Sleep. When he awoke, he was out of all danger.

Fluids. Those proper for the Worms of a viviparous Fly, will be sooneſt full of them. Whereas a longer time is required to hatch the Eggs of the Oviparous.

Now every Animalcule being an organized Body, how delicate muſt the Parts be, that are neceſſary to make it ſuch, and to preſerve its vital Actions? It is hard to conceive, how in ſo narrow a Compaſs, there is an Heart, to be the Fountain of Life, Muſcles neceſſary for its Motions, Glands, to ſecrete its Fluids, Stomach and Bowels to digeſt its Food, and other innumerable Parts, without which an Animal cannot ſubſiſt. And every one of theſe muſt have Fibres, Membranes, Coats, Veins, Arteries, Nerves, and an infinite Number of Tubes, whoſe ſmallneſs exceeds all Efforts of Imagination. And yet there are Parts that muſt be infinitely ſmaller than theſe, namely the Fluids that move thro' them, the Blood, Lymph and Animal Spirits, whoſe Subtilty even in large Animals is incredible.

As to ſome of the Animalcules obſerved by *Leuwenhoeck*, he computed, that 3 or 400 of them placed cloſe together in a line, would only equal the Diameter of a grain of Sand. Twenty Seven Millions then of theſe Animals equal in bulk a grain of Sand!

But *Hartſoeker* carries the Matter ſtill farther. "If ſays he, according to our preſent Syſtem of Generation, all Animals were formed from the beginning of the World, and incloſed one within another, and all of them in the firſt Animal of each Species: How minute muſt the Animalcula produced now, have been at the beginning?

8. Even the meaneſt and moſt contemptible of Inſects, ſhews the Wiſdom of its Creator. *Fleas*, for inſtance, depoſit their Eggs only on ſuch Animals, as afford them a proper Food. Theſe hatch into Worms of a ſhining Peal-Colour, which feed on the Scurf of the Cuticle. In a fortnight they are very active, and if diſturbed, ſuddenly roll themſelves into a Ball. Soon after they begin to creep, with a very ſwift Motion. When arrived at their full ſize, they ſpin a thread out of their Mouth, wherewith they form themſelves a Caſe. After a fortnight's Reſt here, each of them burſts out a perfect Flea, leaving

leaving its Exuviæ behind. It is milk-white 'till the ſecond Day before its Eruption: then it changes Colour and gets Strength, ſo that upon its firſt Delivery, it ſprings nimbly away. [r]

9. A *Louſe* alſo affords to our Obſervation, a very delicate Structure of Parts. It is divided into the Head, the Breaſt and the Tail. In the Head appear two fine, black Eyes, with a Horn that has five Joints and is ſurrounded with Hairs, ſtanding before each Eye. From the Noſe projects in a Sheath the Piercer or Sucker, which it thruſts into the Skin. This is judged to be ſeven hundred times finer than an Hair. It has no other Mouth than this.

The Skin of the Breaſt is tranſparent, and from the under part of it proceed Six Legs, each having five Joints; Each Leg is terminated by Two Claws, which it uſes as we would a Thumb and middle Finger.

If one of them when hungry be placed on the back of the Hand, it will thruſt its Sucker into the Skin, and the Blood it ſucks may be ſeen paſſing in a fine Stream to the Fore-part of the Head. Falling into a roundiſh Cavity there, it paſſes on to another Receptacle in the middle of the Head. Thence it runs to the Breaſt, and then to a Gut which reaches to the hinder Part of the Body, where in a Curve it turns again a little upward. It then ſtands ſtill, and ſeems to undergo a Separation: Some of it becoming clear and watry, while other black Particles paſs down to the Anus.

Lice are not Hermaphrodites; and the Males have Stings, which the Females have not. A Female lays in twelve days an hundred Eggs, which hatch in Six Days. Suppoſe

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[r] Minute Animals are found proportionably much ſtronger and more active than large ones. The Spring of a Flea in its Leap vaſtly exceeds any thing greater Animals are capable of. Mr. De *Liſle* has computed the Velocity of a little Creature, which ran three Inches in half a Second. Now ſuppoſing its Feet to be the fifteenth Part of a Line, it muſt then, in order to travel over ſuch a Space in ſuch a time, make five hundred Steps, in the Space of three Inches: That is, it muſt ſhift its feet five hundred times in a Second, or in the ordinary Pulſation of an Artery. What is the Motion of any large Animal, in compariſon of this? Or what is the Swiftneſs of a Grey-hound or a Race-horſe, to that of ſuch an Animalcule?

Suppoſe theſe produce fifty Males, and as many Females: Theſe Females coming to their full Growth in Eighteen Days, may each in twelve Days lay an hundred Eggs more. And theſe in Six Days more may produce a Young Brood of five thouſand. So ſwiftly do theſe Creatures multiply!

MOST Animals are ſubject to Lice, but each of a different kind, and none of them like the Human. Nay even Inſects are not free. Beetles, Ear-wigs and Snails are particularly ſubject to them. Numberleſs little red Lice are often ſeen about the Legs of Spiders. A ſort of whitiſh Lice are common on Bees. They are alſo found on Ants.

FISHES, one would think, living in the Water, and perpetually moving to and fro, ſhould be free from Lice. But they have their Sorts too, which neſt under their Scales, the Salmon in particular. Beſide which, there are frequently found great numbers of long Worms, in the Stomach and other Parts of Fiſh. And theſe work themſelves ſo deeply into their Fleſh, that they cannot eaſily be got out.

MANY Inſects are bred in the Noſtrils of Sheep. One may take out twenty or thirty rough Maggots at a time. A rough, whitiſh Maggot is found alſo within the Inteſtinum Rectum of Horſes. Others are generated in the Backs of Cows, which at firſt are only a ſmall Knot, being an Egg laid there by ſome Inſect. Afterward it grows bigger, and contains a Maggot, lying in a purulent Matter.

IN *Perſia* ſlender Worms ſix or ſeven Yards long, are bred in the Legs and other Parts of Men's Bodies. Yea, there have been divers Inſtances, of Worms taken out of the Tongue, Gums, Noſe and other Parts, by a Perſon of *Leiceſter*, before many Witneſſes.

10. A VERY extraordinary kind of Inſect, is that which is called a *Death-watch*, becauſe it makes a Noiſe like the beating of a Watch. They are of two kinds. One is a ſmall Beetle, ſomewhat more than a quarter of an inch long, of a dark brown, and ſpotted, having a large Cap on the Head, and two Feelers ſpringing from beneath the Eyes. Dr. *Derham* obſerved it to draw back its

its Mouth, and beat with its Forehead. He kept two, a Male and a Female, in a box, for some Months, and could bring one of them to beat when he pleased, by imitating its beating. And he soon found this ticking to be the way, whereby they wooed one another.

The other kind is a greyish Insect like a Louse, which beats some Hours together without Intermission; and that slowly, whereas the former beats only seven or eight Strokes at a time, and much quicker. It is very common in Summer in all Parts of our Houses, is nimble in running to shelter, and shy of beating, if disturbed; but is free to beat, and to answer their beating, if you do not shake the place where it lies. This commonly, if not always beats, either in or near Paper. It is at first a small, white Egg, like a Nit. It hatches in *March*, and creeps about with its Shell on. It is then smaller than the Egg itself, but soon grows to the perfect Size.

11. A *Female-Fly*, within four and twenty Hours after her Congress with the Male, begins to deposit her Eggs, on some Substance proper to give Nourishment to the Worm that is to be produced. These Eggs in general are white and oblong. But there are some of them which are singular. To describe one Species of them may suffice, the Eggs laid, on Hogs-dung.

They are white and oblong, but of a peculiar make. At one end of each of these Eggs, between that End and the middle, are two little Wings, standing out on either Side. As soon as the Fly has laid her Eggs, she thrusts them into the Dung. This keeps the Coat of the Egg soft; otherwise the Embryo could never get out. But if the whole Egg were thrust in, the Creature would be suffocated, as soon as it is hatched. Therefore Part only is to be immersed, and Part to be left out. And this is admirably provided for by these Wings. For when the Female thrusts in the Egg, it easily enters at the smaller End, which is the Part first protruded from her Body: But it stops at the Wings, and so the upper Part remains open to the Air.

Some Species of Flies fasten their Eggs to the sides of Vessels of Water. All these Eggs have a thin flake running down the two Sides diametrically opposite. So that they

they look as if they were incloſed in a Frame. The Uſe of this Frame is, to hold the Body of the Egg more firmly to the Side of the Veſſel. Thoſe Eggs which have it not, are depoſited by the Female-fly with a viſcous Matter about them.

Some Flies lay their Eggs in the Bodies of Caterpillars. Theſe are at great pains to carry thoſe Caterpillars to the places where it is proper their Eggs ſhould be hatched. There is one Species whoſe Worm can never ſucceed, unleſs it be both bred in the Caterpillar, and that Caterpillar buried under ground. To t is purpoſe the Parent, when ready to lay her Eggs, forms a hole in the ground, and covers it with a little Clod. Then ſhe goes in ſearch of a proper Caterpillar, perhaps one much larger than herſelf, which nevertheleſs ſhe drags to her Hole. This ſhe uncovers and goes in to ſee if all is right. Then ſhe goes and draws the Caterpillar in. depoſits her Eggs in his Fleſh, and ſtops up the Hole with ſeveral Pellets of Dirt, and Duſt carefully rammed in between. When the Worms are hatched, they feed on the fleſh of the Caterpillar till they are full grown. Then they change into *Aureliæ*, and afterward into the form of the parent-fly: In which State they eaſily make their way out of the ground.

Some of theſe lay their Eggs in the Bodies of ſmaller Flies. They often fly with one of them in their Legs, the Head of it being cloſe to their Bellies. They carry theſe to little Holes in the Ground. In the firſt they lay their Eggs. Then they bring others, to be food for their Young when hatched. One Fly is not enough: therefore their Parents carry them more every day: Crawling backward into the Hole: and dragging in the Flies after them. When the Worms change into Aureliæ, their Caſes are made of the Exuviæ of the Flies they have been feeding on. [s]

[s] The Eggs of Inſects are uſually the occaſion of what are termed Blight. Theſe ſeldom happen but on the blowing of ſharp, eaſterly Winds. Many Inſects attend thoſe Winds, and lay their Eggs on proper Plants. Indeed the large Worms or Caterpillars which attend ſome Blights, ſeem to be only *hatched* by thoſe Winds. But they probably *bring* thoſe Swarms of Inſects, which occaſion the curling of the Leaves of Trees.

12. THERE are few Insects more prolific than the *Gnat*. All its Changes from the Egg to the perfect Animal are fulfilled in three Weeks or a Month: And there are usually seven Generations of them in a Year, in each of which the Parent lays 2 or 300 Eggs. These she ranges in the form of a Boat, and Each Egg is shaped like a Nine-pin. The thicker Ends of these are placed downward. They are firmly joined together by their Middles, and their narrower Parts stand upward.

VIEWED with a Microscope, the larger End is observed to be terminated by a short Neck, the End of which is bordered by a kind of Ridge. The Neck of each is sunk in the Water, on which the Boat swims: For it is necessary it should keep on the Surface, since otherwise the Eggs could never be hatched.

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EVERY Insect feeds on one Plant and no other. On this only it lays its Eggs. Hence it is, that one kind of Tree only is blighted, and the rest escape. All Trees then cannot be blighted at once, unless one Wind could bring the Eggs of all Insects, with as many different Degrees of Heat and Cold, as are required to hatch and preserve each Species.

AND what tho' we do not always *perceive* Animals in Blights? By Microscopes we discover Animalcula, a million times less than those that are perceivable by the naked Eye. The gentlest Air may waft these from place to place: So that it is no wonder if they are brought to us from *Great Tartary*, even the cold Air of which may give them Life, and from whence there is not so much Sea as to suffocate them in its Passage, by the Warmth and Saltness of its Vapours.

TREES are preserved from Blights, by sprinkling them with Tobacco-dust or Pepper-dust, which are Death to all Insects.

BUT one kind of Blight is caused, merely by long-continued, dry, easterly Winds. These stop the Perspiration in the tender Blossoms, so that in a short time they wither and decay: Soon after, the tender Leaves are affected; their perspiring Matter becoming thick and glutinous, so as to be a proper Nutriment to the Insects, which are then always found upon them. In this Case, the Insects are not the Cause, but the Effect of the Blight.

IT is a kind of Blight that produces *Galls*, which are the Buds of Oaks swelled out. The Cause is, into the Heart of the tender Bud, a Fly thrusts one or more Eggs. This Egg soon becomes a Worm and eats itself a little Cell in the Pith of the Bud, which would have grown into a Branch. The Sap, which was to nourish that Branch, being diverted into the remaining Parts of the Bud, these grow large and flourishing, and become a Covering for the Cell of the Insect.

THE ranging these in so exact Order, requires the utmost Care in the Parent. Gnats lay their Eggs in the Morning Hours, and that on such Waters, as will give Support to their Young. Here the Parent places herself on a small Stick, a Leaf, or any such Matter near the Water-Edge, in such a manner, that the last Ring but One of her Body, touches the Surface of the Water. The last ring of all, where there is the Passage for the Eggs, is turned upward, and every Egg is thrust out vertically. When it is almost disengaged, She applies it to the Side of the Cluster already formed: to which it readily adheres by means of a viscous Matter wherewith they are covered.

THE great Difficulty is, To place the first laid Eggs in a proper Position to receive the rest, and to sustain themselves and them, in a proper Direction. These she with great Precaution places exactly, by means of her Hinder legs. And when a sufficient number of them

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NOT only the Willow and some other Trees, but Plants also, Nettles, Ground-ivy and others, have such Cases produced upon their Leaves. The Parent-Insect, with its stiff Tail, bores the Rib of the Leaf when tender, and makes way for her Egg into the very Pith. Probably she lays it there, with some proper Juice, to prevent the Vegetation of it. From this Wound arises a small Excrescence, which when the Egg is hatched grows bigger and bigger, as the Worm increases, swelling on each side the Leaf, between the two Membranes. This Worm turns afterwards to an Aurelia, and then to a small, green Fly.

THE *Aleppo-Galls* wherewith we make our Ink, are of this Number, being only Cases of Insects, which gnawed their way out, thro' the little Holes we see in them.

FOR a sample of the tender Balls, see the Balls as round, and sometimes as big as small Musket-bullets, growing under oaken-leaves, close to the Ribs, of a greenish, yellowish Colour. Their Skin is smooth, with frequent risings therein. Inwardly they are very soft and spungy; and in the very Center is a Case, with a white Worm therein, which afterward becomes a Fly. As to this Gall, there is one thing peculiar. The Fly lies all Winter within this Ball, and does not come to Maturity 'till the following Spring. In the Autumn these Balls fall to the ground with their Leaves. Yet the Insect inclosed in them, is fenced against the Winter-Frosts, partly by other Leaves lying upon them, and partly by the thick, spungy Wall, afforded by the Galls themselves.

are arranged, all the reſt is eaſy: Inaſmuch as theſe are a firm Support, to all that follow them.

13. A *Cicadula* is a ſmall Inſect found in *May* and *June*, on the Stalks and Leaves of Plants, in a kind of Froth, commonly called *Cuckoo-ſpit*. This Froth is not from the Plant, but the Mouth of the Animal; and if it be gently wiped away, will be preſently ſeen iſſuing out of its Mouth, 'till there is as large a Quantity of it as before. They are of the ſhape of a Louſe, ſome being whitiſh, ſome yellowiſh, and others green. They often change their Skins, while they live in this Froth, and only creep a little. But when they leave the Plant they hop and fly, having Wings which cover the whole Body.

14. The moſt ſingular Part of the Life of a *Drone-fly*, is that it paſſes in the form of a Worm. It is thus diſtinguiſhed from all other Worms by its long Tail: At different times this is indeed of different Lengths; but it is always longer than the Worm itſelf. It is round, ſmooth, and very ſmall at the Extremity; ſometimes no thicker than a Horſe-hair. To know the Uſe of this Tail, we muſt firſt know the Nature of the Worm itſelf. It is an Aquatic, and never leaves the Water, 'till it changes into its Fly-State. They lie in multitudes in the mud at the bottom of Veſſels of ſtinking Water. Put them into Veſſels of clean Water, and they will ſoon ſhew the Uſe of their Tails. Tho' they live under water, they cannot live without breathing freſh Air. This is the End to which their long Tails ſerve. For even while they lie buried in the Mud, their Tails are extended to the top of the Water, and being open at the Extremity, let Air into their Bodies. And as ſoon as they are in a Veſſel of freſh Water, they get to the bottom and thruſt up their Tails to the Surface. They can lengthen them at pleaſure: To be aſſured of this, you need only pour in more Water. The Worms then lengthen their Tails proportionably, in order to breathe from the Surface: By adding more and more Water you will find, they can extend their tails to the length of five Inches: An extremely remarkable length for a Creature little more than half an inch long. Beyond five Inches however they cannot go. And if you make the Water

of

of a greater Depth, they leave the bottom, and either travel up the ſides of the Veſſel to a proper height; or elſe ſwim in the Water, at the depth of five Inches.

15. No Species of Flies is more remarkable, than the larger *Fire-fly* of *Jamaica*. It is above an inch long, and proportionably broad. Moſt of its internal Parts are luminous; only the thickneſs of the Cover hinders its appearing. But on forcing the Rings that cover the Body a little aſunder, Light iſſues from all the Entrails. The Head has two Spots juſt behind the Eyes, which emit Streams of ſtrong Light. But tho' theſe flow naturally from the Inſect, yet it has a power of interrupting them at pleaſure. And then theſe Spots are as opake as the Surface of the Body.

A Person may read the ſmalleſt Print by the Light of one of theſe Inſects, if held between the fingers, and moved along the Lines, with the luminous Spots over the Letters. They are ſeldom ſeen in the day, but wake with the Evening, and move and ſhine moſt part of the Night. They readily fly toward each other. Hence the Negroes have learned, to hold one between their fingers and wave it up and down, which others ſeeing fly directly toward it, and pitch upon the hand. They are ſo torpid by day, it is hard to make them diſcover Signs of Life; and if they do, they preſently relapſe into the ſame State of Inſenſibility. As long as they remain awake, they emit light: But they are vigorous only in the Night.

16. One more Inſect of the Fly kind, we cannot paſs by unnoticed: The *Ephemeron*, or Fly that lives but Part of a Day. It appears uſually about Midſummer. It is produced about Six in the Evening, and dies about Eleven. But before it becomes a Fly, it exiſts three Years as a Worm in a Clay Caſe. It never eats from the time of its Change to its Death, nor has any Organs for receiving or digeſting Food. The Buſineſs of its Life is ſummed up in few Words. As ſoon as it has dropt its Clay-Coat, the poor, little Animal being now light and agile, ſpends the reſt of its ſhort, winged State, in friſking over the Waters. During this the Female being impregnated, drops her Eggs upon the Water. Theſe ſink to the bottom, where they are

hatched by the heat of the Sun into little Worms, which make themſelves Caſes in the Clay, and feed on the ſame, or on what the Waters afford, without any need of Parental Care. Thus they are Inhabitants of the Water, 'till the Time comes for ſhaking off their Shell, and emerging into Air.

17. The Eggs of *Butterflies* do not increaſe in Bulk while in the Body of the Female. As ſoon as they are impregnated by the Male, they are ready to be laid. But this requires ſome time, both becauſe of their Number, and the Nicety with which ſhe arranges them. This indeed is the whole Buſineſs of her Life. For when they are laid, ſhe dies.

The Female does not depoſit them at random, but ſearches out that ſort of Plant, which the Caterpillars can feed on as ſoon as they are hatched. Neither does ſhe ſcatter them irregularly and without order, but diſpoſes them with perfect Symmetry, and faſtens them together by a viſcous Liquor diſcharged from her own Entrails. And thoſe Species whoſe hinder Part is covered with long Hairs, gradually throw them all off, and therewith make a Neſt, wherein the Eggs are kept ſafely, 'till the time of their hatching.

18. Some *Caterpillars* are hatched in the Spring, as ſoon as the Leaves they are to be fed on begin to bud. After thirteen days, they change into Aureliæ, and having paſt three Weeks in that State, they iſſue forth winged, with all the Beauty of their Parents: Their Wings are ſcarce dry, before they ſeek to propagate their Species. This done, the Male dies. The Female lives only to depoſit her Eggs, and then follows him. Nature never intending they ſhould eat in this State, has given them no Organs for it: So that they would ſoon die of Hunger, could they eſcape thoſe great Devourers of them, the Birds.

Caterpillars are of no Sex, it not being their buſineſs to propagate, 'till they commence Butterflies. Yet many of them are not ſo harmleſs as they ſeem; for they deſtroy their Fellows, whenever they can. Put twenty Caterpillars of the Oak together in a Box, with a ſufficient Quantity of Leaves, their natural Food. Yet their

their numbers will decreaſe daily, 'till only one remains alive. The ſtronger ſeizes the weaker by the Throat, and gives him a mortal Wound. When he is dead, the Murderer begins to eat him up, and leaves only the Skin with the Head and Feet. But this is not the Caſe of all. Many Species live peaceably and comfortably together.

YET even theſe are expoſed to Dangers of a more terrible kind. The Worms of ſeveral Sorts of Flies, continually prey upon them. Some are upon, ſome under the Skin, and both eat up the poor, defenceleſs Animal alive,

IT is ſurprizing to what Induſtry theſe little Creatures weave the Caſes, in which they paſs their Aurelia-State. Some are made of Silk, mixt with their own Hair, with pieces of Bark, Leaves, Wood or Paper. There is one ſort that builds in Wood, and gives its Caſe an Hardneſs greater than that of the Wood itſelf. This is the Caterpillar of the Willow, which is one of thoſe that eat their Exuviæ. He has ſharp teeth, wherewith he cuts the Wood into a number of ſmall Fragments. Theſe he unites together into a Caſe, by means of a peculiar Silk, which is a viſcous Juice that hardens as it dries. In order to make this Silk into the very Subſtance of the Fragments, he moiſtens every one of them, by holding them ſucceſſively in his Mouth, for a conſiderable time. In this firm caſe he is afterward to be included till he becomes a Butterfly. But how ſhall a Creature of this helpleſs kind, which has neither Legs to dig, nor Teeth to gnaw, get out of ſo firm and ſtrong a Lodgment as that wherein it is hatched? Nature has provided for this alſo. As ſoon as it is hatched, it diſcharges a liquor which diſſolves the viſcous Matter that holds the Caſe together, ſo that the Fragments fall in pieces of themſelves. And accordingly, near its Mouth, there is always found a Bladder of the Size of a ſmall Pea, full of this Liquor.

SOME Caterpillars ſpin all the way they walk, a thread of Silk which marks their Journey. Now what End does this ſerve? A little Obſervation will ſhew. Trace one of them till he chances to fall, and you will ſee the Uſe

Uſe of this thread. Being faſtened to the Leaves and Twigs, it ſtops the Creatures Fall. Nor is this all. It can alſo by means of this Thread, re-aſcend to the Place from whence it fell. And when it is ſafe got up again, it continues its Motion as before.

ANOTHER curious Artifice is that by which the ſame Species of the Caterpillars makes themſelves Caſes of Leaves before they change into Aureliæ. The niceſt Hands could not roll theſe up ſo elegantly, as they do without Hands or any thing like them. They perform it thus. The Caterpillar places itſelf on the upper Side of a Leaf, ſo far from the Edge that he can reach it with his Head. Turning himſelf round, he then brings the Edge of the Leaf, to the the point juſt oppoſite to it. It next draws lines from this Edge of the Leaf to that Point: And doing this all the way along the Leaf, its narrowneſs toward the Point makes it form a cloſe Caſe there. It ſtrengthens the firſt bending of the Leaf, by many parallel threads, and then faſtening other threads to the back part of the Leaf, draws them as tight as it can. The Caſe is then formed. The ſame Method repeated makes the additional Caſes, five or ſix over each other. And every one of theſe is ſufficiently ſtrong, ſo as to make the inner ones uſeleſs. He then enters his Cell, and undergoes his Change. Meantime his Covering ſerves him alſo for Food. For ſo long as he has need to eat, he may feed upon the Walls of his Caſtle: All of which may be eaten away, except the outer one of all. Probably every Caterpillar makes his Caſe thick enough, to ſerve the neceſſary Calls of his future Hunger.

MANY Species of Butterflies lay a great number of Eggs in the ſame place. Theſe all hatch very nearly at the ſame time. And one would naturally ſuppoſe, that the young Brood of all, would be inclined to continue and live together. But it is not ſo, the different Species have different inclinations. Some keep together from the time they are hatched, till they change into Aureliæ. Others ſeparate as ſoon as able to crawl, and hunt their fortune ſingle. And others live in Community till a certain time, and then each ſhifts for itſelf. Thoſe

Thoſe that live wholly together, begin by forming a Line with their little Bodies upon a Leaf; their Heads all ſtanding even, and in this manner they move and eat together. And often there are ſeveral Ranges of this ſort, which makes ſo many Phalanxes, and eat into the leaf they ſtand on, with perfect Equality.

Many do this while young, which when they grow large, make one common Habitation, ſurrounded by a Web, which is the joint Work of all: Within which, each has a Neſt of its own Spinning.

When they have made their common Lodging, each takes its courſe over the Tree or Buſh for Food. Thus many hundreds of them form a regular Republic. The ſeparate Cell of each, is finally the place, where it paſſes its Change into the Aurelia and perfect State. But many Species do not ſeparate even then; but are found in their Aurelia-State all huddled together, numbers of their Caſes making one confuſed Maſs.

One thing more is highly obſervable in them, The Regularity of their Marches. They are exactly obedient to their Chief. When they change their Quarters, one marches ſingle firſt. Two others follow, and keep their Bodies very nicely in the ſame poſition with his. After theſe there follows a large Party. Theſe regulate their Motions by the former. And ſo the Order is continued, thro' the whole Company. When the Leader turns to the right or left, the whole Body does the ſame inſtantly. When he ſtops, they all immediately ſtop, and march again the moment he advances.

19. The *Out-ward Covering* of the Body is, in many Animals *changed* ſeveral times: But in none more frequently than the Caterpillar. Moſt of theſe throw it off at leaſt once in Ten days. Indeed in the whole Inſect Claſs, the moſt numerous of all animated Beings, there is ſcarce one which does not caſt its Skin, at leaſt once, before it arrives at its full Growth. But the Caterpillar changes more than his Skin: Even the outward Covering of every, the minuteſt Part of its Body. And what they throw off has the Appearance of a compleat Inſect, preſenting us with all the external Parts of a living Animal. If the Caterpillar be of the hairy kind, the

the Skin it throws off is hairy, containing the Covering of every Hair. And even the Claws and other Parts that are not visible without a Microscope, are as plain in this as in the living Animal. But what is more amazing is, that the solid Parts of the Head, the Skull and Teeth are distinguishable therein. The throwing off an old Skull and Teeth, to make way for new ones, is an Act beyond all Comprehension! A day or two before, the Creature refuses to eat, and walks very slowly, or not at all. He turns from side to side, and often raises his Beak, and gently depresses it again. He frequently raises his Head, and strikes it down rudely against any thing he stands upon Frequently the Fore-part of the Body is raised from the place, and thrust very briskly backward and forward, three or four times together. There are likewise distinct Motions within every Ring. These are severally inflated and contracted alternately, by which the Skin is loosened from them; till by this means, and its remaining without Food, the Body is quite disengaged from its Covering.

When this time approaches, all the Colours of the Skin grow faint and lose their Beauty, receiving no Nourishment from the Body. And as the Creature continues swelling and shrinking, the Skin, being no longer supple, cracks along his back. The Crack always begins, at the second or third Ring, from the Head. As it opens, the New Skin is seen within. This Opening he easily inlarges, thrusting his Body like a Wedge, out of the Slit, till he lengthens it thro' four Rings. Then he has room to draw out the whole Body. First, the Head is by several Motions loosened, drawn out of the old Skull, and raised thro' the Crack: This is then laid softly on the old Skin of the Part. By the same Motions the Tail End is disengaged, drawn out and laid smoothly on the old Skin. It takes the Animal several Days, to prepare for the last Operation. But when the Crack is once made, the whole remaining Work is done in less than a minute.

The Hairs found on the cast Skins of the hairy Caterpillars seem at first, like the other Part of the Exuviæ, to be only the Covering of the Hairs inclosed. But that

is

is not the Caſe. They are ſolid things themſelves, not barely Coverings. In truth, the Creature when firſt hatched, has all its Skins perfectly formed, one under another, each furniſhed with its Hairs, ſo that the old ones fall off with the old Skins. And probably the erecting theſe is one great Means of forcing off the old Skins.

PERHAPS the ſame ſort of Mechaniſm is uſed even by thoſe Caterpillars, which do not *appear* to be hairy. For they really are ſo, as the Miſcroſcope ſhews. When the upper Skin of one juſt ready to change, is ſlit longitudinally in the place where the Crack would be, the Skin may be taken off; and it is eaſily ſeen, how the New One lies below. The Hairs are diſpoſed in the niceſt manner, for lying ſmooth under the Upper Skin. They grow in ſeparate Tuffs, which never lie upon one another, but together form one Surface.

IT is remarkable, That immediately after this Change they appear much larger than they did before. And they really are ſo. The very Head and Skull are greatly larger than before the Change. The Operation of the Cray-fiſh in changing its Shell, may explain this. This alſo is found conſiderably larger, when out of the Shell than before. In both Caſes, the Body had grown ſo much, that it was too big for its Covering. However while it remained in it, the Parts were compreſt, and forced to lie in that narrow Room. But as ſoon as that Covering is off, every Part diſtends itſelf to its proper Size.

INDEED ſo large a Skull, being a hard Subſtance in the Caterpillar, could not have been compreſt into a ſmaller. But the fact is, the New Skull never hardens till the Change approaches, and then imperfectly. At the ſame time it neceſſarily takes from the place it is in, an oblong Form. In this Shape it is found a few Hours before the Old Skin is caſt off; not incloſed within it, but extended under the Skin of the firſt Ring of the Body. When the Old Skull is thrown off, the new one ſoon hardens and takes its proper Figure.

WE call the Creature hatched from the Egg of a Butterfly, a Caterpillar. But it is a real Butterfly all that time. A Caterpillar changes its Skin four or five times, and

and when it throws off one, appears in another of the same form. But when it throws off the last, as it is now so perfect, as to need no farther Nourishment, so there is no farther need of Teeth, or any other Parts of a Caterpillar.

'Tis plain from hence, that the Change of a Caterpillar into an Aurelia, is not the Work of a moment, but is carrying on, from the very time of its hatching from the Egg. But while the Butterfly lies in the Body of the Caterpillar, its Wings are long and narrow, and wound up into the form of a Cord, and the Feelers are rolled up on the Head. The Trunk also is twisted up and laid on the Head, but in a very different manner, from what it is in the perfect Animal, or indeed in the Aurelia.

A Butterfly then in all its Parts, is in the Caterpillar in all its States. But it is more easily traced, as it comes nearer the time of being changed into an Aurelia. The very Eggs hereafter to be laid by the Butterfly, are to be found not only in the Aurelia, but even in the Caterpillar, all arranged in their natural, regular Order. In the Caterpillar indeed they are transparent: But in the Aurelia, they have their proper Colour.

As soon as the Limbs of the Butterfly are fit to be exposed to the more open Air, they are thrown out from the Body of the Caterpillar, surrounded only with thin Membranes. And as soon as they arrive at a proper degree of Strength and Solidity, they break thro' these and appear in their perfect Form.

The Animal then creeps a little on, and there rests: The Wings being quite folded up. But by degrees they expand, and in less than half an hour, appear in all their Beauty. [t]

20. The

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[t] The kind of Sea-shrubs, as they were formerly accounted, usually termed *Corallines*, are in reality no other than Cases for various Species of Insects. A *French* Gentleman was the first who discovered this. Observing a great number of Insects lodged in several Parts of these marine Productions, soon inferred, That these were only Cases made by these Creatures for their Habitations: And many of them have since been found to be the Covers of Marine

20. The *Ant* lays Eggs like Flies, from which are hatched small Worms without Legs. These are sharp at one end, and blunt at the other: After a short time they change into large, white Aureliæ; vulgarly called *Ants-Eggs*: Whereas they are larger than the Ants themselves. They move these at their pleasure. When

Polype: A strange kind of Animal, so nearly partaking the nature of some Vegetables, that new, perfect Polypes perpetually grow like Branches from the Trunk of the Parent. Yea, if a Polype be cut in pieces, every Piece will grow into a perfect Polype.

A late Writer informs us, "At the Isle of *Skeppey*, I had the opportunity of seeing several branched Corallines, alive in Sea-water, by the help of a commodious Microscope, and was fully assured, that these apparent Plants were real Animals, in their proper Cases, which were fixt to the Shells of Oysters and other small Shell-fish. And at *Brightbelmstone*, I saw those Corallines in motion, whose Polypes are contained in Cups, supported by a long Stem that appears full of Rings, or twisted in form of a Screw. In the middle of the transparent Stems or Cases, I could easily discern the thread-like tender Part of the Animals. On several Parts of these Corallines there are little Bodies, which thro' the Microscope appear as so many Bladders. To the use of these I was quite a stranger before; but I now discovered, they are Habitations of young Polypes, which are produced here and there on the sides of the Parent, as in the fresh-water Polype: Only in the marine ones they are protected by this vesicular Covering. These Vesicles appear at a certain season of the Year, according to the different Species of Corallines, and fall off, like the Blossoms of Plants, as soon as the Polypes arrive at maturity.

But Corallines are Cases not of Polypes only, but of various Sorts of Animals: Which occasions their being made of various Materials, and in great Variety of Forms. Some are united closely and compactly together, forming irregular Branches, like Trees. Others rise in Tufts, like the tubular Sort of Plants, distinct from one another. Some *Maltese* Corallines are of a peculiar kind. The Animals inclosed in these, resemble the many-legged Spiders, usually known by the name of *Scolopendræ*. Their outside Coats are formed of an ash-coloured earthy matter, and closely united to an inner Coat, which is tough, horny, transparent, and extremely smooth. The Cavity of the Tube is quite round, tho' the Animal is of a long Figure, like a Leech extended. It can turn itself in this Tube, and move up and down the better to attack and secure its Prey.

It has two remarkable Arms. The Left much larger than the Right. These are doubly feathered. The number of its Feet on each side of the Body exceeds an hundred and fifty.

an Ant's Neſt is diſturbed, and the Aureliæ ſcattered abroad, the Ants are at infinite pains to gather them and make them a Neſt again. Nay, thoſe of one Neſt will often do this for the Aureliæ of another.

At the bottom of an Ant's Neſt, which is built with ſmall pieces of dry Earth, there is always a large Quantity of Eggs, Worms and Aureliæ. The Aureliæ are covered only with a thin Skin, and if opened ſhew the Ant in its ſeveral Stages toward Perfection.

In every Neſt, as in every Bee-hive, there are three kinds of the Inſect, Males, Females, and working Ants, or Labourers. Theſe laſt are neither Male nor Female, nor have any Buſineſs, but taking care of the young Brood. Male Ants have four Wings and three lucid Points on their Head, and their Eyes are larger than thoſe of the Females, or Labourers. They are not found in the Neſts at all Seaſons, but only at particular times. It ſeems they are killed, (like Drone Bees) as ſoon as the Seaſon for impregnating the Females is over.

The Body of the Female is larger and thicker than that of the Male, or Labourer; and contains a great number of Eggs, placed in regular lines. She has alſo the three lucid Points on her Head, which ſeem to be three Eyes.

The Ant examined by the Microſcope appears a very beautiful Creature. Its Head is adorned with two Horns, each having twelve Points. Its Jaws are indented with ſeven little Teeth, which exactly tally. They open ſideways exceeding wide, by which means the Ant is often ſeen graſping and carrying away Bodies of three times its own Bulk. It is naturally divided into the Head, the Breaſt and the Belly, each joined to the other by a ſlender Ligament. From the Breaſt proceed three Legs on each ſide. The whole Body is caſed over with a ſort of Armour, ſo hard as ſcarce to be penetrated by a Lancet, and thick-ſet with ſhining, whitiſh Briſles.

To prevent the ſprouting of the Corn, the Ants cut off all the Buds, before they lay it up. Yet tho' the Buds are cut off, there remains another Difficulty. Corn under ground will ſwell and rot. To prevent this they have an Expedient, whereby it is kept as dry in their

their Nests as in our Granaries. They bring it out about Noon every Day, and spread it near their Nest, in little Heaps, on a kind of dry Earth, provided for that purpose. They carry it back at Night to their Magazine. But it is observable, they never bring it out, unless in a Day that promises to be fair. In the Prognosticks of this they shew great Sagacity. Where it is dangerous to expose their Riches in the Day time, by reason of the Birds, they vary their Rule, bringing it out in the Night, and carrying it back in the Morning.

They scout round the Country in quest of Corn. Sometimes they find none. However none returns empty. One brings a Grain of Wheat; Another, of Rye or Oats. A third, if he find nothing else, a particle of dry Earth, to lay the Corn upon.

They do not eat at all in Winter, but sleep like most other Insects. So that the Provision they make in Summer is intended, not for themselves but for their Young. There is a strait Hole in every Ants Nest, about half an inch deep; after which it goes sloping into their Magazine, which is a different Place from that where they eat and rest. Over the Hole they lay a flat Stone or Tile, to secure them from their great Enemy, the Rain. In a fair Day, the Hole is open; but when they foresee it will rain, and every Night, the Cover is drawn over, with great Ingenuity as well as Labour. Fifty of the strongest of them surround the Stone, and draw and shove in Concert. The like pains they take every Morning, to thrust it back again.

An Ant never goes into any Nest but her own; if she did, she would be severely punished. And if she returned again after this Warning, the others would tear her in pieces. Therefore they never attempt it, but in the last Extremity: Sometimes they will rather suffer themselves to be taken.

Ants do not bite, as is vulgarly supposed. But Red Ants have a Sting, which expresses a corrosive Liquor, that raises a slight Inflammation. The black Ants have no Sting.

On opening an Ant-hill, a great Quantity of Eggs is usually found. They look like the Scatterings of fine

Salt, and are too minute to be ſeen diſtinctly by the naked Eye. Thro' a Microſcope they appear like the Eggs of ſmall Birds, and are as clear as the Air-bladder of Fiſhes. They lie in Cluſters under cover of ſome light Earth. The Ants ſeem to brood over them, till every Granule is hatched into a Worm, not much larger then a Mite. In a ſhort time theſe turn yelloiwſh and hairy and grow to near as big as their Parent. They then get a whitiſh Film over them, and are of an oval Form. If this Cover be opened after ſome Days, all the Lineaments of an Ant may be traced; tho' the whole is tranſparent, except the Eyes, which are two dark Specks.

The Care theſe Creatures take of their Young is amazing. Whenever a Hill is diſturbed, all the Ants are found buſy, in conſulting the Safety, not of themſelves, but of their Offspring. They carry them out of ſight as ſoon as poſſible; and will do it over and over, as often as they are diſturbed. They carry the Eggs and Worms together in their haſte: But as ſoon as the Danger is over they carefully ſeparate them, and place each by themſelves, under ſhelter of different kinds, and at various Depths, according to the different degrees of Warmth which their different States require.

In the Summer they every Morning bring up the Aureliæ near the Surface of the Earth. And from Ten in the Morning till about five in the Afternoon, they may be found juſt under the Surface. But if you ſearch at Eight in the Evening, they will be found to have carried them all down. And if rainy Weather be coming on, they lodge them at leaſt a foot deep.

21. One of the moſt dreadful Enemies of the Ants is the *Formica-leo* or *Ant-Eater*: It is ſoft as a Spider, but has in its Form ſome reſemblance of a Wood-louſe. Its Body is compoſed of ſeveral Rings: It has ſix Legs, four joined to the Breaſt; and the other Two to a long Part, which may be termed the Neck. Its Head is ſmall and flat, and it has two remarkable Horns; the Sixth of an inch long, as thick as a Hair, hard, hollow and hooked at the End. At the origin of each of theſe Horns, it has a clear and bright black Eye.

He is not able to hunt after Prey, nor to deſtroy large Inſects. He can only inſnare ſuch as come by his Habitation, and of theſe, few are ſuch as he can manage. All the winged Tribe eſcape by flight, and thoſe that have hard Shells are of no uſe to him, the Smallneſs of the Ant, and its want of Wings, make it his deſtined Prey. The Manner wherein he proceeds is this. He uſually incamps under an old Wall for Shelter, and always chuſes a place where the Soil is compoſed of a light, dry Sand. In this he makes a Pit in ſhape of a Funnel, which he does in the following manner.

If he intends the Pit to be but ſmall, he thruſts his hinder Parts into the Sand, and by degrees works himſelf into it. When he is deep enough, he toſſes out with his Head the looſe Sand which is run down, artfully throwing it off, beyond the Edges of the Pit. Then he lies at the bottom of the ſmall Hollow, which comes ſloping down to his Body.

But if he is to make a larger Pit, he firſt traces a larger Circle in the Sand. Then he buries himſelf in it, and carefully throws off the Sand, beyond the Circle. Thus he continues running down backward in a ſpiral Line, and throwing off the Sand above him all the way, till he comes to the point of the hollow Cone, which he has formed by his Paſſage. The length of his Neck and the Flatneſs of his Head, enable him to uſe the whole as a Spade. And his Strength is ſo great, that he can throw a Quantity of Sand, to ſix Inches diſtance. He likewiſe throws away the remains of the Animals he has devoured, that they may not fright other Creatures of the ſame Species.

Where the Sand is unmixt, he makes and repairs his Pit with great Eaſe. But it is not ſo, where other Subſtances are mixt with it. If when he has half formed his pit, he comes to a ſtone not too large, he goes on, leaving that to the laſt. When the Pit is finiſhed, he creeps up backward to the Stone, and getting his backſide under it, takes great pains to get it on a true poiſe, and then creeps backward with it, to the top of the Pit.

We may often ſee one thus labouring at a Stone four times as big as his own body. And as it can only move

back-ward, and the poiſe is hard to keep, eſpecially up a ſlope of crumbly Sand, the Stone frequently ſlips when near the verge, and rolls down to the bottom. In this Caſe he attacks it again, and is not diſcouraged by five or ſix Miſcarriages; but attempts it again, till at length he gets it over the verge of his place. Yet he does not leave it there, leſt it ſhould roll in again, but always removes it to a convenient Diſtance.

When his pit is finiſhed, he buries himſelf at the bottom of it in the Sand, leaving no part above it, but the tips of his Horns, which he extends to the two Sides of the pit. Thus he waits for his Prey. If an Ant walk on the edge of his pit, it throws down a little of the Sand. This gives notice, to toſs up the Sand from his Head on the Ant; of which he throws more and more, till he brings him down to the bottom, between his Horns. Theſe he then plunges into the Ant, and having ſucked all the blood, throws out the Skin as far as poſſible. This done he mounts up the Edges of his Pit, and if they have ſuffered any Injury, repairs it carefully. He then immediately buries himſelf again in the Center, to wait for another Meal.

This Creature has no Mouth, but it is thro' its Horns that it receives all its Nouriſhment. And as they are ſo neceſſary for its Life, Nature has provided for the reſtoring them, in caſe of Accidents: So that if they are cut off, they ſoon grow again.

When he has lived his Stated time, he leaves his pit, and is only ſeen drawing traces on the Sand. After this he buries himſelf under it, and incloſes himſelf in a Caſe. This is made of a ſort of Silk with Grains of Sand cemented together by a glutinous Humour which he emits. But this would be too harſh for his Body: So it ſerves only for the Outward Covering. He ſpins within it One of pure, fine, pearl-coloured Silk, which covers his whole Body. When he has lain ſometime in this Caſe he throws off his outer Skin, with the Eyes, the Horns and all other exterior Parts, and becomes an oblong Worm, in which may be traced the form of the future Fly. Thro' its tranſparent Skin may be ſeen, new Eyes, new Horns and all other Parts of the perfect Animal. This

Worm

Worm makes its way about half out of the Case, and so remains, without farther Life or Motion, 'till the perfect Fly makes its way out of a Slit in the back. It much resembles the Dragon-fly. The Male then couples with the Female and dies.

22. The Sagacity of *Bees* in making their Combs, cannot be too much admired. The Labour is distributed regularly among them. The same Bees, sometimes carry the Wax in their Jaws, and moisten it with a Liquor which they distil upon it, and sometimes build the Walls of their Cells. But they that *form* the Cells, never polish them. Others make the Angles exact, and smooth the Surface. The bits of Wax which are scraped off in doing this, others pick up, that none may be lost.

Those that polish, work longer than those that build the Walls; Polishing not being so laborious a Work as building. They begin the Comb at the top of the Hive, fastning it to the most solid Part thereof. Hence they continue it from top to bottom, and from Side to side. And to make it more solid, they add a kind of tempered Wax, pretty much like Glew. The Cells are always Six-sided: A Figure, which beside the Advantage it has in common with the Square, of leaving no Vacancies between the Cells, has this peculiar to itself, that it includes a greater Space within the same Surface than any other Figure.

Honey exsudes from all sorts of Flowers, the bitterest not excepted, if they have any Utricle at the bottom of the Flower-leaves; for there chiefly it is lodged. The Bee thrusting in his trunk sucks it out, into a small Bladder in his Belly. When this is full he returns, enters one of the Cells, and discharges it there, thro' his Mouth, which he then opens wide, moving his Head at the same time to and fro. If a Drop be ill placed, he sucks it up again, and discharges it anew. When a Cell is filled, they stop it up with Wax.

It is a grand Question, Is there any Part of a Plant without Iron? It is certain, Honey is not. And if so delicate an extract from the finest Part of Flowers, and that farther elaborated in the bowels of the Insect: If this be not without Iron, we may despair of seeing any Part so.

The

THE *Sting* of a Bee or Wasp is a curious piece of Work. It is an hollow Tube, within which, as in a Sheath, are two sharp-bearded Spears. A Wasp's Sting has Eight Beards on the Side of each Spear, somewhat like the Beards of Fish-hooks. These Spears in the Sheath lie one with its Point a little before that of the other. One is first darted into the Flesh, which being fixt, by means of its foremost Beard, the other strikes in too, and so they alternately pierce deeper, the Beards taking more and more hold in the flesh: Afterward the Sheath follows, to convey the poison into the Wound. When the Beards are lodged deep in the Flesh, Bees often leave their Stings behind them, if they are disturbed, before they have time, to withdraw their Spears into their Scabbard.

THE *Queen-Bee* is somewhat larger, considerably longer, and of a brighter Red than Others. Her Office is, to direct and lead the Swarm, and to raise a new Breed. She brings forth Ten, Fifteen, or Twenty Thousand young ones in a Year: So that She may literally be said to be the *Mother* of her People. In an Hive of Eight or Ten Thousand, there is usually but One Queen Bee.

Drones, or *Males* have no Stings, and are larger and darker-coloured than the working Bees. The Eggs for them are placed in a larger sort of Cells. They are also Nurses to the Young Brood.

IT is certain Bees foresee Rain, tho' we know not how. Hence no Bee is ever caught in a sudden Shower: Unless it be far distant from the Hive, or any way hurt or sickly.

THUS much may be seen on the Outside of the Hive. But when we look within, how is the Wonder increased! To see so many thousands all so busily at work, and with such admirable Regularity! Nor is there less wonder in observing the Clusters of them, when they take some rest. Their Method then is, to get together, and hang one to another in vast Numbers. When these Clusters are large, they are only shapeless Heaps; when smaller, they are a sort of Festoon or Garland, each End being fastened to the Branch

Branch, and the middle dropping from it. The manner in which they hang is this. Each with one or both of his Fore-legs lays hold of one or both of the Hinder-legs of the Bee that is next above it.

THRO' a Glass-hive we see, that as the Combs are carried down from the top to the bottom of the Hive, each is placed parallel to the former, but not touching it, there being a Space between for the Bees to walk. These are their public Streets, and by means of these they can make use of every Cell. There are likewise Alleys cut from Street to Street, thro' the Substance of the several Combs.

ALL the Cells are used in common. Some of them contain only Honey, and are covered with a Lid of Wax. These are never touched by any Bee. But other Cells are open, and a Bee is often seen so lodged in one of these, that only its hinder Part appears. The Meaning hereof is, each of these open Cells contains at the bottom a Bee-Worm. Certain Bees duly visit these, plunging their Heads into the several Cells, one after another.

THE Fruitfulness of the Female is the less strange, when we consider the number of the Males. In any Hive there are, at the Season, several Hundreds: In some, two or three thousand. These are the joint Fathers of the numerous Offspring, and when they have done their Work, are all killed. The Wings of the Female reach only to the third Ring of her Body; Whereas those of all other Bees cover the whole Body. But tho' she is thus easy to be distinguished, yet few have ever seen a Queen-Bee: As she is always close covered in the Hive.

MR. *Reaumur*, desiring to try, how far the Accounts given of the Homage paid by the others to the Queen-Bee was true, caused a Swarm of Bees to be swept down into a Glass-hive. Among these there was one Female. She was soon distinguished by her Shape, and the Shortness of her Wings. For a while she walked alone at the bottom of the Hive; the rest seeming to regard nothing but their own Safety. The Female after going twice or thrice up the sides of the Hive, to the top of it, where they were hung, at last going

going in among the Cluſter, brought down about a dozen with her. Attended with theſe, ſhe walked along ſlowly at the bottom of the Hive. But the reſt continuing at the top, ſhe went again and again, 'till they all came down and formed a Circle about her, leaving her a free Paſſage wherever ſhe turned to walk, and feeding her with the Honey they had gathered for themſelves.

The Hive was large enough for more than their Number. However the Female ſeemed to find, it would not be large enough for the Family ſhe was to produce. So gathering them all about her, ſhe went out and flew to a neighbouring Tree. All followed her, and formed a Cluſter about her, in the common way.

The Bees follow their Queen wherever ſhe goes. And if ſhe be tied by one of the Legs to a Stick, all the Swarm will gather in a Cluſter about her, and by removing the Stick may be carried any where.

Nature ſeems to have informed the common Bees, that they are to bring up the Offspring of this Female. Therefore they ſerve her in every thing. If by any means ſhe is dirted, all the reſt try who ſhall clean her. And in cold Weather, they cluſter together about her, to keep her warm. Nor do they ſhew this reſpect to One Female only. Mr. *Reaumur*, at ſeveral times, put ſeveral Females, marked with different Colours, into the ſame Swarm. And all theſe were, for a time, received as well as the proper Female.

The Swarm which leaves an old Hive, have often three or more Females. Theſe have their ſeveral Followers. And each with her Followers, were the number ſufficient, would form a diſtinct Swarm. As it is not, they all go into the ſame Hive. But all, except one, are ſoon deſtroyed. The reaſon is, The working Bees of an Hive have enough to do to prepare Cells, for lodging the Eggs of one Female, and it would be impoſſible for them, to prepare twice or thrice that number.

Sometimes in Two Parts of a Swarm, there are more than two Female Bees. In this caſe too, as ſoon as they

they are lodged in the Hive, all are killed but One. Nature deſigns but one Female for each Swarm. But as many things may deſtroy, the Egg or Worm of this ſingle Female, it was needful, that Proviſion ſhould be made for Accidents. So that there are often twenty Females which live to Maturity with the Bees of one Swarm. But One only is then ſpared, whether they go out with the Swarm, or remain within.

As ſoon as the Swarm is gone out, the firſt Work of the remaining Bees, is to deſtroy the young Females. Theſe are all immediately killed and carried out of the Hive: and it is common, the Morning after the going out of a Swarm, to ſee ſix, eight or more Female Bees, lying dead at ſome diſtance from the Hive. What determines the Bees in favour of One, is her having Eggs ready to be hatched. Accordingly if new made Cells be examined, ſhe will be found the very next day, to have laid Eggs in many, if not all. Whereas if the Bodies of the rejected Females be examined, there will be found either no Eggs at all, or Eggs ſo extremely minute, that it muſt have been a long time before any could have been laid.

It is not at all times however, that the Bees are thus cruel to the ſupernumerary Females; but only at the time when they are newly eſtabliſhed in their Habitation, and in Want of all things. At other times they are as kind to ſtrange Females as to their own. Mr. *Reaumur* tried the Experiment, by putting a ſtrange Female into a Hive, where the Combs were perfect, and filled with Honey. And the Bees ſhewed the ſame Reſpect to Her, as to their proper Sovereign.

The *Wax* is furniſhed by the *Farina* or *Meal* of Flowers; the *Honey*, by certain Veſicles, near the Baſis of the Flower-leaves, which continually ſecrete a ſweet Juice. From theſe the Bee ſucks either Honey, or a Juice of ſuch a Nature as will produce Honey, under her Management.

The Common Food of the Bee is the Farina of Flowers: A great Part of which after it has ſerved them for Nouriſhment, is thrown out at their Mouths in form

form of Wax. The Honey depoſited in their waxen Cells, is for Food when they cannot go abroad to ſearch for other Food.

The Bee that comes loaded to any Cell, ſoon diſcharges his Honey into it. No ſooner is he gone, than another comes, and ſo on, till the whole Cell is filled. But that which lies uppermoſt is always of a different Appearance from the reſt of the Honey. It is a kind of Cream, which both keeps the Honey moiſt, and prevents its running out by Accident.

This Cruſt or Cream was not, as one would think, voided laſt, but was gathering from the firſt. For the Bee which comes loaded to the Cell, does not at once diſcharge his Honey, but entering into it as deep as may be, thruſts out his fore-legs, and pierces an Hole thro' the Cruſt. Keeping this open with his feet, he diſgorges the Honey in large Drops from his Mouth. He then cloſes the Hole, and this is regularly done by every Bee that contributes to the common Store.

But every Bee that comes loaded to the Hive, does not depoſit his Honey in the Cell. They often diſpoſe of it by the way. Inſtead of going to any Cell, they often go to thoſe that are at work and call them to feed upon the Honey they have brought, that they may not be obliged to intermit their Work, on the account of Hunger. Theſe feed on the ſtore of the friendly Bee, by putting their Trunk into her Mouth, exactly in the ſame manner as they do, into the bottoms of Flowers.

Some Cells in every Hive contain Honey for immediate Conſumption, as in caſe of bad Weather. And theſe are always open at the top. Others contain their Proviſion for the Winter. Theſe are all cloſed down with a ſtrong Lid, not eaſily to be removed. Such is the Wiſdom which the Great Author of Nature has imparted to ſome of the moſt inconſiderable of his Creatures!

CHAP.

CHAP. VI.

General Obſervations and Reflections.

1. AS to the *Number* of Animals, The Species of *Beaſts*, including alſo *Serpents*, are not very numerous. Such as are certainly known and clearly deſcribed, are not above an hundred and fifty. And yet probably not many that are of any conſiderable Bigneſs, have eſcaped the Notice of the Curious.

THE Species of *Birds*, known and deſcribed are near five Hundred, and the Species of *Fiſhes*, excluding Shell-fiſh, as many: But if the *Shell-fiſh* are taken in, above ſix times the Number. How many of each Genus remain undiſcovered, we cannot very nearly conjecture. But we may ſuppoſe, the whole Sum of Beaſts and Birds to exceed by a Third Part, and Fiſhes by one Half, thoſe that are known.

THE *Inſects*, taking in the Exſanguious, both terreſtrial and aquatic, may for number vie even with Plants themſelves. The Exſanguious alone, by what Dr. *Liſter* has obſerved and delineated, we may conjecture cannot be leſs (if not many more) than three thouſand Species. Indeed this Computation ſeems to be much too low: for if there are a thouſand Species in this Iſland and the Sea near it; and if the ſame proportion hold between the Inſects native of *England*, and thoſe of the reſt of the World (about a Tenth:) The Species of Inſects on the whole Globe, will amount to Ten thouſand.

Now if the number of Creatures even in this lower World, be ſo exceeding great; How great, how immenſe muſt be the Power and Wiſdom of Him that formed them All! For as it argues far more Skill in an Artificer, to be able to frame both Clocks and Watches and Pumps and many other Sorts of Ma-

thines, than he could diſplay in making but one of thoſe Sorts of Engines: So the Almighty declares more of his Wiſdom, in forming ſuch a multitude of different Sorts of Creatures, and all with admirable and unreprovable Art, than if he had created but a few.

2. Again. The ſame Superiority of Knowledge would be diſplayed, by contriving Engines for the ſame Purpoſes after different Faſhions, as the moving Clocks or other Engines by Springs inſtead of Weights: And the infinitely wiſe Creator, has ſhewn by many Inſtances, that he is not confined to one only Inſtrument, for the working one Effect, but can perform the ſame thing by divers Means. So tho' moſt flying Creatures have Feathers, yet hath he enabled ſeveral to fly without them, as the Bat, one ſort of Lizard, two ſorts of Fiſhes, and numberleſs Inſects. In like manner, altho' the Air-bladder in Fiſhes ſeem neceſſary for Swimming: Yet are many ſo formed as to ſwim without it, as firſt the *Cartilaginous* kind, which nevertheleſs do aſcend and deſcend at pleaſure, altho' by what means we cannot tell. Secondly, The *Cetaceous* kind: The Air which they receive into their Lungs, in ſome meaſure anſwering the ſame End.

Yet again. Tho' God has tempered the Blood and Bodies of moſt Fiſhes to their cold Element, yet to ſhew he can preſerve a Creature as hot as Beaſts themſelves in the coldeſt Water, he has placed variety of theſe Cetaceous Fiſhes in the Northermoſt Seas. And the copious Fat wherewith their Body is incloſed, by reflecting the internal Heat, and keeping off the external Cold, keeps them warm even in the neighbourhood of the Pole.

Another Proof that God can by different Means produce the ſame Effect, is the various Ways of extracting the Nutritious Juice out of the Aliment in various Creatures.

In *Man* and *Beaſts* the Food, firſt chewed, is received into the Stomach, where it is concocted and reduced into Chyle, and ſo evacuated into the Inteſtines, where, being mixt with the Choler and Pancreatic Juice,

Juice, it is farther ſubtilized, and rendered ſo fluid, that its finer Parts eaſily enter the Mouth of the Lacteal Veins.

In *Birds* there is no chewing: But in ſuch as are not Carnivorous, it is immediately ſwallowed into the Crop, or Anti-Stomach (which is obſerved in many, eſpecially piſcivorous Birds) where it is moiſtened by ſome proper Juice, and then transferred to the Gizzard, by the working of whoſe Muſcles, aſſiſted by ſmall Pebbles, which they ſwallow for that purpoſe, it is ground ſmall, and ſo tranſmitted to the Inteſtines.

In oviparous *Reptiles*, and all kind of *Serpents*, there is neither Chewing nor Comminution in the Stomach, but they ſwallow Animals whole, ſo they void the Skins unbroken, having extracted the nutritious Juices. Here, by the by, we may obſerve the wonderful Dilatability of the Throats and Gullets of Serpents. Two entire adult Mice have been taken out of the Stomach of an Adder, whoſe Neck was no bigger than one's little finger.

Fiſhes, which neither chew, nor grind their Meat, do, by means of a corroſive Juice in their Stomach, reduce Skin, Bones and all into Chyle. And yet this Juice ſhews no Acidity to the Taſte. But how mild ſo ever it taſtes, it corrodes all animal Subſtances, as Aquafortis does Iron.

3. Several eminent Men have been of Opinion, that all Brutes are mere Machines. This may be agreeable enough to the Pride of Man; but it is not agreeable to daily Obſervation. Do we not continually obſerve in the Brutes which are round about us, a degree of Reaſon? Many of their Actions cannot be accounted for without it: As that commonly noted of Dogs, that running before their Maſters, they will ſtop at a Parting of the Road, 'till they ſee which way their Maſters take. And when they have gotten what they fear will be taken from them, they run away and hide it. Nay, what account can be given, why a Dog being to leap on a Table, which he ſees he cannot reach at once, if a Stool or Chair ſtands near it,

firſt mounts That, and thence proceeds to the Table? If he were mere Clock-work, and his Motion cauſed by a material Spring, that Spring being once ſet to work, would carry the Machine in a right Line, toward the Object that put it in motion.

WERE it true, that Brutes were mere Machines, they could have no Perception of Pleaſure or Pain. But how contrary is this, to the doleful Significations they give, when beaten or tormented? How contrary to the common Senſe of Mankind? For do we not all naturally pity them, apprehending them to feel Pain juſt as we do? Whereas no man is troubled to ſee a Plant torn, or cut, or mangled how you pleaſe. And how contrary to Scripture? *A righteous man regardeth the life of his beaſt: but the tender mercies of the wicked are cruel. Prov.* xii. 10. The former Clauſe is uſually rendered, *A good man is merciful to his beaſt.* And this is the true rendering, as appears by the oppoſite Clauſe, That *the wicked is cruel.* Cruelty then may be exerciſed toward Beaſts. But this could not be, were they mere Machines.

4. THE *Natural Inſtinct* of all Creatures, and the ſpecial Proviſion made for ſome of the moſt helpleſs, do in a particular manner demonſtrate the great Creator's Care.

FIRST, What an admirable Principle is the Natural Affection of all Creatures toward their Young! By means of this, with what Care do they nurſe them up, thinking no pains too great to be taken for them, no Danger too great to be ventured upon, for their Guard, and Security! How will they careſs them with their Affectionate Notes, 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 ſo many Nurſes, deputed by the ſovereign LORD of the World, to help ſuch young and ſhiftleſs Creatures, till they are able to ſhift for themſelves.

OTHER Animals, Inſects in particular, whoſe Offſpring is too numerous for the Parent's Proviſion, are ſo generated, as to need none of their Care. For they arrive

arrive immediately at their perfect State, and so are able to shift for themselves. Yet thus far the Parental Instinct (equal to the most rational Fore-sight) extends, that they do not drop their Eggs any where, but in commodious Places, suitable to their Species. And some including in their Nests, sufficient and agreeable Food, to serve their Young till they come to Maturity.

And for the Young themselves. As the Parent is not able to carry them about, to cloath them and dandle them, as Man doth: How admirably is it contrived, that they can soon walk about, and begin to shift for themselves! How naturally do they hunt for their Teat, suck, pick and take in their proper Food!

On the other hand, the Young of Man, (as their Parent's Reason is sufficient, to help, to nurse, feed and cloath them) are born utterly helpless, and are more absolutely than any Creature, cast upon their Parent's Care.

Secondly, What admirable Provision is made for some of the most helpless Creatures, at a time when they must otherwise utterly perish! The Winter is an improper Season to afford Food to Insects and many other Animals. When the Fields, Trees and Plants are naked, and the Air is chilled with Frost; what would become of such Animals, whose tender Bodies are impatient of Cold: And who are nourished only by the Produce of the Spring or Summer? To prevent their total Destruction, the wise Preserver of the World has so ordered, that in the first place, those which are impatient of Cold, should have such a peculiar Structure of Body, as during that Season, not to suffer any Waste, nor consequently need any Recruit. Hence many Sorts of Birds, and almost all Insects, pass the whole Winter without any Food. And most of them without any Respiration. It seems all Motion of the Animal Juices is extinct. For tho' cut in pieces they do not awake, nor does any Fluid ooze out at the Wound. This Sleep therefore is little less than Death,

and their Waking, than a Reſurrection: When the returning Sun revives them and their Food together.

The next Proviſion is for ſuch Creatures as can bear the Cold, but would want Food. This is provided againſt in Some, by a long Patience of Hunger, in Others by their wonderful Inſtinct, in laying up Food before-hand, againſt the approaching Winter. By ſome of theſe, their little Treaſuries are at the proper Seaſon well ſtocked with Proviſions. Yea, whole Fields are here and there beſpread, with the Fruits of the neighbouring Trees, laid carefully up in the Earth and covered ſafe, by provident little Animals.

5. And what a prodigious Act is it of the Creator's Indulgence, to the poor, ſhiftleſs Irrationals, that they are all ready furniſhed with ſuch *Cloathing*, as is proper to their Place and Buſineſs! With Hair, with Feathers, with Shells, or with firm Armature, all nicely accommodated, as well to the Element wherein they live, as to their ſeveral Occaſions there. To *Beaſts* Hair is a commodious Cloathing; which together with the apt Texture of their Skin, fits them in all Weathers, to lie on the Ground, and to do their Service to Man. The thick and warm Fleeces of others, are a good Defence againſt the Cold and Wet, and alſo a ſoft Bed: Yea, and to many a comfortable Covering for their tender Young.

And as Hair is a commodious Dreſs for Beaſts, ſo are Feathers for *Birds*. They are not only a good Guard againſt Wet and Cold, but nicely placed every where on the Body, to give them an eaſy Paſſage thro' the Air, and to waft them thro' that thin Medium. How curious is their Texture for Lightneſs, and withall cloſe and firm for Strength! And where it is neceſſary they ſhould be filled, what a light, medullary Subſtance are they filled with? So that even the ſtrongeſt Parts, far from being a load to the Body, rather help to make it light and buoyant. And how curiouſly are the Vanes of the Feathers wrought, with capillary Filaments, neatly interwoven together, whereby they are ſufficiently cloſe and ſtrong, both to guard the Body againſt the Injuries of the Weather, and

and to impower the Wings, like ſo many Sails, to make ſtrong Impulſes on the Air in their Flight.

No leſs curious is the Cloathing of *Reptiles*. How well adapted are the Rings of ſome, and the Contortions of the Skin of others, not only to fence the Body ſufficiently, but to enable them to creep, to perforate the Earth, and to perform all the Offices of their State, better than any other Covering?

Observe, for inſtance, the Tegument of the *Earth-worms*, made in the completeſt manner, for making their Paſſage thro' the Earth, wherever their Occaſions lead them. Their Body is made throughout of ſmall Rings, which have a curious Apparatus of Muſcles, that enable them with great Strength to dilate, extend or contract their whole Body. Each Ring is likewiſe armed with ſtiff, ſharp Prickles, which they can open at pleaſure, or ſhut cloſe to their Body. Laſtly, under their Skin there is a ſlimy Juice, which they emit, as occaſion requires, to lubricate the Body, and facilitate their Paſſage into the Earth. By all theſe means they are enabled, with eaſe and ſpeed, to work themſelves into the Earth, which they could not do, were they covered with Hair, Feathers, Scales, or ſuch Cloathing as any of the other Creatures.

How wiſely likewiſe are the Inhabitants of the Waters cloathed! The Shells of ſome *Fiſhes*, are a ſtrong Guard to their tender Bodies, and conſiſtent enough with their ſlow Motion: While the Scales and Fins of others afford them an eaſy and ſwift Paſſage thro' the Waters.

6. Admirable likewiſe is the Sagacity of Brute-Animals, in the Conveniency and Method of their *Habitations*. Their architectonic Skill herein, exceeds all the Skill of Man. With what inimitable Art do ſome of theſe poor, untaught Creatures, lay a parcel of rude, ugly Sticks or Straws together! with what Curioſity do they line them within, yea, wind and place, every Hair, Feather or Lock of Wool, to guard and keep warm the tender Bodies, both of themſelves and their Young? And with what Art do they thatch over and coat their Neſts without, to deceive the Eye of

of the Spectators, as well as to guard and fence them againſt the Injuries of the Weather?

EVEN *Inſects*, thoſe little, weak, tender Creatures, what Artiſts are they in building their Habitations? How does the Bee gather its Comb from various Flowers, the Waſp from ſolid Timber? [u] With what Accuracy do other Inſects perforate, the Earth, Wood, yea, Stone itſelf? Farther yet, With what Care and Neatneſs do moſt of them line their Houſes within, and ſeal them up and fence them without? How artifically do others fold up the Leaves of Trees; Others glue light Bodies together, and make floating Houſes, to tranſport themſelves to and fro, as their various Occaſions require!

7. ANOTHER Inſtance of the Wiſdom of Him that made and governs the World we have in the *Balance of Creatures*. The whole Surface of the Terraqueous Globe, can afford Room and Support, to no more than a determinate Number of all Sorts of Creatures. And if they ſhould increaſe to double or treble the Number, they muſt ſtarve or devour one another. To keep the Balance even, the great Author of Nature has determined the Life of all Creatures to ſuch a Length, and their Increaſe to ſuch a Number, proportioned to their Uſe in the World. The Life indeed of ſome hurtful Creatures is long; of the Lion in particular. But then their Increaſe is exceeding ſmall: And by that means they do not overſtock the World. On the other hand, where the Increaſe is great, the Lives of thoſe Creatures are generally ſhort. And beſide this, they are of great Uſe to Man, either for Food, or on other Occaſions. This indeed ſhould be particularly obſerved, as a ſignal Inſtance of Divine Providence, That uſeful Creatures are produced in great Plenty; Others in ſmaller

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[u] WASPS at their firſt coming frequent Poſts, Boards and other dry Wood that is ſound, but never any that is rotten. This they ſcrape and gnaw, and what they gnaw off, they keep cloſe together between their Chin and Fore-legs, until they have gotten enough for a Burden. They then carry it away in their Mouths, to make their Combs with.

ſmaller numbers. The prodigious Increaſe of Inſects, both in and out of the Waters may exemplify the former Obſervation. For innumerable Creatures feed upon them, and would periſh, were it not for this Supply. And the latter is confirmed by what many have remarked, That Creatures of little Uſe, or by their Voraciouſneſs pernicious, either ſeldom bring forth, or have but one or two at a Birth.

8. How remarkable is the *Deſtruction* and *Reparation* of the whole *Animal* Creation? The Surface of the Earth is the inexhauſtible Source whence both Man and Beaſt derive their Subſiſtence. Whatever lives, lives on what vegetates, and Vegetables in their turn, live, on whatever has lived or vegetated. It is impoſſible for any thing to live, without deſtroying ſomething elſe. It is thus only that Animals can ſubſiſt themſelves, and propagate their Species.

God in creating the firſt individual of each Species, Animal or Vegetable, not only gave a form to the Duſt of the Earth, but a Principle of Life, incloſing in each, a greater or ſmaller Quantity of Organical Particles, indeſtructible, and common to all organized Beings. Theſe paſs from Body to Body, ſupporting the Life, and miniſtring to the Nutrition and Growth of each. And when any Body is reduced to aſhes, theſe organical Particles, on which Death hath no power, ſurvive and paſs into other Beings, bringing with them Nouriſhment and Life. Thus every production, every Renovation, every increaſe by Generation or Nutrition, ſuppoſe a preceding Deſtruction, a Converſion of Subſtance, an acceſſion of theſe organical Particles, which ever ſubſiſting in an equal number, render Nature always equally full of Life.

The total Quantity of Life in the Univerſe is therefore perpetually the ſame. And whatever Death ſeems to deſtroy, it deſtroys no part of that primitive Life, which is diffuſed thro' all organized Beings. Inſtead of injuring Nature, it only cauſes it to ſhine with the greater Luſtre. If Death is permitted to cut down Individuals, it is only, in order to make of the Univerſe, by the Reproduction of Beings, a theatre ever crouded, a ſpectacle ever new. But it is never

ver permitted to deſtroy the moſt inconſiderable Species.

That Beings may ſucceed each other, it is neceſſary that there be a Deſtruction among them. Yet like a provident Mother, Nature in the midſt of her inexhauſtible abundance, has prevented any Waſte, by the few Species of carnivorous Animals, and the few Individuals of each Species; multiplying at the ſame time both the Species and Individuals of thoſe that feed on Herbage. In Vegetables ſhe ſeems to be profuſe, both with regard to the Number and Fertility of the Species.

In the Sea indeed all the Species are carnivorous. But tho' they are perpetually preying upon, they never deſtroy each other, becauſe their Fruitfulneſs is equal to their Depredations.

"Thus thro' ſucceſſive Ages ſtands
Firm fixt thy providential Care!
Pleaſed with the Works of thy own hands
Thou doſt the Waſtes of Time repair."

9. I add a few more Reflections on the World in general. The ſame wiſe Being, who was pleaſed to make Man, prepared for him alſo an Habitation, ſo advantageouſly placed, that the Heavens and the reſt of the Univerſe might ſerve it both as an Ornament and a Covering. He conſtructed likewiſe the Air which man was to breathe, and the Fire which was to ſuſtain his Life. He prepared alſo Metals, Salts and all terreſtrial Elements to renew and maintain throughout all Ages, whatever might be on any account neceſſary for the Inhabitants of the Earth.

The ſame Divine Ruler is manifeſt in all the Objects that compoſe the Univerſe. It is he that cauſed the Dry-land to appear, above the Surface of the Ocean, that gauged the Capacity of that amazing Reſervoir, and proportioned it to the Fluid it contains. He collects the riſing Vapours and cauſes them to diſtill in gentle Showers. At his Command the Sun darts his inlivening Rays, and the Winds ſcatter the noxious

noxious Effluvia, which if they were collected together might destroy the Human Race.

He formed those Hills and lofty Mountains which receive and retain the Water within their bowels, in order to distribute it with œconomy to the inhabitants of the Plains, and to give it such an impulse, as might enable it to overcome the unevenness of the lands, and convey it to the remotest Habitations.

He spread under the Plains Beds of Clay or compact Earths, there to stop the Waters, which after a great Rain, make their way, thro' innumerable little Passages. These Sheets of Water frequently remain in a level with the neighbouring Rivers, and fill our Wells with their redundancy, or as those subside, flow into them again.

He proportioned the Variety of Plants in each Country, to the Exigences of the Inhabitants, and adapted the Variety of the Soils, to the Nature of those Plants.

He endued numerous Animals with mild Dispositions, to make them the Domestics of Man: And taught the other Animals to govern themselves, with an aversion to Dependence, in order to continue their Species without loading Man with too many Cares.

If we more nearly survey the Animal and Vegetable World, we find all Animals and Plants, have a certain and determined Form, which is invariably the same. So that if a Monster ever appear, it cannot propagate its kind, and introduce a new Species into the Universe. Great indeed is the Variety of organized Bodies. But their number is limited. Nor is it possible to add a new Genus either of Plants or Animals, to those of which God has created the Germina, and determined the Form.

The same Almighty Power, has created a precise number of simple Elements, essentially different from each other, and invariably the same. By these he varies the Scene of the Universe, and at the same time prevents its Destruction, by the very Immutability of the Nature and Number of these Elements. So that the World is for ever changed, and yet eternally the same.

Yet

YET if we would *account for* the origin of these Elements, we are involved in endless Uncertainty. We can only say, he who has appointed their different Uses in all Ages, has rendered those Uses infallible, by the impossibility of either destroying or increasing them.

HEREIN we read the Characters of his Power, which is invariably obeyed; of his Wisdom, which has abundantly provided for every thing, and of his tender Kindness toward Man for whom he has provided Services equally various and infallible. It is an additional Proof of his continual Care of his Creatures, that tho' every thing be composed of simple Elements, all placed within our reach, yet no power is able to destroy the least Particle of them. Nothing but the same Cause which was able to give them birth, can annihilate them, or change their Nature. In truth, the Design and Will of the Creator, is the only physical Cause of the General Œconomy of the World: the only physical Cause of every organized Body, every Germen that flourishes in it; the only physical Cause of every minute, elementary Particle, which enters into the Composition of all.

WE must not then expect, ever to have clear and full Conceptions of Effects, Natures and Causes. For where is the thing which we can fully conceive? We can no more comprehend either what Body in general is, or any particular Body, suppose a mass of Clay, or a Ball of Lead, than what a Spirit, or what GOD is.

IF we turn our Eyes to the minutest Parts of animal Life, we should be lost in Astonishment! And tho' every thing is alike easy to the Almighty, yet to *us* it is matter of the highest wonder, that in those Specks of Life, we find a greater number of members to be put in motion, more Wheels and Pullies to be kept going, and a greater Variety of Machinery, more Elegance and Workmanship (so to speak) in the Composition, more Beauty and Ornament in the finishing, than are seen in the enormous bulk of the Crocodile, the Elephant, or the Whale. Yea, they seem to be the Effects of an Art, as much more

more exquisite, as the Movements of a Watch are, than those of a Coach or Waggon.

Hence we learn, That an Atom to God is as a World, and a World but as an Atom: Just as to Him, one Day is as a thousand Years; and a thousand Years but as one Day. Every Species likewise of these Animalcula may serve to correct our Pride, and shew how inadequate our Notions are, to the real Nature of things. How extremely little can we possibly know, either of the largest or smallest Part of the Creation? We are furnished with Organs capable of discerning, to a certain Degree of Great or Little only. All beyond is as far beyond the reach of our Conceptions, as if it had never existed.

Proofs of a wise, a good and powerful Being are indeed deducible from every thing around us: But the extremely Great and the extremely Small seem to furnish us with those that are most convincing. And perhaps, if duly considered, the Fabrick of a World, and the Fabric of a Mite, may be found equally striking and conclusive.

Glasses discover to us numberless kinds of living Creatures, quite indiscernible to the naked Eye. And how many thousand kinds may there be, gradually decreasing in size, which we cannot see by any help whatever? Yet to all these we must believe God has not only appointed the most wise means for Preservation and Propagation, but has adorned them with Beauty equal at least to any thing our eyes have seen.

In short, the World around us is the mighty Volume wherein God hath declared himself. Human Languages and Characters are different in different Nations: And those of one Nation are not understood by the rest. But the Book of Nature is written in an universal Character, which every man may read in his own Language. It consists not of Words, but Things, which picture out the Divine Perfections. The Firmament every where expanded, with all its starry Host, declares the Immensity and Magnificence, the Power and Wisdom of its Creator. Thunder, Lightning, Storms, Earthquakes and Vulcanos, shew the terror of his Wrath. Seasonable Rains, Sun-shine and Harvest, denote his Bounty and

Goodneſs, and demonſtrate how he opens his hand, and fill all things living with plenteouſneſs. The conſtantly ſucceeding Generations of Plants and Animals, imply the Eternity of their Firſt Cauſe. Life ſubſiſting in Millions of different Forms, ſhews the vaſt diffuſion of his animating Power, and Death the infinite Diſproportion between him and every living thing.

Even the Actions of Animals are an eloquent and pathetic Language. Thoſe that want the help of Man have a thouſand engaging Ways, which, like the Voice of God ſpeaking to his heart, command him to preſerve and cheriſh them. In the meantime the Motions or Looks of thoſe which might do him harm, ſtrike him with terror, and warn him, either to fly from, or arm himſelf againſt them. Thus it is, that every Part of Nature directs us to Nature's God.

10. The Reader will eaſily excuſe my concluding this Chapter alſo, with an Extract from Mr. *Hervey*.

"In all the Animal World, we find no Tribe, no Individual neglected by its Creator. Even the ignoble Creatures are moſt wiſely circumſtanced and moſt liberally accommodated.

They all generate in that particular Seaſon, which ſupplies them with a ſtock of Proviſions, ſufficient not only for themſelves, but for their increaſing Families. The Sheep yean, when there is Herbage to fill their Udders, and create Milk for their Lambs. The Birds hatch their Young, when new-born Inſects ſwarm on every ſide. So that the Caterer, whether it be the Male or Female Parent, needs only to alight on the Ground, or make a little Excurſion into the Air, and find a Feaſt ready dreſt for the Mouths at home.

Their Love to their Offspring, while they are helpleſs, is invincibly ſtrong: Whereas the moment they are able to ſhift for themſelves, it vaniſhes as tho' it had never been. The Hen that marches at the head of her little Brood, would fly at a Maſtiff in their defence. Yet within a few Weeks, ſhe leaves them to the wide World, and does not even know them any more.

If the God of *Israel* inspired *Bezaleel* and *Aholiab with wisdom and knowledge in all manner of workmanship*, the God of Nature has not been wanting, in his Instructions to the Fowls of the Air. The Skill with which they erect their Houses, and adjust their Apartments is inimitable. The Caution with which they hide their Abodes from the searching Eye or intruding Hand is admirable. No General, tho' fruitful in Expedients, could plan a more artful Concealment. No Architect, with his Rule and Line, could build so commodious a Lodgment. Give the most celebrated Artificer the same Materials, which these weak and unexperienced Creatures use. Let a *Jones* or a *Demoivre* have only some rude Stones or ugly Sticks, a few bits of Dirt or Scraps of Hair, a lock of Wool, or a coarse Sprig of Moss: And what Works could they produce?

We extol the Commander, who knows how to take advantage of the Ground; who by every Circumstance embarrasses the Forces of his Enemy, and advances the Success of his own. Does not this Praise belong to the feathered Leaders? Who fix their pensile Camp, on the dangerous Branches that wave aloft in the Air, or dance over the Stream? By this means the vernal Gales rock their Cradle, and the murmuring Waters lull their Young, while both concur to terrify their Enemies, and keep them at a distance. Some hide their little Houshold from view, amidst the Shelter of intangled Furze. Others remove it from Discovery, in the Center of a thorny Thicket. And by one Stratagem or another they are generally as secure, as if they intrenched themselves in the Earth.

If the *Swan* has large, sweeping Wings and a copious Stock of Feathers, to spread over his callow Young, the *Wren* makes up by Contrivance, what is wanting in her Bulk. Small as she is, she will be obliged to nurse up, a very numerous Issue. Therefore with surprizing Judgment she designs, and with wonderful Diligence finishes her Nest. It is a neat Oval, bottomed and vaulted over with a regular Concave: Within made soft with Down, without

thatched with Moss, only a small Aperture left for her Entrance. By this means the Inlivening Heat of her Body is greatly increased during the time of Incubation. And her Young no sooner burst the Shell, than they find themselves screened from the Annoyance of the Weather, and comfortably reposed, till they gather Strength, in the Warmth of a Bagnio.

PERHAPS we have been accustomed to look upon *Insects*, as so many rude Scraps of Creation. But if we examine them with Attention, they will appear some of the most polished pieces of Divine Workmanship. Many of them are decked with the richest Finery. Their Eyes are an Assemblage of Microscopes: The common Fly, for instance, who surrounded with Enemies, has neither Strength to *resist*, nor a Place of Retreat to secure herself. For this reason she has need to be very vigilant, and always upon her guard. But her Head is so fixt, that it cannot turn to see what passes, either behind or around her. Providence therefore has given her, not barely a Retinue, but more than a Legion of Eyes: Insomuch that a single Fly is supposed to be mistress of no less than Eight Thousand. By the help of this truly amazing Apparatus, she sees on every side, with the utmost Ease and Speed, tho' without any Motion of the Eye, or Flexion of the Neck.

THE *Dress* of Insects is a Vesture of resplendent Colours, set with an Arrangement of the brightest Gems. Their *Wings* are the finest Expansion imaginable, compared to which, Lawn is coarse as Sackcloth. The *Cases*, which inclose their Wings glitter with the finest Varnish, are scooped into ornamental Flutings, are studded with radiant Spots, or pinked with elegant Holes. Not one but is endued with Weapons to seize their Prey, and Dexterity to escape their Foe, to dispatch the Business of their Station, and enjoy the Pleasures of their Condition.

WHAT if the Elephant is distinguished by his huge *Probosci's*? The Use of this is answered in these his meaner Relations, by their curious *Feelers*, remarkable, if not for their enormous Size, yet for their ready

ready Flexion and quick Senſibility. By theſe they explore their Way in the darkeſt Road: By theſe they diſcover and avoid, whatever might defile their neat Apparel, or endanger their tender Lives.

Every one admires the majeſtic Horſe. With how rapid a Carreer does he bound along the Plain? Yet the *Graſs-hopper* ſprings forward with a Bound abundantly more impetuous. The *Ant* too, in proportion to his Size, excells him both in Swiftneſs and Strength: And will climb Precipices, which the moſt couragious Courſer dares not attempt to ſcale. If the *Snail* moves more ſlowly, ſhe has however no need to go the ſame way twice over: Becauſe whenever ſhe departs, wherever ſhe removes, ſhe is always at home.

The *Eagle* it is true, is privileged with Pinions that out-ſtrip the Wind. Yet neither is that poor outcaſt, the groveling *Mole*, diſregarded by Divine Providence. Becauſe ſhe is to dig her Cell in the Earth, her Paws ſerve her for a Pickax and Spade. Her Eye is ſunk deep into its Socket, that it may not be hurt by her rugged Situation. And as it needs very little Light, ſhe has no Reaſon to complain of her dark Abode. So that her ſubterranean Habitation, which ſome might call a Dungeon, yields her all the Safety of a fortified Caſtle, and all the Delights of a decorated Grot.

Even the *Spider*, tho' abhorred by Man, is the Care of all-ſuſtaining Heaven. She is to ſupport herſelf by trepanning the wandring Fly. Suitably to her Employ, ſhe has Bags of glutinous Moiſture. From this ſhe ſpins a clammy Thread and weaves it into a tenacious Net. This ſhe ſpreads in the moſt opportune Place. But knowing her Appearance would deter him from approaching, ſhe then retires out of ſight. Yet ſhe conſtantly keeps within diſtance, ſo as to receive immediate Intelligence when any thing falls into her toils, ready to ſpring out in the very Inſtant. And it is obſervable, when Winter chills the Air, and no more Inſects rove thro' it, knowing her labour would be in vain, ſhe leaves her ſtand, and diſcontinues her Work.

I must not forget the Inhabitants of the Hive. The *Bees* ſubſiſt as a regular Community. And their induſ-

gent Creator has given them all Implements neceſſary, either for building their Combs, or compoſing their Honey. They have each a portable Veſſel, in which they bring home their collected Sweets: And they have the moſt commodious Store-houſes, wherein they depoſit them. They readily diſtinguiſh every Plant, which affords Materials for their Buſineſs: And are complete Practitioners in the Arts of Separation and Refinement. They are aware that the vernal Bloom and Summer Sun continue but for a Seaſon. Therefore they improve to the utmoſt every ſhining Hour, and lay up a Stock ſufficient to ſupply the whole State, till their flowry Harveſt returns.

If the Maſter of this lower Creation, is ennobled with the Powers of Reaſon, the meaneſt Claſſes of ſenſitive Beings, are endued with the Faculty of *Inſtinct*: A Sagacity, which is neither derived from Obſervation, nor waits the finiſhings of Experience: Which without a Tutor teaches them all neceſſary Skill, and enables them without a Pattern, to perform every needful Operation. And what is more remarkable, it never miſleads them, either into erroneous Principles, or pernicious Practices: Nor ever fails them in the moſt nice and difficult of their Undertakings.

Let us ſtep into another Element, and juſt viſit the Watry World. There is not one among the innumerable Myriads, that ſwim the boundleſs Ocean, but is watched over by the ſovereign Eye, and ſupported by his almighty Hand. He has condeſcended even to beautify them. He has given the moſt exact proportion to their Shape, the gayeſt Colours to their Skin, and a poliſhed Surface to their Scales. The Eyes of ſome are ſurrounded with a ſcarlet Circle; the Backs of others, diverſified with crimſon Stains. View them when they glance along the Stream, or when they are freſh from their native Brine, the Silver is not more bright, nor the Rainbow more glowing than their vivid, glofſy Hues.

But as they have neither Hands nor Feet, how can they help themſelves, or eſcape their Enemies? By the beneficial, as well as ornamental Furniture of *Fins*. Theſe when expanded, like Maſts above and Ballaſt below

low, poiſe their floating Bodies, and keep them ſteddily upright. They are likewiſe greatly aſſiſted by the Flexibility and vigorous Activity of their Tails. With which they ſhoot thro' the Paths of the Sea, ſwifter than a Veſſel with all its Sails. But we are loſt in Wonder at the exquiſite Contrivance and delicate Formation of their *Gills:* By which they are accommodated, even in that denſe Medium, with the Benefits of Reſpiration! A piece of Mechaniſm this, indulged to the meaneſt of the Fry: Yet infinitely ſurpaſſing in the Fineneſs of its Structure and Operation, whatever is curious in the Works of Art, or commodious in the Palaces of Princes.

Part the Third.

Of Plants *and* Foſſils.

CHAP. I.

Of Plants.

1. BY *Plants* we mean organized Bodies, deſtitute of Senſe and Motion, fixt in the Earth, and drawing their Nouriſhment from it by their Roots. Touching theſe, we may conſider, firſt, the Structure of their Parts, and then their Nutrition and their Generation.

2. THE *Parts* of which they are compoſed are either *liquid* or *ſolid*. The Liquid are uſually divided into *Juices* and *Tears*. The Juice is to the Plant what Blood is

to an Animal, and is various in the various kinds of Plants. Tears are Liquors which are emitted from them, whether they sweat out of them naturally; or are drawn out of them, either by Art, or by the Heat of the Sun. Some of these remain liquid; Others grow by degrees into a firm consistence.

3. Plants consist of three *dissimilar*, *solid* Parts, the *Root*, the *Trunk*, and the *Branches*. In each of these we may observe three *Similar* Parts, the *Bark*, the *Wood* and the *Pith*.

4. To begin with the Trunk. Here we may first observe the *Bark*; whose Surface consists of little Bladders, which surround the Trunk like a Ring. These, which are commonly filled with some kind of Juice, being removed, there occur various Ranks of wooddy Fibres, curiously wrought in a kind of Net-work, one Row above another. The Intervals also between those Fibres, are all filled with little Vessels. The Use of the Bark seems to be, not only like Skin, to cover the Wood and Pith, but also to concoct the Nutritive Juice, and forward the Growth of the Plant. And as to the Nutrition of the Bark, it is probable the Juice ascends from the Root, thro' the Fibres, and is sustained by the Unevenness therein, till it is lodged in the Vessels. In those the new Juice being mixt, with that they contained before, is fermented and rarefied to such a Degree, as is needful for its Nourishment.

It has been a common Opinion, That Trees only live by the Ascent of the Sap in the Bark, or between the Bark and the Wood: But this evidently appears to be a Vulgar Error, from the Instance of a large old Elm, in *Magdalene-College* Grove at *Oxford*, which was quite disbarked all round, at most places two feet, at some, four feet from the Ground. Notwithstanding this, it grew and flourished many Years, as well as any Tree in the Grove. What is more, it was likewise without all Pith, being hollow within as a Drum. Add to this, that the Plane and Cork-trees, divest themselves every Year, of all their old Bark, (as Snakes do of their Skins) and acquire a new one. Now during the Change from one to the other, it is clear they are not nourished by the

the Bark. Therefore there must be other Vessels, beside those of the Bark, capable of conveying the Sap. It is probable, the Bark may ordinarily do this: But that when the ordinary Conveyance fails, some the of the wooddy Parts (which were all Sap-vessels once) resume their antient Office: So far, at least, as to keep the Tree alive, tho' not to increase its Bulk. Perhaps this is the Use of the Sap-vessels in the Wood, different from that of those in the Bark. These are designed for the Continuation of a Tree, those in the Bark for its Augmentation.

Again. As Animals are furnished with a *Panniculus Adiposus*, usually replete with Fat, which invests and covers all the fleshy Parts, and screens them from external Cold: So Plants are incompast with a Bark, replete with fatty Juices, by means whereof even the Winter Cold is kept off, and hindred from freezing the Juices in the Vessels. And those sorts of Trees, whose Bark abounds with Oil, remain green all the Year round.

5. In the *Wood* likewise there are observed concave Fibres, woven as it were of various Vesicles, and stretching all the length of the Wood, as do the Fibres of the Bark. These have Intervals between them, in which are transverse Vesicles, reaching to the very Pith. There are other Fibres, which run obliquely, and are far larger, but not so numerous as the former. In some Trees there are also several Rows of Tubes, which emit a thick, milky Liquor.

6. The *Pith* is in the middle of the Wood. It consists of various Rows of hollow Globules, covered with a fine Membrane. In some trees it contains a peculiar Juice, which sometimes hardens, or grows black. In tender Shoots the Pith (which is frequently hexagonal) is not exactly in the middle: but is nearer the Bark on the South-side, than on the North-side of the Plant. It is a constant Observation, that the Pith lessens as the Tree grows. Some have imagined it to be the Heart of the Plant: But this cannot be. For some Trees will flourish and bear Fruit, after the Pith is taken out. Beside this, there is in some Trees a white and tender Substance, between the Bark and the Wood.

7. The

7. The *Root* has nearly the same vessels as the Trunk. Through it the Juice passes that nourishes the Plant. The Roots of some Plants are full of hollow Threads, which transmit Nourishment to the Upper Parts. This in other Plants insinuates itself thro' the Pores that are in the Bark of the Root. The *Branches* of a Plant agree with the Trunk, in all the essential Parts of its Structure.

8. On the smallest Part of the Branches grow the *Leaves*; Of these we may observe, 1. The *Fibres* of the Leaf stand not on the Stalk in an even Line, but always in an *angular* or *circular* Posture: And their vascular Fibres or Threads, are three, five or seven. The Reason of this Position is, for the more erect Growth, and for the greater Strength of the Leaf; as also for the Security of its Sap: 2. The accurate *Position* of these Fibres, so as often to take in the Eight Part of a Circle, as in Mallows; in some Plants a Tenth; but in most a Twelfth. 3. The Art in *folding* up the Leaves before their Eruption, is incomparable both for Elegance and Security. They take up the least room their form will bear; and are so conveniently couched, as to be capable of receiving Protection from other Parts, and of giving it to each other.

Leaves consist of Fibres continued from the Trunk of the Tree. They are cloathed with an extremely thin Pellicle which is covered with the finest Down. Their Skin or Coat is only that of the Branches extended, as Gold is by beating. In the Bud they are folded up, almost in the manner of a Fan, sometimes in two, sometimes in several Plaits. But if they are two thick to plait commodiously in Two, and to be ranged against each other, or if they are too small a Number, or their Fibres too delicate; instead of being plaited, they are rolled up, and form either a single Roll, or two Rolls, which begin at each Extremity of the Leaf, and meet in the middle. There are also some Plants, as Fern in particular, which form three Rolls.

The chief Uses of Leaves seem to be, 1. To catch the Dew and Rain, and so convey more Nourishment to the Plant, than the Root alone could do: 2. To take in Air; (of which more hereafter:) And 3. To minister

to

to a kind of Insensible Perspiration, by which Redundancies may be thrown off.

9. The *Nutrition* of Plants seems to be performed thus. As the Earth abounds with Particles of every sort, those which suit each Plant, being dissolved by Moisture and agitated by Heat, enter the Root thro' its Threads or Pores, ascend thro' the wooddy Fibres, and being in the Vesicles of the Plant mixt with its native Juice, and subtilized by Fermentation, insinuate themselves into all the Parts of it. Part of this nourishes the Plant and forms the Fruit; the Residue transpires. But as all Particles are not equally fit to enter the Pore of every Plant, neither can all be fermented into a Juice proper to nourish it; the Reason is plain; why every Plant will not flourish in every Soil.

But altho' Vegetables delight in peculiar Soils, they do not owe their Nourishment, to the Earth itself, but to Juices residing therein. Of this Mr. *Boyle* has given us plain Proof. He ordered his Gardiner to dig up some Earth, to dry it in an oven, to weigh it, and then plant therein some *Spanish Seeds*, (a kind of *Pumpkin.)* The Seeds when sown were watred with Rain or Spring-Water only. A plant was produced in one Experiment, of near three pound; in another of above Fourteen. And yet the Earth when dried and weighed again, was not diminisht at all in its weight.

10. As to the *Motion* of the Nutritive Juice, some think it ascends by the Wood, and descends by the Bark. But it is not easy to shew, by what particular Tubes it either ascends or descends. Neither after all our Researches does it appear, what is the Principle of this Motion? Whether there be any such thing as an Attractive Force in the Plant itself: Or whether it be performed on the mere Principles of Mechanism, by the Expansion of the Air contained in the Juice, which moves and propells the Particles of it into every Part of the Plant.

However that the Sap in Plants does circulate is made probable by an easy Experiment. On a Branch of a plain Jessamine, whose Stem spreads into two or three Branches, inoculate in Autumn a Bud of the yellow stri-

ped

ed Jeſſamine. When the Tree ſhoots the next Summer, ſome of the Leaves will be ſtriped with yellow, even on the Branches not inoculated. And by degrees, the whole Tree will be ſtriped, yea the very Wood of the young Branches.

It is probable the Circulation is performed thus. The Wood of Plants conſiſts of fine, capillary Tubes, which run parallel with each other from the Root, and may be looked upon as *Arteries*. On the outſide of theſe, between the Wood and the inner Bark, are larger Tubes, which may do the Office of *Veins*. Now the Root having imbibed Juice from the Earth, this is put into Motion by the Heat. Hereby it is rarefied and cauſed to aſcend in the form of a Steam or Vapour; 'till meeting the Mouths of the Arterial Veſſels, it paſſes thro' them to the Top, and to the extreme Parts of the Tree, with a Force anſwerable to the Heat whereby it is moved. When it arrives there, meeting with the Cold of the External Air, it condenſes into a Liquor, and in that Form returns by its own Weight, to the Root of the Venal Veſſels.

II. From what has been ſaid it plainly appears, that there is a conſiderable *Agreement between Plants and Animals*, as well with regard to their Nutrition, as to the Structure of their Parts. Some extend this farther, and think there is ſomething in Plants anſwerable to *Reſpiration* in Animals. They ſuppoſe the Spiral Fibres to be in the place of Lungs, and to ſerve this very purpoſe: That in each of theſe there is a ſpiral Lamina, which is extended or contracted, as it is impelled this way or that, by the elaſtic Air it includes: That theſe Fibres aſcending ſtrait thro' the Trunk, are diſperſed thro' all the Branches, and thence into the Leaves, where they are woven together in a kind of Net-work. By this means the more ſubtle Parts of the Air are ſtrained thro' thoſe Spiral Fibres, to keep the Juices of the Plant fluid, and perhaps to ſupply them with Nitre or Ether, to aſſiſt their Fermentation.

The Air enters Vegetables various ways, by the Trunk, Leaves, Roots and Branches. For the Reception as well as Expulſion of it, the Pores are very large in ſome Plants. So one ſort of walking-Canes ſeem

full of large Pin-holes, reſembling the Pores of the Skin in the Ends of our Fingers. In the Leaves of the Pine, if viewed thro' a Glaſs, they make an elegant Show, Standing, as it were, in rank and file, throughout the Length of the Leaves.

AIR-VESSELS are found in the Leaves of all Plants, and in many are viſible to the naked Eye. For on breaking the chief Fibres of the Leaf, the likeneſs of a fine, woolly Subſtance, or rather of curious, ſmall Cob-webs may be ſeen to hang at both the broken Ends. Now theſe are the Fibres of the Air-veſſels, looſed from their ſpiral Poſition, and drawn out in length.

THE Pores in the Leaves of Plants are almoſt innumerable. Mr. *Lewenhoeck* found above an hundred, and ſeventy two thouſand, on one ſide of a Leaf of Box. The Leaves of *Rue* are as full of Holes as an Honey-Comb. Thoſe of St. *John's Wort* likewiſe appear full of Pin-holes to the naked Eye. But the places where thoſe Holes ſeem to be, are really covered with a thin and white Membrane. Thro' a Miſcroſcope the Backſide of the Herb *Mercury* looks, as if rough with Silver; and all the Ribs are full of white, round, tranſparent Balls, faſtened by ſlender Stalks, like ſo many Grapes. A *Sage*-leaf appears like a Rug or Shag, full of Tufts of Silver-Thrumbs, and embelliſhed with round, chryſtal Beads, faſtened by tender Foot-ſtalks. The Prickles of a *Nettle* are formed for acting juſt as the Sting of Animals. Every one of them is hollow, and terminates in a fine Point, with an opening near its End. At the bottom of each Prickle lies a pellucid Bag, containing a clear Liquor, which upon the leaſt touching the Prickle, is ejected at the little Out-let, and if it enters the Skin cauſes Pain and Inflammation, by the Pungency of its Salts.

THE *Leaves* of Plants are of great Conſequence to their Life. At theſe the Air paſſes in, and goes thro' the whole Plant, and out again at the Roots. If the Leaves have no Air, the Plant will die, as is eaſily proved by the Air-pump: Whereas if the Leaves be left on the Outſide of the Receiver (parted by a Hole cemented with Wax) while theſe have Air, the Plant will thrive and

and grow, tho' its Roots and Stalks are kept in Vacuo. The Leaves likewiſe chiefly perform the neceſſary Work (But who can explain the Manner?) of altering the Water received at the Roots, into the Nature of the Juices of the Plant. And hence it is, that the Life of Plants depends ſo immediately upon their Leaves. The Huſbandman often ſuffers, for want of this Knowledge. A Crop of *Saint-foin* is valuable; and its Root being perennial, will yield an Increaſe many Years. But it is often deſtroyed at firſt, by ſuffering it to be fed upon by Sheep. For if they eat up all the Leaves, the Root can't be ſupplied with Air, and ſo the whole periſhes.

Leaves being ſo neceſſary in all perennial Plants, a reverſionary Stock of them is provided. The Leaves of theſe Plants are always formed in Autumn, tho' not unfolded 'till the following Spring. They then open and increaſe, in proportion to the Motion of the Sap, and the Quantity of Nouriſhment it receives. Theſe Leaves alſo, tho' not yet appearing out of the Bud, may ſuffice for the extremely ſmall Motion, which the Sap of thoſe perennial Plants, that drop their Leaves, has in Winter.

But beſide theſe Autumnal Leaves, there is another ſet formed in Spring and expanding 'till Midſummer. Theſe are of infinite Service to many ſort of Trees, particularly to the Mulberry, as they ſave its Life, when the firſt Set of Leaves have been all eaten up by the Silk-worms.

The Analogy between the Parts of Plants and thoſe of Animals may now more fully appear. The Parts of Plants are 1. The *Root*, compoſed of Abſorbent Veſſels, analogous to the Lacteals in Animals: Indeed performing the Office of all thoſe Parts of the Abdomen, that miniſter to Nutrition: 2. The *Wood*, compoſed of capillary Tubes running parallel from the Roots, altho' the Apertures of them are commonly too minute to be ſeen. Thro' theſe, which are analogous to *Arteries*, the Sap aſcends from the Root to the top: 3. Thoſe larger Veſſels, which are analogous to *Veins*. Thro' theſe it deſcends from the Top to the Root: 4. The *Bark*, which communicates with the Pith by little Strings, paſſing between

the Arteries: 5. The *Pith* consisting of transparent Globules, like the Bubbles that compose Froth.

The Sap enters the Plant in the form of pure Water, and the nearer the Root, the more it retains of that Nature. The farther it goes, the more it partakes of the Nature of the Plant. In the Trunk and Branches it remains acid. In the Buds it is more concocted. It is farther prepared in the Leaves, (as Blood in the Lungs) which being exposed to the alternate Action of Heat by day, and Cold by Night, are alternately dilated and contracted.

Is not then the Motion of the Sap in Plants, (like that of the Blood in Animals) produced chiefly by the Action of the Air? All Plants have the two Orders of Vessels, 1. Those which convey the nutritious Juices, 2. Air-vessels, hollow Tubes, within which all the other Vessels are contained. Now the least Heat rarefies the Air in these Air-vessels, thereby dilating them, and so causing a perpetual Spring, which promotes the Circulation of the Juices. For by the Expansion of the Air-vessels, the Sap vessels are preſt, and the Sap continually propelled. By the same Propulsion it is comminuted more and more, and so fitted to enter finer and finer Vessels. While the thicker Part is deposited in the lateral Cells of the Bark, to defend the Plant from Cold and other Injuries.

Thus is every Plant acted on by Heat in the Day-time, especially in Summer; the Sap protruded, then evacuated, and then exhausted. In the Night the Air-vessels being contracted by the Cold, the Sap-vessels are relaxed, and disposed to receive fresh Food, for the next Day's Digestion. And thus Plants do, as it were, eat and drink during the Night-Season.

The Vessels themselves consist of mere Earth, cemented by Oil and Water: Which being exhausted by Fire, Air or Age, the plant returns to its Earth. Thus in Plants, burnt by the fiercest Fire, the Matter of the Vessels is left entire: Which consequently is neither Water, Air, Salt, nor Sulphur, but Earth alone. The Sap consists of some Fossile Parts; others derived from Air, Rain, and putrified Plants or Animals. Consequently in Plants

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are contained, Salts, Oils, Water, Earth; and probably all Metals too. In fact, the Ashes of all Vegetables yield something, which the Loadstone attracts. [a]

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[a] PLANTS do likewise *perspire*. To find the Quantity imbibed and *perspired* by Plants, Dr. *Hale* took a Pot with a large *Sun-flower* planted in it, and by various Experiments found, the greatest Perspiration in a very warm day, to be one pound, fourteen Ounces; the middle perspiration, one pound, four Ounces. It perspired 3 Ounces in a warm Night, when there was no Dew. If small Dew fell, it perspired nothing; if a large Dew, it gained 2 or 3 Ounces.

THE Weight of this Flower was three Pounds: the weight of a well-sized Man is 160. The Flower perspires 22 Ounces in 24 hours: The Man about 25: (besides six Ounces, which are carried off by Respiration from the Lungs.)

A MIDDLING Man eats and drinks in 24 hours, about four pounds, ten Ounces. The Plant imbibed and perspired in the same time 22 ounces. But taken bulk for bulk, the Plant imbibes seventeen times more Food than the Man. For deducting five Ounces for Fæces, there will remain but four pounds, 5 ounces, which enter the Veins and pass off in 24 Hours. And since, taken bulk for bulk, the Plant imbibes so much more Food than the Man, it was necessary, by giving it an extensive Surface, to provide for a plentiful Perspiration, since it has no other way of discharging Superfluities, as a Man has. It was necessary likewise, that the Plant should imbibe a larger Quantity of fresh Fluid than the Man, because the Fluid filtrated thro' its Roots does not contain so many nutritive Particles, as the Chyle which enters our Veins.

BUT there is a Latitude of Perspiration both in Men and Plants. In this Flower it varied from 16 to 28 ounces during 12 Hours day, as it was watered less or more: In an healthy Man it varies from a pound and half to 3 Pounds.

Ever greens perspire far less than other Plants. In proportion, they need less Nourishment: Hereby they are better able to bear the Winter: Like Insects, which as they perspire little, live the whole Winter without Food.

IN order to try whether any Sap rose in Winter, He made various Experiments: From all which it appeared, it does rise then also, tho' but in small Quantities. And hence we see, why an Ever-green grafted on an Oak will remain verdant, when the Oak-leaves drop. Perspiring less, it needs less Nourishment than the Oak, and so is sufficiently fed by the Sap that rises even in Winter.

IN Summer, when hot Sunshine follows a Shower, the Vines in the middle of an Hop-ground, are often all scorched up, almost from one End of a large Ground to the other: At the same time the Vapours ascend plentifully. The scorching of the Vines seems to be caused by these scorching Vapours, which ascend most in the middle.

THERE is a conſiderable Difference as to the Time when different Plants revive after the Winter. No ſooner does the Sun begin to warm the Earth, than the vernal Flowers appear, and the Trees, one after another, open their Buds, and cloathe themſelves with Leaves. But why do many Wood-plants, as Coltsfoot, Pile-wort, Violets, and many Garden-plants, as Snowdrops, Aſſara-bacca, Crocus, flower in the very beginning of Spring, when we cannot by any pains or care, bring them to flower after the Summer Solſtice? Nay, theſe very Plants, which are ſo patient of Cold in Spring, are in the Autum ſo very weak and tender, that they die on the firſt touch of Froſt. Why, on the contrary, do Thiſtles and many other plants, never flower before the Summer Solſtice?

IN the ſame manner, Trees obſerve fixt Laws, and a certain order in their Leafing. Does the Cauſe lie in the

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of the Ground, the Air there being more denſe, and conſequently hotter than on the outſides.

THE white Clouds likewiſe which appear in Summer-time, occaſion a vehement heat, by reflecting many of the Solar Rays, which otherwiſe would not touch the Earth. And if the Sun be on one ſide, and the Clouds on the other, they are perfect Burning-glaſſes.

SOMETIMES there is a kind of hollow Clouds, full of Hail or Snow. During the continuance of theſe the Heat is extreme, ſince by ſuch Condenſation they reflect more ſtrongly. By theſe likewiſe thoſe Blaſts may be produced, as well as by the reflection of denſe Vapours.

THE Sun-flower being tender, if the Sun riſe clear, faces to the Eaſt. The Sun continuing to ſhine, at Noon it faces to the South, and at Six in the Evening to the Weſt. The Cauſe is that Side of the Stem which is next the Sun, perſpires the moſt, and thereby ſhrinks.

"WHAT degree of *Heat* will Plants bear"? The common temperate point in *Thermometers* is 18 Degrees. The external Heat of an Human Body, will raiſe it to 54 Degrees. Very hot Sunſhine will raiſe it to 88. Plants endure a conſiderably greater Heat than this, near the Line, for ſome Hours a day. But the hanging of the Leaves of many of them ſhews, they could not long ſubſiſt under it.

THE Winter Heat is from the freezing point to Ten Degrees; the Vernal and Autumnal, from 10 to 20. The May and June Heat, is from 17 to 30, in which the Generality of Plants flouriſh

the different Depth of their Roots? If ſo Shrubs would have Leaves before Trees of the ſame kind. But they have not. We can only ſay, the Fact we know, but the Reaſon of it we know not.

THE Order of the leafing of ſeveral Trees and Shrubs, obſerved in *Norfolk* in 1755 was as follows.

1. Honey ſuckle, — — — — — January 15.
2. Gooſeberry, Currant, Elder, —— March 11.
3. Birch, Weeping-willow, — — — April 1.
4. Raſberry, Bramble, —— —— —— 3.
5. Briar, — — — — — — — — 4.
6. Plum, Apricot, Peach, —— —— 6.
7. Filbird, Sallow, Alder, — — — — 7.
8. Sycamore, —— —— —— —— 8.
9. Elm, Quince, — — — — — — 10.
10. Marſh-Elder, —— —— —— —— 11.
11. Wych-Elm, — — — — — — — 12.
12. Horn-beam, — —— —— —— 13.
13. Apple-tree, — — — — — — 14.
14. Abel, Cheſnut, —— —— — 16.
15. Willow, — — — — — — — 17.
16. Oak, Lime, — —— —— —— 18.
17. Maple, — — — — — — — 19.
18. Walnut, Plane, Black Poplar, Beech, — — 21.
19. Aſh, Carolina-Poplar, — —— —— 22.

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beſt. The Heat of July is, in the Shade, about 38 degrees: in the Sunſhine, at Noon, about 50. The Heat of an Hot-bed, when too hot for Plants, is 85 or more: And near this is the Heat of the Blood in high Fevers. The due Heat of an hot bed is 56 degrees; and the ſame Heat hatches Eggs.

A CONTINUAL Steam is aſcending during the Summer; the Sun-beams giving the Moiſture of the Earth, at two foot depth, a briſk, undulating Motion, which rarefied by Heat, aſcends in the form of Vapours. And the vigour of warm and confined Vapour (ſuch as is that which is 2 or 3 feet deep in the Earth) muſt be great, and penetrate the Roots with ſome vigour; as we may reaſonably ſuppoſe, from the vaſt force of confined Vapour in the Engine for raiſing Water by Fire.

THO' Vegetables have not, like Animals, an Engine which by its alternate Dilatations and Contractions, drives their Juices thro' them, yet has Nature contrived other Means, powerfully to raiſe the Sap and keep it in motion. And their Roots are covered with a

INDEED the Leafing of ſeveral of theſe varies much, as the Spring is earlier or later. But others of them, be the Winter ever ſo mild, do not put out before their time. This alſo depends on ſome ſecret Properties, which Man is not able to explain.

THAT the Leaves of certain Plants aſſume at Night a Diſpoſition different from that of the Day, is well known. But to what is this owing? Not to the variation of Heat or Cold, Moiſture or Dryneſs. For however theſe are varied, the ſame thing happens with equal Regularity. It is Light alone that occaſions this Change, which by the ſmalneſs of its Particles, is capable of entering Bodies, and by its Activity, of producing great Changes in them. It changes the Poſition of the Leaves of Plants, by a Motion it excites among their Fibres. The natural Poſition of the Lobes

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very fine, thick Strainer, that nothing may enter but what can be readily carried off by Perſpiration.

THAT there is a *lateral Communication* of the Sap-veſſels in Plants, as of the Blood-veſſels in Animals, plainly appears from the experiment of inarching Trees. For when three Wall-trees are thus incorporated, the Root of the middlemoſt may be dug up, and the Tree will grow ſtill, as receiving Nouriſhment, from the trees with which it is connected. And hence Elders, Willows, Vines and moſt Shrubs, will grow with their tops downward in the Earth. For the ſame reaſon, if you frequently, in an Evening, waſh the Bodies of new-planted Trees, they will grow quicker and better than any others of the ſame Plantation.

WHETHER the Sap in Plants circulates or no, is ſtill warmly diſputed. To the Argument drawn from the *Jeſſamine*-tree, Dr. *Hal.* replies, "We have many viſible Proofs in ſeveral Trees, of the Saps receding, and puſhing forward alternately, at different times of the Day and Night." Probably in all Trees, it recedes in ſome meaſure from the tops of Branches, as the Sun leaves them; becauſe its rarefying Power then ceaſing, the rarefied Sap and Air mixt with it, will condenſe and take up leſs room, and the Dew and Rain will then be ſtrongly imbibed by the Leaves: and the Body and Branches which have been exhauſted by the Evaporation of the Day, will imbibe the moiſture from them.

THAT the Sap does not deſcend between the Bark and the Wood, as the Favourers of a Circulation ſuppoſe, ſeems plain from hence, That if the Bark be taken off 3 or 4 inches broad quite round, the bleeding of the tree *above* the place will much abate: Whereas juſt the contrary muſt happen, if the Sap deſcended by the Bark.

Lobes in these Leaves is drooping. This is their Posture of Repose. But, Vegetation is very imperfectly performed, while they remain in it. It is Light which alters that Position, by its quick Vibrations.

In the Evening, August 7. (in order to make a full Experiment) Dr. *Hill* placed a Plant of *Abrus*, in a room where it had moderate Day light, without the Sun's shining upon it. The lobes of the Leaves were then fallen perpendicularly from the middle Rib, and closed together by their under sides. Thus they continued all night. Half an hour after Day-break, they began to separate, and a quarter of an hour after Sun-rise, were perfectly expanded. Long before Sun-set they began to drop again, and toward Evening were closed as at first.

Next Day the Plant was set, where there was less Light. The Lobes were raised in the Morning, but not so much. And they drooped earlier at Evening.

The third Day it was set in a South Window, open to the full Sun. Early in the Morning the Leaves had attained their Horizontal Situation: By nine o'clock, they were raised above it, and continued so till Evening. Then they fell to the Horizontal Situation, and thence gradually to the usual State of Rest.

The Fourth Day the Plant stood in the same Place, but the Sun did not appear. The Lobes early attained their horizontal Situation, but did not rise beyond it, and in the Evening, closed as usual.

These experiments prove, that the whole Change is occasioned by Light only. To put this beyond dispute, in the Evening of the Sixth Day the Plant was set in a Book-Case, on which the Morning Sun shone, the Doors standing open. The next Day was bright. The Lobes which had closed in the Evening, began to open early in the Morning, and by Nine o'clock, they were raised in the usual manner. I then shut the Doors of the Book-case; on opening them an hour after, the Lobes were all closed as at Midnight. On opening the Doors, they opened again, and in twenty minutes they were fully expanded. This has since been many times repeated, and always with the same Success. We can therefore

therefore, by admitting or excluding the Light, make the Plant put on all its Changes. Hence we are certain, that what is called the *Sleep* of Plants, is cauſed by the Abſence of Light alone, and that their various intermediate States are owing to its different Degrees.

It has been ſuppoſed that the daily Motions of the *Senſitive Plant*, were likewiſe owing to Light and Darkneſs; becauſe it expands itſelf in the Morning and cloſes again in the Evening. From the main Branches of this Plant ſpring ſeveral ſmaller ones, and from theſe others ſtill leſs, which ſupport the Leaves, ranged on each ſide, in pairs over againſt one another. Several other Plants are of the ſame Form, and all theſe cloſe their Leaves in the Evening, and open them in the Morning, which therefore is not peculiar to the Senſitive Plant. But this cloſes them at any time of the Day, if touched, and ſoon after opens them again. You can ſcarce touch the Leaf of a vigorous, ſenſitive Plant ſo lightly, as not to make it cloſe. The large Rib which runs along its middle, is as an Hinge, on which the two halves of the Leaf move, when they turn upon being touched, 'till they ſtand erect, and by that means meet one another. The ſlighteſt touch gives this Motion to one Leaf; if a little harder, it gives the ſame Motion to the Leaf oppoſite. If the touch be ſtill rougher, the whole Arrangement of Leaves on the ſame rib cloſe in the ſame manner. If it be ſtronger ſtill, the Rib itſelf moves upward toward the Branch on which it grows. And if the touch be yet more rough, the very Branches ſhrink up toward the main Stem. The Motion which has the greateſt Effect of all others upon it, is the ſhaking one. Winds and heavy rains alſo cauſe this Plant, to cloſe its Leaves; but not gentle Showers: The Contraction being cauſed by the Agitation of the Wind, and the Strokes given by the large Drops.

The natural ſhutting and opening of its leaves at Night and Morning, are not ſo fixt, as not to be variable by many Circumſtances. In *Auguſt* a ſenſitive Plant was carried in a pot into a dark Cave. The Shaking in the carriage ſhut up its Leaves, ſo that they did not open for four and twenty hours. And when they did open, they cloſed

closed no more for three Days and Nights. Being then brought again into the open Air, they recovered their natural Motions, shutting at night and opening in the Morning, as vigorously as ever. While in the Cave, it was as much affected by the Touch, as in the open Air.

By this and many Experiments it appears, that it is not the Light that opens these Plants, nor the Darkness which shuts them. Neither is it owing to the Increase of Heat or Cold. Indeed great Heat will affect them a little, but not in any considerable Degree. Concerning the real Cause, we may form many Conjectures: But nothing certain can be known.

12. As to the *Generation* of Plants, first the Tree produces *Buds*, which afterward expand into Leaves, Flowers or Branches. In the Buds entire Plants are contained. A small Stalk, consisting of wooddy and spiral Fibres, springs out of the middle of the Plant, wherein the Bud inheres. It is involved in a thin Bark, which may be divided into various Leaves, lying one upon another like Scales.

13. Buds are followed by Leaves and *Flowers*. [b] The Flower is as it were the Womb, which contains the Eggs or Seeds of Plants, and in due time brings them forth. It is near the Bud, and lies hid with it during the Winter, 'till it is brought out by the Heat of the Summer. The most simple Plants bear a Bud, which contains

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[b] In Flowers we may consider 1. The *Calix* or outer Cup, designed to be a Security to the other Parts of the Flower. Those whose Leaves are firm and strong, as *Tulips*, have no Calix at all, *Carnations*, whose leaves are strong, but slender, have a Calix of one Piece. Others have it consisting of several Pieces, and in divers Rounds: 2. The *Foliation* or *Petala*, the *Flower-leaves*, which are properly the Flower itself. In these not only the admirable Beauty, and luxuriant Colours are observable, but also their curious *Foldings* in the Calix, before they are expanded.

It is remarkable, that many, if not most Vegetables, especially those of a tender kind, expand their Flowers, or Down, every day, if it be warm, sun-shiny Weather. But they close them, as the Evening approaches; and some, at the approach of Rain. This is particularly done, at the beginning of Flowering, while the Seed is young and tender: As is easily seen in the Down of *Dandelion*, and eminently in the Flower of *Pimpernel*. These serve as a Weather glass to the Countryman: By the opening or shutting of these, he can tell, without any danger of being deceived, whether the Weather will be foul the next Day.

contains a Seed, of an Oval Figure. We may eaſily diſtinguiſh from the Flower itſelf, the *Leaves* of the *Covering* which involves the Bud. From theſe ariſe the *Leaves* of the *Flower*, ſerving for the laſt Concoction of the Sap: in which are both wooddy and ſpiral Fibres, with various Rows of Utricles. In the middle of Flowers *Filaments* and *little Pillars* ariſe, whoſe Extremities are covered with a kind of *Duſt*. Theſe Pillars are hollow, and have Veſicles full of Liquor, and the Rudiments of Seeds, which gradually grow and harden.

That Duſt is of two kinds, Male and Female. The Male Duſt is formed in the top of the Filaments, where when it is ripe, it burſts its Caſe, and is ſpilt on the Heads of the Pillars, and thence conveyed to the Utricle or Matrix thereof, to impregnate the Female Duſt contained therein.

This Duſt in any one Plant being viewed with a Microſcope, every Particle is of the ſame Size and Figure. But in different Plants, the Colour, Size and Figure are widely different. In ſome it is clear and tranſparent, as Chryſtal; in others, white and opake: In ſome, blue, purple or red, and in others, fleſh-coloured. And its Colour varies in the ſame Species, ſuppoſe Tulips, according to the Colour of the Flower.

The moſt general Figure is the Oval, more or leſs Sharp at the Ends, with one or more Furrows running lengthways. But the Seeds of *Melilot* are Cylinders. Thoſe of the *Panſy* are Priſms, with four irregular Sides. Others repreſent two Chryſtal Globules faſtened together. Thoſe of the *Junquil* are in the form of a Kidney. But indeed the Varieties are not poſſible to be numbered. [c]

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[c] The Seeds of the ſeveral Species of *Fern*, were wholly unknown to the Antients. But it is now well known, that in the Female Fern, the whole Surface of the Leaf on the Under-ſide is covered with a Congeries of Seeds, ſo that they guard one another, and need no other Covering. And in the Common Male Fern, there are found at the proper Seaſon, ſeveral brown Spots, placed in a very regular manner. Theſe are a fungous Matter, round which the ſmall Seed-veſſels are inſerted.

The Fruitfulneſs of Plants, in producing Seeds, tranſcends all Imagination. An Elm living an hundred Years, ordinarly produces

The Office of the *Bloſſom* is partly to protect, partly to draw Nouriſhment to the Embryo, Fruit or Seed. The Gourd, Pumkin, Melon, Cucumber, and moſt bearing Trees, have both Male and Female Bloſſoms on the ſame Plant. Male-Bloſſoms, (uſually called *Catkins*) may be diſtinguiſhed from Female, by having no *Piſtil* or Rudiment of Fruit about them; but only a large Thrum, covered with Duſt in their middle. The Female Bloſſoms have always a Piſtil, within the Flower-leaves: and the Rudiments of the Fruit is always apparent, at the bottom of the Fruit before it opens.

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thirty three Millions of Seeds. Add, that if its Head be cut off, it puts forth as many Branches within half an inch of the Place where it was cut as it had before. And at whatever height it is cut off, the Effect will be the ſame. Hence it appears, that the whole Trunk, from the Ground to the riſe of the Branches, is full of Embryo-Branches, each of which will actually ſpring forth, if the Head be lopped off juſt over it. Now if theſe had ſprung out, they would have borne an equal Number of Seeds, with thoſe that did. Theſe Seeds therefore are already contained in them: And if ſo the Tree really contains 1584000000 Seeds, wherewith to multiply itſelf as many times. But what ſhall we ſay, if each Seed contains another Tree, containing the ſame number of Seeds? And if we can never come, either at a Seed which does not contain Trees, or a Tree which does not contain Seed?

Timber-Trees of any kind might certainly be planted to more advantage than they generally are. There is a Foreſt two miles from *St. Loe* in *Normandy*, planted chiefly with Oaks, many of which are but of a moderate Height, tho' of a large Circumference. But near its Entrance from *St. Loe*, there is a Plantation, about twenty five years old, wherein none of the Oaks are under Seventy, and ſome an hundred feet high. They are ſet ſo cloſe, that they almoſt ſeem to touch one another, and are no more than four or five inches in diameter. This timber is of great uſe, both for making Charcoal, and many other Purpoſes. And the Owners may reap four Crops of them in an hundred Years.

This Foreſt belongs to the King of *France*, who ordered the Plantation to be made by way of trial. And his Miniſters have cauſed ſeveral of the trees, an hundred feet high, to be tranſplanted, to ſee them branch at the top, and to leave ſtanding Proofs, of the wonderful Effects of the Experiment.

As to *Sowing*, the Perfection of Agriculture conſiſts, in ſetting Plants at due Diſtances, and giving a ſufficient Depth to the Roots, that they may ſpread and receive due Nouriſhment. Yet this is

But there is a Species of Willow, which appears to change its Sex every Year. One Year it produces Male-Bloſſoms, and Female-Bloſſoms, the next.

14. The *Seed*, when it is ripe, is incloſed in a peculiar Covering. In ſome Plants it ſo increaſes, as to become a *Fruit*. And in theſe alſo we find Fibres and Utricles diſperſed with endleſs Variety.

Various are the Methods which the Wiſdom of God takes for ſowing Seeds of various kinds. Thoſe of *Arum* and *Poppy* are heavy enough to fall directly to the Ground. Others that are light, have *Hooks* to ſtop them, from ſtraying too far from their proper Place. So have *Agrimony* and *Gooſe-Graſs*, the one wanting a warm Bank, the other an Hedge for its Support.

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little regarded, but all Sorts of Grain are ſown by Handfulls caſt at random. By this means four Parts in 5 of the Seed is utterly loſt. To remedy this a Spaniſh Gentleman contrived an Engine (deſcribed in the *Philoſophical Tranſactions*, under the name of the *Spaniſh Sembrador*) which being faſtened to the Plow, the whole Buſineſs of Plowing, Sowing and Harrowing is performed at once; and the Grain is ſpread at equal Diſtances, and equally deep in the Furrow. An Experiment being made, Land which uſually produced five-fold, by this means produced Sixty fold. One Stalk is all that ſprings immediately from one Grain: But on the ſides of this, near, if not within the ground, iſſue ſeveral lateral Stalks. And ſome of theſe ſend forth roots, whence one or ſeveral other Stalks ſpring, if they are early formed, the ſoil good, and the Weather favourable. By this means one Grain of Wheat planted in a Garden, has produced 90, yea 100 Ears. If then each Ear, taking one with another, contain 50 Grains, a ſingle Grain may produce five thouſand. Nay a Gentleman in *Yorkſhire*, who made the Experiment in his Gardens ſome Years ago, counted upwards of Eight Thouſand Grains, which ſprung from a ſingle one.

After all that has been ſaid and wrote for ſo many Centuries, on the Generation or Propagation of Plants and Animals, a late Author (to whom the *French* Naturaliſts in general ſubſcribe) totally denies the whole, and cenſures all who pretend to diſcover any Animalcula in the Semen of Animals. He will by no Means allow, that every Animal or Plant, proceeds from an Egg lodged in the Parent Plant or Animal. On the contrary, he ſuppoſes, "there are in Matter certain organical Parts, diſpoſed for the formation of animal and vegetable Subſtances, which by coalition conſtitute the firſt Stamina of all Animal and Vegetable Bodies. Theſe are ſimple,

On the other hand, many Seeds have *Wings*, that the Wind may carry them off the Plant, and may ſcatter them aſunder, that they may not fall together, and come up too thick. The Kernels of *Pines* have very ſhort Wings, juſt enabling them to flutter on the ground. But ſome Seeds have many long Feathers, by which they are wafted about every where.

Others are lodged in Elaſtic Caſes, which dart out the Seed to convenient Diſtances. Thus *Wood-ſorrel* having a running Root, needs to have its Seeds ſown diſtant from each other. And this is done, by means of a tendinous Cover, which when it begins to dry, burſts open on one ſide in an inſtant, and is violently turned inſide out. The Seed of *Harts-tongue* is diſperſed in a different manner. It has a Spring wound round its Caſe. When it is ripe, this ſuddenly breaks the Caſe in two Halves, and ſo throws out the Seed. Equally remarkable is the way wherein *Fern*-Seed is ſcattered. If a quantity of this be laid on a Paper, the ſeminal Veſſels burſt, and are ſeen by a Microſcope projecting the Seeds to a conſiderable Diſtance.

X 2 *Blunt*

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uniform, common to all, and conſequently to be found, more or leſs, in every Portion of nutritive Juice. From thence they are digeſted, and when the Subject becomes adult, ſecreted for the formation of the Seed of every Plant and Animal. Theſe Organical Parts, moving when diſengaged, and thence imagined to be alive, are extremely ſimple in their Compoſition, being perhaps only elaſtic Springs, more or leſs compreſt, more or leſs diverſified in the direction of their force.

"All *microſcopic Animals*, ſo called, are indeed no other than ſuch organical Particles. Seeds macerated in Water, firſt diſunite into ſmall Particles, which ſoon after, move and ſeem alive, tho' they are not ſo. The ſame may be obſerved of the Juices of Animals, as Mutton-Gravy and the like. And as to the common Imagination that the Male Semen, while in the Veſſels, contains Millions of Animalcula like Tadpoles, it is certain, they are produced, after the Evacuation of the Fluid, and riſe from Principles contained therein, by a real Vegetation, and a ſubſequent Change from the vegetable to the Animal Life.

"Semen immediately evacuated is an homogeneous Fluid: In a few moments it begins to ſeparate, and after this a kind of vege-

Blue-flowered Gentianella requires wet Weather to be sown in. As soon as any Rain touches the Seed-vessels, they burst open and throw the Seed on every side. *Cardamines* burst their Pods and dart out their Seed, on a slight Touch of the Hand: Nay, the *Cardamine Impatiens* does so, even by the Approach of the Hand. Other Seeds, by their agreeable Taste or Smell, invite Birds to feed upon them, who drop them again, fertilized by passing thro' their Body. So *Misseltoe* is usually sown.

THE Progress of Germination was accurately observed by *Malpighi* in the Seed of a *Gourd*. The day after it was committed to the ground, he found the outer Coat

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table Filaments grow in it, and shoot out ramifications on every side. These open and divide into moving Globules, which trail after them something like long Tails; which are in truth only Strings of the visible Matter, from among which the Globules were separated. By degrees the Globules get rid of them, and then move about at ease.

"THIS vegetable power of shooting into Filaments, is in all Animal and Vegetable Substances, down to the least microscopic Point. And to this is really owing, all that is called Animal Life, in the Fluids produced from Vegetables.

"IN all our Observations on these Substances, the whole Quantity of Matter, after a separation of some volatile and saline Parts, always divides into Filaments and vegetates into numberless Zoophytes, which afterward yield all the Species of microscopic Animals. After this, those supposed Animals themselves subside to the bottom of the liquor, become motionless, resolve into a gelatinous, filamentous Substance, and then afford new Zoophytes or Animals of a smaller kind.

"HENCE we may observe, That every Animal or Vegetable Substance, advances as fast as it can, to resolve into one common Principle, which is the Source of all: a kind of universal Semen, from which each Atom may again ascend to a New Life. These Animalcula then in the Semen of Animals, and in the Infusions and Juices of Animal and Vegetable Substances, are not of the nature of any other Beings, nor to be ranked with them. They constitute a Class apart from all others, the Characteristic of which is, that they neither are generated, nor subsist by Nutriment, like other Plants or Animals, nor do they generate in the ordinary way."

WHAT then becomes of this whole boasted Branch of Modern Philosophy? If this be so, most of our Microscopic Discoveries, vanish into Air!

Coat a little ſwelled; and in its Tip a ſmall Cleft appeared, thro' which the Sperm was ſeen. The Second Day the outward Coat was much ſofter, the Inner torn and corrupted, the Germ ſomewhat longer and more ſwelled, and the beginning of the Root appeared. The Third Day, the Root had made itſelf a Paſſage thro' the Coat, near the former Cleft. The Germ and Seed-leaves alſo were now grown much bigger. On the Sixth, more of the Seed-leaves had broken thro', and were found thicker and harder. The Root had ſhot out many Fibres, and the Stem grown a finger's Length. About the twenty firſt Day the Plant ſeemed compleat, from which time the Seed-leaves began to droop, 'till they died away.

15. THE *Parts* of different *Fruits* are different: But in all, the eſſential Parts of the Fruit, are only Continuations of the Fibres, obſerved in the other Parts of the Tree. And there is a direct Communication between the Fruit and the remoteſt Part of the Tree. Thus an Apple cut croſsways appears to conſiſt of four Parts. Firſt, the *Skin*, derived from the outer Bark of the Tree; 2. The *Pulp*, which is an Expanſion of the inner Bark: 3. *Ramifications* of the wooddy Part of the Tree, diſperſed throughout the Pulp. To theſe are faſtened the Coats of the Kirnels. And theſe being at firſt extended to the Flower, Part of them directly, and Part obliquely, furniſh it with its Nouriſhment. But the Fruit increaſing intercepts the Aliment: And then the Flower is ſtarved and falls off: 4. The *Core*, which is a Production of the Pith of the Plant, ſtrengthened by Fibres of the Wood intermixt. This is a Caſe for the Kernels, filtrates the Juice of the Pulp and conveys it to them.

FRUITS ſerve not only for the Food of Animals, but to guard and nouriſh the Seed incloſed; to filtrate the coarſer Part of the nutritious Juice, and tranſmit only the pureſt for the Support and Growth of the Plantule.

IN every ſort of *Grain*, Wheat, Barley or any other, there are three Particulars obſervable, 1. The *Outer-Coat* which contains all the reſt. This in the ſame

Species of Grain, is of a very different Thickneſs in different Years, as alſo in different Soils: 2. The *Germ* or *Bud*. This is always hid in the Grain, and is the Plant in Miniature: and 3. The *Meal* which is incloſed in the Skin, that ſurrounds the Germ and gives it Nouriſhment, when firſt put into the Earth, before it is capable of drawing it from the Earth itſelf.

THE whole Structure of the Plant which produces theſe Grains is equally admirable. The *chaffy Huſk* is well adapted to defend the Grain, as long as that is neceſſary, and then to let it fall: The *Stalk*, hollow and round, is at once light and ſtrong, capable of ſuſtaining the Ear, without abſorbing too much of the Juices deſtined for its Nouriſhment. And the *Beards* are a defence againſt the Birds, that would otherwiſe deſtroy the Grain before it ripened. The *Covering* of the Grain is formed of Fibres, which meet in a line and form a kind of Furrow. This is the Place at which the Seed, when moiſtened, is to burſt open. Were not this Means prepared for the Germ's coming out, the Toughneſs of the outer Coat, would have kept in both the Meal and the Germ, 'till they had rotted together.

NOR is this the only Uſe of this Place of Opening. The Grain is deſigned, not only for Seed, but for Food alſo. Men have Art enough to erect Machines, for reducing it to powder. But the Birds eat it as it is, and it would paſs them whole, without doing them any Good, were it not, that when it is moiſtened, it burſts open at the Furrow and yields them Nouriſhment.

THE Meal is compoſed of an infinite Number, of round, white, tranſparent Bodies. Theſe incloſe the young Plant, and by their Figure being eaſily put in motion, as ſoon as affected by the Heat and Moiſture of the Earth, they inſinuate into the Veſſels of the Plant, and give it increaſe, till it is in a Condition to feed on the Juices of the Earth. The ſame Proceſs of Nature is obſervable, when Grains of Corn grow out of Time, on being thrown careleſly together, in a moiſt Place.

I CANNOT

I CANNOT better conclude this Chapter, than by tracing the *Analogy* between the *Propagation* of Animals and that of Vegetables. The Roes of Fiſhes, the Eggs of Inſects, Birds and all other Animals, nearly reſemble each other. They are compact Bodies of ſuch Forms as beſt ſuit their Natures. They all have integuments nobly contrived for their preſervation, with firm Coverings, to ſecure them from outward Injuries. Thoſe to be kept in the Body have Coverings alſo; but ſoft and membranous. Every kind contains its peculiar Subſtance, differing from that of every other kind. And all theſe Characters belong alſo to *Seeds* of every kind. They have their Coverings, more or leſs compact, according to their Neceſſities. Their Forms are convenient. The Subſtances they contain are ſpecifically different from each other: and their Offspring proceeds from them in the ſame manner, as Animals proceed from their Eggs.

BUT beſide the Subſtances peculiar to each Seed, there is a peculiar Organization treaſured up in each, which is the rudiment of the future Plant, capable of being propagated into ſuch a Plant as it ſprung from, and no other. So in every one of the Nut-kind, there is a viſible Organization, peculiar to each Species. And if ſuch Organizations appear in every Seed, which is large enough to be viewed clearly, we cannot reaſonably doubt of their Exiſtence, even in thoſe which are ſo ſmall as to eſcape our Sight. There are multitudes of Seeds, which produce large Plants, and yet appear only like Duſt, and a vaſt number, which we cannot ſee, but by the Microſcope. And yet theſe doubtleſs have all their peculiar Forms, and their Organizations as well as the larger.

BUT from what are theſe Organizations produced? How does every Plant or Animal, bring forth a freſh one after its kind? A little of this we may underſtand, if we trace a Tree and an Animal thro' every Stage, from the Egg, to their utmoſt Growth.

SEE a young Tree puſhing out its Leaves and Flowers, till it has extruded an entire Set of Boughs and Branches. One Part regularly opens after another, from

from the firſt Shoot, till it comes to perfection. Then and not before, it produces Seeds, containing the Rudiments of other Trees like itſelf. The Fibres of its general Organization grow into little Knots, ſome to form Leaves, ſome the Calix, ſome the Petals, ſome the Piſtil and Utricle, ſome again the little ſeeds, each growing from its own Pedicle. For the Male Parts, other Fibres are formed into Stamina, and from theſe terminate into Apices: And again from theſe, others terminate into the minute Grains, commonly called the *Farina fœcundans*; each Grain growing on its own Pedicle, juſt as the Leaves or Fruits of Trees.

See an Animal, exactly in the ſame manner, unfolding itſelf by degrees, till its Parts are explicated entirely, and it is complete in every Organ. Then and not before each Female is capable of producing Eggs, each being a Continuation of the General Organization, and growing upon its own Pedicle. Each Male likewiſe, when at its ſtate of Perfection, is capable of producing from itſelf the fœcundating Matter, neceſſary for the Propagation of the ſpecies.

Let us again view a full grown Tree or Plant, putting forth its Parts for Fructification. Obſerve the Apices on the ſtamina, loaden with the globules of the farina fœcundans, the Pulp of each Globule containing an exalted Fluid, and conveying it to one of the Papillæ of the Piſtil. The Utricle is now filled with green, ſoft ſeeds, ready to be impregnated by the Globule, and containing a Fluid, which afterward becomes a hard Covering to each. And within this the little Organizations gradually increaſe.

As then a refined Fluid from the ſeminal Matter of the Male, impregnates the Organization in the Egg of a female Animal, mingles with the ſubtle Fluids contained therein and promotes its Growth and Progreſs: ſo the refined Part of the pulpy Fluid contained in the Globule, impregnates the Organization in the ſeed of a Plant, mixes with its Juices, and gradually promotes its Growth into a perfect Plant. And doubtleſs both the impregnating Effluvia of Animals and Vegetables, and the innate Juices of the Organization, have

have Qualities peculiar to themselves: Hence the Offspring of a Black and a White Parent, is of a Colour between both. And thus if the Farina of one sort of Flower impregnate the Egg of another, the Colour of the Flower produced thereby is variegated proportionably.

The Juices imbibed by a Plant, being composed of innumerable various Substances, after every Part has attracted its kindred Particles, the superfluous ones are carried off by Perspiration: Chiefly by the Leaves, which are the Emunctories, that throw off those Juices which have no kindred Particles in the Plant. Accordingly when the warm Sun begins to rarefy the Fluids, which during the Winter were condensed and inactive, the new Leaves then begin to put forth, from their several Organizations. When Winter comes, as no more Fluids ascend in Trees, so there is no Perspiration. Consequently most of them need Leaves no longer, which therefore fall off. Nor are they succeeded by others, till the vegetable begins to receive fresh Nourishment, and has occasion therefore for excretary Vessels to carry off Superfluities. Just so the superfluous Juices in Animals, are continually carried off by Perspiration: An Obstruction of which is equally pernicious to Animals and Vegetables.

But is there any thing in the vegetable Kingdom, analogous to that strange Animal, the *Polypus*, which multiplies by being cut in pieces? There is. View, for instance, a young Willow. This is an organized Body, capable of growing, till it come to its perfect Growth, by means of the vegetative Principle. The *Polypus* is an organized Body, capable of being extended 'till it come to its perfect growth, and of Feeding and Loco-motion, by its animating Principle. The Willow as it grows, is gradually sending off new Branches, which are its Fœtuses, proceeding from the Organizations lodged in every Part. The Polypus in like manner, gradually sends off new Fœtuses, from Organizations placed in every part of it. If the Willow be cut in pieces and planted, each piece will

by

be explicated into a Tree, and then ſend forth new Fœtuſes, like its Parent. And if the Polypus be cut in pieces, each piece will be explicated into a Polypus, and then extrude new Fœtuſes: So that cutting it in pieces, is but anticipating the propagation of thoſe Organizations in the pieces, which would, if let alone for a while, themſelves iſſue from the ſides of the Parent.

If we obſerve the extreme Tenderneſs of this Animal, liable to be wounded, nay torn in pieces, by any hard Body, which is carried down the Streams, or moved in the Ponds wherein they dwell: We ſee the Providential Reaſon, for this Contrivance to propagate them: As perhaps no other Animal is of ſo tender a texture, and ſo eaſily deſtroyed, having neither ſagacity to avoid Danger, nor ſtrength to bear the leaſt Violence.

CHAP. II.

1. *Of ſome particular Plants:* 2. *Of the Corruption of Plants and Animals:* 3. *General Reflections.*

1. IT remains, to give a ſhort Account of ſome remarkable Productions of the Vegetable kind.

Pepper grows on a Shrub in ſeveral Parts of the *Eaſt-Indies*, which is of the Reptile-kind; and for that Reaſon is uſually planted at the foot of ſome larger Tree. It grows in Cluſters, which at firſt are green. As the Grains ripen, they grow reddiſh; and after being expoſed a while to the Sun become black. To make *White Pepper*, they moiſten it with Sea-Water, and then expoſing it to the Sun, diveſt the Grains of the outer Bark, which of conſequence leaves them white.

THE Plant which affords *Ginger*, reſembles our Reed, both in its Stem and Leaves. The Root ſpreads itſelf near the Surface of the Ground, in form not unlike a man's

man's Hand. When it is ripe they dig it up, and dry it either in the Sun, or in an Oven.

Nutmegs are incloſed in four different Covers: The Firſt, thick and Fleſhy, like that of our Walnuts: The Second is a thin, reddiſh Coat, of an agreeable Smell, called *Mace*. The Third is a hard, blackiſh Shell. The Fourth is a greeniſh Film. In this the Nutmeg is found, which is properly the Kernel of the Fruit.

Sago is procured from a Tree growing in the *Molucca* Iſlands. They cleave this, and take out the Pith, which they pound in a Mortar to a kind of Meal. They then put it in a Searſe over a Ciſtern, and by pouring Water upon it, ſeparate the pure Part of the Powder, from the Veins of Wood. This Flower they make into Paſte, and bake in an earthen Furnace.

The Tree which produces *Cotton* is common in ſeveral Parts both of the *Eaſt* and *Weſt-Indies*. The Fruit is oval, about the Size of a Nut. As it ripens, The Outſide grows black, 'till opening in ſeveral places by the Heat of the Sun, it diſcovers the Cotton, of an admirable Whiteneſs.

The *Tallow-Tree*, which grows plentifully in *China*, is about the Height of a Cherry-tree. Its Bark is very ſmooth and its Leaves of a deep, ſhinning Red. Its Fruit grows in a Pod, like a Cheſnut, conſiſting of three white Grains: Each of which is about the Size, and of the Form of a ſmall Nut. In each is a little Stone, ſurrounded with a white Pulp, in Conſiſtence, Colour, and even Smell like Tallow. And this it is, of which the *Chineſe* in general make their Candles.

The *Coco-tree* grows ſtreight, without any Branches thirty or 40 foot high. Near the top it bears twelve Leaves, each ten foot long, and half a foot broad. Theſe are uſed in making Mats, covering Houſes, and for many other Purpoſes. Above the Leaves grows a large Excreſcence, in the form of a Cabbage. But the taking it off kills the Tree. Between the Leaves and the Top grow ſeveral Shoots, as thick as a Man's Arm, which when cut, yield a white, ſweet, agreeable Liquor, ſerving as Wine, and equally intoxicating. Yet at the End of four and twenty Hours, it becomes a ſtrong Vi-

negar.

negar. As long as this Liquor diſtills, the Tree bears no Fruit: But when theſe Shoots are ſuffered to grow, it puts forth a large Bunch, wherein the Coco-Nuts are to the number of ten or twelve. In each there is firſt about half a pint of clear, cooling Water. In a little while this becomes a white, ſoft Pulp, which afterward condenſes into a Nut. The Tree yields Fruit thrice a Year. Some of the Nuts are as large as a Man's Head.

The *Wild pine*, as it is called, is a wonderful Inſtance of the wiſe Providence of God. The Leaves of it are channelled, to catch and convey Water into their Reſervoirs. Theſe Reſervoirs are ſo made, as to contain much Water. And they cloſe at the top when they are full, to hinder its Evaporation. Theſe Plants grow on the Arms of the Trees in the Woods, as alſo on the Bark of their Trunks. Another Contrivance of Nature in this Vegetable is very admirable. The Seed has many long and fine Threads, that it may be carried every where by the Wind, and that by theſe when driven thro' the Boughs it may be held faſt, and ſtick to the Arms or Trunks of Trees. As ſoon as it ſprouts, altho' it be on the under Part of a Bough, its Leaves and Stalk riſe perpendicular, becauſe if it had any other Poſition, the Ciſtern made of hollow Leaves could not hold Water, which is neceſſary for the Life of the Plant. In ſcarcity of Water, this Reſervoir is not only neceſſary and ſufficient for the Plant itſelf, but likewiſe uſeful to Men, Birds and Inſects. Hither they then come in Troops, and ſeldom go away without Refreſhment.

These Leaves will hold a Pint and an half, or a Quart of Rain-water. When we find theſe Pines, ſays Captain *Dampier*, we ſtick our Knives into the Leaves, juſt above the Root; and that lets out the Water, which we catch in our Hats, to our great Relief.

The ſame Providential Deſign is anſwered by the *Water-with* of *Jamaica*. This, which is a kind of Vine, grows on dry Hills in the Woods, where no Water is to be found. Its Trunk, if cut into pieces, two or three yards long, and held by either End to the Mouth, affords a limpid, innocent and refreſhing ſap, as clear as Water:

Water: And that in so great abundance, as gives new Life to the weary and thirsty Traveller.

But of all Productions of the vegetable kind, there is none more remarkable than the *Aloe*. It grows exceeding slowly. But the Slowness of its Growth is afterwards compensated, by the Bulk to which it arrives, the Velocity with which it shoots, and the prodigious number of Flowers it produces, which ordinarily amount to several Thousands. It usually takes up three Months, May, June and July, from the first budding of the Stem, to the finishing of the Flowers. There are however Exceptions to this Rule. The Aloe in the Garden of Cardinal *Farnese* at *Rome*, shot up in the space of one Month, to the height of twenty-three feet. Another at *Madrid* grew ten feet in one Night, and twenty-five more, in the Eight following.

The Progress of the *Venetian* Aloe, in the Garden of Signior *Papatava*, was as follows. It began to shoot its Stem on the 20th of May, which by the 19th of June, was risen 4 *Paduan* feet and an inch. On the 24th it had gained ten Inches more, and on the 29th Eight more, on which day it began to emit Branches. On the Sixth of July it had gained One foot, one inch; on the 17th one foot, eight Inches more, on the Seventh of August, one foot and an half. From that day to the 30th, it grew very slowly, but continued emitting Branches and Flowers. The Trunk was at the bottom a foot thick; the Branches were twenty-three in number. On the top of each was a Knot or Collection of Flowers. On each of the first Branches there were an hundred and twelve; on others an hundred and ten, and on others an hundred. They yielded little Smell; but what was of it was agreeable.

When the Tree has once flowered, it quickly dies, being quite exhausted by so copious a Birth. They seldom flower 'till they are of a considerable Age, when they are of a large Size and a great Height. As soon as the Flower-Stem begins to shoot from the middle of the Plant, it draws all the Nourishment from the Leaves, so that as that advances, these decay. And when the Flowers are fully blown, scarce any of the Leaves re-

main alive. But whenever this happens, the old Root ſends forth a numerous Quantity of offsets for Increaſe.

PERHAPS there is ſcarce any Plant in the Creation which is of ſo general Uſe. The Wood of it is firm, and ſerves for Fences, and for the Uſe of the Carpenter. The Leaves make Coverings for Houſes: The Strings and Fibres ſerve, in the room of Hemp, Flax and Cotton. Of the Prickles are made Nails and Awls, as alſo Pins and Needles. And from a large Aloe, when rightly tapped, may be drawn three or four hundred Gallons of Juice, which by Diſtillation grows ſweeter and thicker, 'till it becomes Sugar.

IT has been before obſerved, That as all Animals are from Eggs, ſo all Vegetables are from Seeds. But many have ſuppoſed, there is one Sort of Vegetable, which is an Exception to this: Namely, *Muſhrooms*, the Seeds whereof have been long ſought in vain. And it is certain, if you only range in April, Balls of Horſe-dung, as big as one's Fiſt, in Lines three Foot diſtant from each other, and one foot under the ground: covering them all over with mould, and that again with Horſe-dung: In the beginning of Auguſt the upper pieces of Dung will begin to grow white; being covered with fine white Threads, woven about the Straws whereof the Dung is compoſed. By degrees the Extremities of theſe Threads grow round into a kind of Button; which inlarging itſelf by little and little at length forms itſelf into a Muſhroom. At the Foot of each, when at its full Growth, is an infinity of little ones. The white Threads of the Dung preſerve themſelves a long time without rotting if kept dry. And if they are laid again in the ground, they will produce new Muſhrooms.

"ARE theſe then any thing elſe than the Mouldineſs or Putrefaction of Horſe-dung?" Yes certainly. Indeed all *Mouldineſs*, ſo called, is a Congeries of very ſmall Plants. And theſe in particular, like all other Plants, have their Origin from Seeds. But before theſe Seeds can vegetate there are required, certain Juices, proper to penetrate their Coats, to excite a fermentation in them, and to nouriſh the minute Parts thereof. Hence ariſes that vaſt Diverſity of Places, wherein different Sorts of this Plant

are

are produced. Some will only grow on other particular Plants, whoſe Trunk or Roots have the Juices proper for them. Nay, there is one Sort which grows only on the Fillets and Bandages of the Patients in the Hoſpital at *Paris*. It is not therefore at all ſurprizing that Horſe-dung ſhould be a fit Soil for common Muſhrooms. It is probable the Seeds of theſe are ſpread in numberleſs Places, well-nigh throughout the whole Earth. And the ſame may be ſaid concerning the Seeds of many Plants, as well as the Eggs of many Inſects: More eſpecially of thoſe which are ſo minute, that we can ſcarce diſcern them even with Glaſſes: Seeing the ſmaller they are, the more eaſily may the leaſt Wind convey them hither and thither. So that in truth the Earth is full of an inconceivable number both of Animals and Vegetables, perfectly formed in all their Parts, and deſigned as it were in Miniature; only waiting for certain favourable Circumſtances to enable them to make their Appearance at large. How rich then muſt that Hand be, which hath ſown them with ſo much Profuſion!

It may not be improper before concluding this Head, to deſcribe one Species of *Sea-plants*. *Coral* grows chiefly in Grottos which open to the South, and whoſe Concave Arch is nearly parallel to the Surface of the Earth. It will not grow at all, but where the ſea is quiet as a Pond. It vegetates the contrary way to all other Plants; its Root adhering to the top of the Grotto and its Branches ſhooting downward. The Root takes the exact Form of the ſolid it grows to, and covers it (as far as it goes) like a Plate: And this is a probable Proof, that its ſubſtance was originally Fluid. Accordingly Corals ſometimes line the inſide of a Shell, which they could not have entered but in a fluid Form. All its Organiſm, with regard to Vegetation, ſeems to conſiſt in its Rind, in the little Tubes whereof the Juice runs to the Extremities of the Branches. And this Juice petrifying both in the Cells, that incompaſs the corralline ſubſtance, and in thoſe at the Extremities of the Branches, whoſe ſubſtance is not yet formed, by this means inlarge the Plant to its full Dimenſions, both in Height and Bulk. It

is vulgarly believed, That Coral is ſoft while in the Water. But Experiment proves the contrary.

It is obſervable, that all *Sea-plants*, (except the *Alga*) are without Roots. Nor have they any longitudinal, capillary ſap-veſſels, thro' which rooted Plants draw nouriſhment to every Part. But the whole ſubſtance of ſea-plants is compoſed of Veſicles, which receive their Nouriſhment immediately from the ſurrounding Water. Conſequently they can have no Circulation of the ſap, having no Veſſels to convey it from one end of the Plant to the other.

There is one *Sea-production*, if it may be ſo termed, that is not commonly underſtood. *Ambergris* is vulgarly ſuppoſed to be the ſcum of the ſea. But it is not: Nor is it the Excrement of the Whale. It is in reality a kind of Gum, which iſſues out of the root of a Tree. That Tree always ſhoots forth its root toward the ſea; And when this Gum is diſcharged into it, it is ſo tough, that it is not eaſily broken from the Root. But when it is ſeparated from it, either by its own Weight, or the toſſing of the ſea, it floats upon the Water.

2. The Principle of *Corruption* in Plants and Animals, is probably the very ſame, which during a ſtate of Circulation, is the Principle of Life: Namely, the Air, which is found in conſiderable Quantities, mixt with all ſorts of Fluids. This has two very different Motions; an Expanſive one, ariſing from its natural Elaſticity, by which it gives their Fluids an inteſtine Motion, and gradually extends the Parts that contain them: And a Progreſſive Motion. It does not appear, that this is eſſential to it. Rather it is occaſioned by the Reſiſtence of the ſolid Parts. This reſtraining its Expanſion, obliges it to take the Courſe that is more free and open, which is thro' the Veſſels of Plants and Animals.

When this Courſe is ſtopped, the expanſive Motion remains, and ſtill continues to act, 'till it has ſo fully overcome the including Bodies, as to bring itſelf to the ſame degree of Expanſion with the outward Air. But this it cannot do, without deſtroying the Texture and Continuity of thoſe ſolids, which we call *Corruption*.

This

This deſtructive Quality of the Air is promoted, either by weakening the Tone or Coheſion of the including Parts; As when Fruit is bruiſed, which corrupts in that Part much ſooner than in the others: Or by increaſing the Expanſive Force of the Air, by Heat or ſome other co-operating Circumſtance.

And certainly there is no Corruption, or Putrefaction, without Air. Hence either Vegetable or Animal Bodies buried deep in the Earth or Water, remain for Ages entire, which when expoſed to the Air, quickly moulder away. And hence ſuch Vegetables as are moſt apt to putrefy, remain unchanged in vacuo.

Yet various Experiments ſeem to ſhew, That Air muſt be impregnated by Water, before it can occaſion Putrefaction, either in Animal or Vegetable Subſtances. For take a Pound of freſh Fleſh, and keep it in a moderate Heat, and it will throughly putrefy in a few Days. But if you firſt extract the moiſture, it will harden like a Stone. And it may then be kept for Ages, without any Putrefaction. Even Blood, if you deprive it of its Watry Part, may be kept for fifty Years. But if you then diſſolve it in Water, and place it in a gentle Warmth, it will putrefy immediately.

The Proceſs of Putrefaction may be learned from an eaſy Experiment. Take the green, juicy Parts of any freſh Vegetable, Throw them together in a large Heap, in a warm Air, and lay a Weight upon them. The middle Part of the Heap will ſoon conceive a ſmall degree of Heat. It will grow hotter and hotter, 'till it comes to a boiling Heat, and is perfectly putrefied.

In three Days from the firſt putting them together, the Heat will equal that of an Human Body in Health. By the fifth Day, the Heat will be ſuch as the Hand can hardly bear. By the ſeventh or Eighth, all the Juices are generally ready to boil. Sometimes the Matter will even flame, (as does moiſt Hay) 'till it burns away. But commonly it acquires a cadaverous Taſte and Smell, and turns into one ſoft, pulpy

Mass, much resembling human Excrements in the Scent, and putrefied Flesh in the Taste.

If this be distilled, there will come from it, 1. An urinous Spirit, perfectly like that obtained from Animals, and Separable by fresh Distillation into pure Water, and a large Quantity of white, dry, volatile Salt, not to be distinguished from Animal Salts. 2. An oily Salt, which shoots into Globes; 3. A thick, fetid Oil, both which are entirely like those of Animals. 4. The Remainder, being calcined in an open Fire, yields not the least Particle of Fixt Salt: Just as if the Subject had been of the Animal, not the Vegetable Kingdom. And this Process holds equally in all kinds of Vegetables, tho' of ever so different Natures: Yea, in Dry Vegetables, so they be moistened by Water, before they are thrown into Heaps.

By this means the Difference between One Vegetable and another, is entirely taken away. By this process, they are all reduced to one common Nature: So that Wormwood, for example, and Sage, become one and the same thing. Nay, by this means the Difference between Vegetables and Animals is quite taken away: Putrefied Vegetables being no way distinguishable from putrefied Flesh. Thus is there an easy and reciprocal Transition of Animal into Vegetable, and vegetable into Animal.

3. So true it is, that Matter, as Matter, has no concern in the Qualities of Bodies. All depend on the Arrangement of the Particles, whereof each Body consists. Hence Water, tho' tasteless, feeds aromatic Mint, and the same Earth gives nourishment to Bread and Poison.

As to this Arrangement, the first View of a Vegetable gives us an idea, of infinitely numerous and various Parts: And so complex, that many have been discouraged from prosecuting the Research. But upon examination the Parts which appear so numerous, are reduced to a very small account. For a careful Maceration in soft Water will shew, that the Parts really distinct are only Seven. These 1. An outer Bark, 2. an inner Rind, 3. a Blea, 4. a Fleshy Substance, 5. a Pith

5. a Pith. There is between the Fleſh and the Blea, 6. A vaſcular Series, and 7. Cones of Veſſels take their Courſe within the Fleſh.

WHATEVER Part of the Plant we examine, we find theſe, be it a Fibre, the Root or the Stem. We never find more. And tracing theſe, we ſee the other Parts of the Plants are only the Productions of them. Thus the Root, its deſcending Fibre, and the aſcending Stalk, we find are one, not three Subſtances. The ſame ſeven Parts are continued from one to the other, and what are ſuppoſed at its Summit, to be many new and ſtrange Parts, are found to be no more than the Terminations of theſe Seven. The external Parts are alſo ſeven 1. The Cup, 2. The outer Petals, 3. The inner Petals, 4. The Nectaria, either diſtinct, or connected in one Ring, 5. The Filaments. 6. The Receptacle of Seeds, and 7. The Seed-veſſels or Seeds. And theſe are only the Terminations of the Seven conſtituent Subſtances of the Plant. The outer Bark terminates in the Cup, the inner Rind in the outer Petals; the Blea forms the inner Petals, the vaſcular Series ends in the Nectaria, and the Fleſh in the Filaments: The Cones form the Receptacle, the Pith the Seed and their Capſules. Theſe are univerſal in Plants, tho' their Courſe be leſs plain in ſome, and their Terminations leſs diſtinct in others.

EVERY piece therefore cut from a Plant tranſverſely contains all the Parts of the Plant, ready to grow in length into a Stalk upwards, and into a Root downwards, and to ſeparate at a due height from the root, into the ſeveral Parts of a Flower.

THUS we ſee the Arrangement of the common Particles of Matter into a Vegetable Body, altho' it be a Work worthy of his Hand who formed it, yet is not ſo complex a thing as it appears. And this Arrangement being once made in one individual, the Species is created for ever. For Growth is the Conſequence of the arrangement, when it has Heat and Moiſture.

4. UPON the whole: If we conſider every Part of a Plant, we ſhall find none without its Uſe. The *Root* draws Nouriſhment from the Earth: The *Fibres* convey

convey the Sap : The *larger Veſſels* contain the Specific Juice of the Plant : *Others* carry Air for ſuch a Reſpiration as it needs. The Outer and Inner *Bark* in Trees, defend them from Heat and Cold and Drought, and convey that Sap which is required, for the annual Increaſe of the Tree. And in truth every Tree may in ſome Senſe be ſaid to be an annual Plant. For both Leaf, Flower and Fruit proceed from the Coat that was ſuperinduced over the Wood the Laſt Year. And this never bears more, but together with the Old Wood ſerves as a Block to ſuſtain the ſucceeding Annual Coat. The *Leaves* ſerve, before the Bud unfolds, to defend the Flower and Fruit, which is even then formed ; and afterward to preſerve them and the Branches, from the Injuries of the Summer Sun. They ſerve alſo to hinder the too haſty Evaporation of the Moiſture about the Root. But their chief Uſe is, to concoct the Sap, for the Nouriſhment of the whole Plant : Both that they receive from the Root, and that they take in from the Dew, the Rain and the moiſt Air. Add to this, that they are as Lungs, which ſupply the Plant with the neceſſary Quantity of Air, and as Excretory Ducts, which throw off Superfluities by inſenſible Perſpiration. And ſo neceſſary is their Service, that moſt Trees, if quite ſtript of their Leaves, will die. And if in Summer you ſtrip a Vine-branch of its Leaves, the Grapes will never come to Maturity. Not that they are hurt by the Sun : Expoſe them to this as you pleaſe, ſo the Leaves remain, and they will ripen well.

5. Another Point worthy our Conſideration is, The immenſe *Smallneſs* of the Seeds of ſome Plants. Some are ſo extremely minute, as not at all to be diſcovered by the naked Eye. Hence the number of Seeds produced by ſome Plants, is beyond Imagination : A Plant of *Redmace*, for inſtance, and many Sorts of Fern produce above a Million : A convincing Argument of the infinite Underſtanding of the Former of them.

And it is remarkable, that ſuch *Moſſes* as grow upon Walls, the Roofs of Houſes and other high Places, have

have Seeds ſo exceſſively ſmall, that when ſhaken out of their Veſſels they appear like Smoke or Vapour. Theſe therefore may either aſcend of themſelves or by an eaſy Impulſe of the Wind be raiſed to the tops of Walls, Houſes or Rocks. And we need not wonder how the Moſſes got thither, or imagine they ſprung up ſpontaneouſly.

6. Concerning Vegetables in general we may farther remark, 1. That becauſe they are intended to be Food for numberleſs Species of Animals, therefore Nature has taken ſo extraordinary Care, and made ſo abundant Proviſion, for their Propagation and Increaſe. So that they are propagated and multiplied, not only by the Seed, but alſo by the Root: producing Shoots or Offsets in ſome; creeping underground in Others. Some likewiſe are propagated by Slips or Cuttings; and ſome by ſeveral of theſe Ways. Secondly; for the Security of ſuch Species as are produced only by Seed, moſt Seeds are endued with a laſting Vitality: So that if by reaſon of exceſſive Cold, or Drought, or any other Accident, it happens not to ſpring up the firſt Year, it may continue its Fruitfulneſs, I do not ſay, ſix or ſeven only, but even twenty or thirty Years. Nay, after this term, if the Hindrance be removed, it will ſpring, and bring forth fruit. Hence it is, that Plants are ſometimes loſt for a conſiderable time, in places wherein they abounded before. And after ſome Years appear anew. They are loſt, either becauſe of the unfavourable Seaſons, becauſe the Land was fallowed; or becauſe plenty of Weeds, or other Plants, prevented their coming up. And as ſoon as theſe Impediments are removed, they ſpring up again. Thirdly, Many Vegetables are armed with Prickles or Thorns, to ſecure them from the browzing of Beaſts; as alſo to defend others, which grow under their Shelter. Hereby likewiſe they are made particularly uſeful to Man, either for quick or dead Fences. Fourthly, Such Vegetables as are weak and not able to ſupport themſelves, have a wonderfull Faculty, to uſe the Strength of their Neighbours, embracing and climbing up upon them, and uſing them

them as Crutches to their feeble Bodies. Some twiſt themſelves about others like a Screw: Some lay faſt hold upon them, by their curious *Claſpers* or *Tendrils*, which herein are equivalent to Hands. Some ſtrike in a kind of Root: Others by the emiſſion of a natural Glue, firmly adhere to any thing which has Strength ſufficient to ſupport them. Claſpers are of a compound Nature, between a Root and a Branch. Sometimes they ſerve for Support only; as in the Claſpers of Vines, whoſe Branches being long and ſlender, would otherwiſe ſink with their own Weight: Sometimes, for a Supply of Nouriſhment alſo: As in the Trunk Roots of Ivy; which mounting very high, and being of a cloſe and very compact Nature, the Sap would not be ſufficiently ſupplied to the upper Sprouts, unleſs theſe aſſiſted the Mother-root. Fifthly, The beſt of all Grain, and what affords the moſt wholſome and agreeable Nouriſhment is *Wheat*. And it is moſt patient of all Climates, bearing the Extremes both of Heat and Cold. It grows, and brings its ſeed to Maturity, not only in the temperate Countries, but alſo in the Cold Regions of *Scotland*, *Denmark*, *Norway*, *and Muſcovy*, on the one hand, and on the other, in the ſultry Heat of *Spain*, *Egypt*, *Barbary*, *Mauritania* and the *Eaſt-Indies*. Nor is it leſs obſervable, that nothing is more fruitful. One Buſhel, when ſown in a proper ſoil, having been found to yield an hundred and fifty, and in ſome Inſtances, abundantly more.

7. It may be of uſe to ſubjoin here, Firſt a General View of *Vegetation*, ſecondly, ſome additional *Reflections* on the Vegetable Kingdom.

And firſt. As to Vegetation itſelf, We are ſenſible all our reaſonings about the wonderful Operations of Nature, are ſo full of uncertainty, that as the wiſe man truly obſerves, *hardly do we gueſs aright at the things that are upon earth, and with labour do we find the things that are before us*. This is abundantly verified in the vegetable Nature. For tho' its Productions are ſo obvious to us, yet are we ſtrangely in the dark concerning them, becauſe the texture of their Veſſels is ſo fine

fine and intricate, that we can trace but few of them, tho' aſſiſted with the beſt Microſcopes. But altho' we can never hope to come to the bottom and firſt Principles of things, yet may we every where ſee plain ſignatures of the Hand of a Divine Architect.

All Vegetables are compoſed of volatile Salt, Sulphur, Water and Earth, Principles which ſtrongly attract each other: And a large Portion of Air, which ſtrongly attracts when fixt, but ſtrongly repells when in an elaſtic ſtate. By the Combination, Action and Re-action of theſe few Princples, all the Operation in Vegetables are effected.

The Particles of Air diſtend each ductile Part, and invigorate their ſap, and meeting with the other mutually attracting Principles, they are by gentle Heat and Motion enabled to aſſimilate into the Nouriſhment of the reſpective Parts. Thus Nutrition is gradually advanced, by the nearer and nearer Union of theſe Principles, 'till they arrive at ſuch a degree of Conſiſtency, as to form the ſeveral Parts of Vegetables. And at length by the flying off of the watry Vehicle, they are compacted into hard Subſtances.

But when the watry Particles again ſoak into and diſunite them, then is the Union of the Parts of Vegetables diſolved, and they are prepared by Putrefaction, to appear in ſome new Form, whereby the Nutritive Fund of Nature can never be exhauſted.

All theſe Principles are in all the Parts of Vegetables. But there is more Oil in the more exalted Parts of them. Thus Seeds abound with Oil, and conſequently with Sulphur and Air. And indeed as they contain the Rudiments of future Vegetables, it was neceſſary they ſhould be ſtored with Principles, that would both preſerve them from Putrefaction, and alſo be active in promoting Germination and Vegetation.

And as Oil is an excellent Preſervative againſt Cold, ſo it abounds in the Sap of the more Northern Trees. And it is this by which the Ever-greens are enabled to keep their Leaves all the Winter.

Leaves

LEAVES not only bring Nouriſhment from the lower Parts within the Attraction of the growing Fruit, (which like young Animals is furniſhed with proper Inſtruments to ſuck it thence) but alſo carry off the redundant watry Fluid, while they imbibe the Dew and Rain, which contain much Salt and Sulphur. For the Air is full of acid and ſulphureous Particles; and the various combinations of theſe, are doubtleſs very ſerviceable in promoting the Work of Vegetation. Indeed ſo fine a Fluid as the Air, is a more proper Medium, wherein to prepare and combine, the more exalted Principles of Vegetables, than the groſs, watry Fluid of the Sap. And that there is plenty of theſe Particles in the Leaves is evident, from the ſulphureous Exudations often found on their Edges. To theſe refined aëreal Particles, not only the moſt racy, generous Taſtes of Fruits, but likewiſe the moſt grateful Odours of Flowers, yea, and their beautiful Colours are probably owing.

IN order to ſupply tender Shoots with Nouriſhment, Nature is careful to furniſh, at ſmall diſtances, the young Shoots of all ſort of Trees, with many Leaves throughout their whole Length, which as ſo many jointly-acting Powers, draw plenty of Sap to them.

THE like proviſion has Nature made, in the Corn, Graſs, and Reed-kind: the leafy Spires, which draw Nouriſhment to each Joint, being provided long before the Stem ſhoots: Theſe tender Stems would eaſily break, or dry up, ſo as to prevent their Growth had not theſe Scabbards been provided, which both ſupport, and keep them in a ſupple and ductile State.

THE Growth of a young Bud to a Shoot, conſiſts in the gradual Dilatation and Extenſion of every Part, till it is ſtretched out to its full Length. And the capillary Tubes ſtill retain their hollowneſs, notwithſtanding their being extended, as we ſee melted Glaſs-Tubes remain hollow, tho' drawn out to the fineſt Thread.

THE Pith of Trees is always full of Moiſture, while the Shoot is growing, by the Expanſion of which, the tender, ductile Shoot is diſtended in every Part. But when each Year's Shoot is fully grown, then the

the Pith gradually dries up. Meantime Nature carefully provides for the growth of the ſucceeding year, by preſerving a tender, ductile Part in the Bud, replete with ſucculent Pith. Great Care is likewiſe taken to keep the Parts between the Bark and Wood always ſupple with ſlimy moiſture, from which ductile Matter the wooddy Fibres, Veſicles and Buds are formed.

THE great Variety of different Subſtances in the ſame Vegetable proves, that there are peculiar Veſſels for conveying different ſorts of nutriment. In many Vegetables ſome of thoſe Veſſels are plainly ſeen, full of milky, yellow or red nutriment.

WHERE a Secretion is deſigned to compoſe an hard Subſtance, viz. the Kernel or Seed of hard-ſtone Fruits, it does not immediately grow from the Stone, which would be the ſhorteſt Way to convey nouriſhment to it. But the umbilical Veſſel fetches a compaſs round the concave of the Stone, and then enters the Kernel near its Cone. By this artifice the Veſſel being much prolonged, the Motion of the Sap is thereby retarded, and a viſcid Nutriment conveyed to the Seed, which turns to hard Subſtance.

LET us trace the Vegetation of a Tree, from the Seed to its full Maturity. When the Seed is ſown, in a few days it imbibes ſo much Moiſture, as to ſwell with very great force, by which it is enabled both to ſtrike its roots down, and to force its Stem out of the ground. As it grows up, the firſt, ſecond, third and fourth Order of lateral Branches ſhoot out, each lower order being longer than thoſe immediately above them: Not only as ſhooting firſt, but becauſe inſerted nearer the Root, and ſo drawing greater Plenty of Sap. So that a tree is a complicated Engine, which has as many different Powers, as it has Branches. And the whole of each yearly Growth of the Tree, is proportioned to the whole of the Nouriſhment they attract.

BUT Leaves alſo are ſo neceſſary to promote its Growth, that Nature provides ſmall, thin Expanſions, which may be called *primary Leaves*, to draw nouriſhment to the buds and young ſhoot, before the Leaf is

expanded. These bring nutriment to them in a quantity sufficient for their small Demands: A greater quantity of which is afterward provided, in proportion to their need, by the greater Expansion of the Leaves. A still more beautiful Apparatus we find, in the curious Expansions of Blossoms and Flowers, which both protect and convey Nourishment to the Embryo, Fruit and Seeds. But as soon as the Calix is formed into a small Fruit, containing a minute, seminal Tree, the Blossom falls off, leaving it to imbibe Nourishment for itself, which is brought within the reach of its Suction, by the adjoining Leaves.

8. I PROCEED to make some additional *Reflections* upon the vegetable Kingdom.

ALL Plants produce Seeds: but they are intirely unfit for Propagation, 'till they are impregnated. This is performed within the Flower, by the Dust of the *Antheræ* falling upon the moist *Stigmata*, where it bursts and sends forth a very subtle matter, which is absorbed by the *Style*, and conveyed down to the Seed. As soon as this Operation is over, those Organs wither and fall. But one Flower does not always contain all these: Often the male Organs are on one, the Female, on another. And that nothing may be wanting, the whole Apparatus of the Antheræ and Stigmata is in all Flowers contrived with wonderful Wisdom. In most, the Stamina surround the Pistil, and are of the same height. But where the Pistil is longer than the Stamina, the Flowers recline, that the Dust may fall into the Stigma, and when impregnated, rise again, that the Seeds may not fall out. In other Flowers the Pistil is shorter, and there the Flowers preserve an erect Situation. Nay, when the flowering Season comes on, they become erect, tho' they were drooping before. Lastly, when the male Flowers are placed below the Female, the Leaves are very small and narrow, that they may not hinder the Dust from flying upward like Smoke: And when in the same Species one Plant is male, and the other female, there the Dust is carried in abundance by the Wind from the male to the female. We cannot also without admiration

admiration obſerve, that moſt Flowers expand themſelves when the Sun ſhines, and cloſe when either Rain, Clouds or Evening is coming on, leſt the Genital Duſt ſhould be coagulated, or otherwiſe rendered uſeleſs. Yet when the Impregnation is over, they do not cloſe, either upon Showers, or the approach of Evening.

For the ſcattering of Seed Nature has provided numberleſs ways. Various Berries are given for Food to Animals; but while they eat the Pulp, they ſow the Seed. Either they diſperſe them at the ſame time; or if they ſwallow them, they are returned with intereſt. The Miſleto always grows on other Trees; becauſe the Thruſh that eats the Seeds of them, caſts them forth with his Dung. The Junipers alſo which fill our Woods, are ſown in the ſame manner. The Croſs-bill that lives on Fir-cones, and the Haw-finch which feeds on Pine-cones, ſow many of thoſe Seeds, eſpecially when they carry the Cone to a Stone or Stump, to ſtrip off its ſcales. Swine likewiſe and Moles by throwing up the Earth, prepare it for the reception of Seeds.

The great Parent of all decreed that the whole Earth ſhould be covered with Plants. In order to this he adapted the Nature of each to the Climate where it grows. So that ſome can bear intenſe Heat, others intenſe Cold. Some love a moderate Warmth. Many delight in dry, others in moiſt ground. The *Alpine* Plants love Mountains whoſe tops are covered with eternal Snow. And they blow, and ripen their Seeds very early, leſt the Winter ſhould overtake and deſtroy them. Plants which will grow no where elſe, flouriſh in *Siberia*, and near *Hudſon's Bay*. Graſs can bear almoſt any temperature of the Air: In which the good Providence of God appears: This being ſo neceſſary all over the Globe, for the nouriſhment of Cattle.

Thus neither the ſcorching Sun nor the pinching Cold hinders any Country from having its vegetables. Nor is there any Soil which does not bring forth ſome. Pond-weed and Water-lillies inhabit the Waters. Some Plants cover the bottom of Rivers and Seas:

Others fill the Marſhes. Some cloathe the Plains: Others grow in the drieſt woods, and in places that ſcarce ever ſee the Sun. Nay, Stones and the Trunks of trees are not void, but covered with Liver-wort.

THE Wiſdom of the Creator appears no where more, than in the manner of the Growth of Trees. As their Roots deſcend deeper than thoſe of other Plants, they do not rob them of Nouriſhment. And as their Stems ſhoot up ſo high, they are eaſily preſerved from Cattle. Their leaves falling in Autumn guard many Plants againſt the rigor of Winter: And in the Summer afford both Them and us a Defence againſt the Heat of the Sun. They likewiſe imbibe the Water from the Earth, part of which tranſpiring thro' their Leaves, is inſenſibly diſperſed, and helps to moiſten the Plants that are round about. Laſtly, the particular Structure of Trees contributes very much to the Propagation of Inſects. Multitudes of theſe lay their Eggs upon their Leaves, where they find both Food and Safety.

MANY Plants and Shrubs are armed with Thorns, to keep the Animals from deſtroying their Fruits. At the ſame Time theſe cover many other Plants, under their Branches, ſo that while the adjacent Grounds are robbed of all Plants, ſome may be preſerved, to continue the Species.

THE *Moſſes* which adorn the moſt barren Places, preſerve the ſmaller Plants when they begin to ſhoot from Cold and Drought. They alſo hinder the fermenting Earth from forcing the roots of Plants upward in the Spring, as we ſee happen annually to Trunks of Trees. Hence few Moſſes grow in Southern Climates, not being neceſſary there to theſe Ends.

Sea-Matweed will bear no Soil but pure Sand. Sand is often blown by violent Winds, ſo as to deluge, as it were Meadows and Fields. But where this grows, it fixes the Sand, and gathers it into Hillocks. Thus other Lands are formed, the Ground increaſed, and the Sea repelled, by this wonderful Diſpoſition of Nature.

How

How careful is Nature to preſerve that uſeful Plant Graſs? The more its Leaves are eaten, the more they increaſe. For the Author of Nature intended, that Vegetables which have ſlender Stalks and erect Leaves ſhould be copious and thick ſet, and thus afford Food for ſo vaſt a Quantity of grazing Animals. But what increaſes our wonder is, that altho' Graſs is the principal Food of ſuch Animals, yet they touch not the flower and ſeed-bearing ſtems, that ſo the ſeeds may ripen and be ſown.

The Caterpillar of the Moth, which feeds upon Graſs to the great Deſtruction thereof, ſeems to be formed in order to keep a due proportion between theſe and other Plants. For graſs, when left to grow freely, increaſes to that degree as to exclude all other Plants, which would conſequently be extirpated, unleſs the Inſect ſometimes prepared a place for them. And hence it is, that more ſpecies of Plants appear, when this Caterpillar has been, and laid waſte the Paſture the preceding year, than at any other time.

But all Plants, ſooner or later, muſt ſubmit to Death. They ſpring up, they grow, they flouriſh, they bear fruit, and having finiſhed their Courſe, return to the Duſt again. Almoſt all the black Mould which covers the Earth is owing to dead Vegetables. Indeed after the Leaves and Stem are gone, the Roots of Plants remain; but theſe too at laſt rot and change into mould. And the Earth thus prepared, reſtores to Plants what it has received from them. For when Seeds are committed to the Earth, they draw and accommodate to their own Nature the more ſubtle Parts of this Mould: So that the talleſt Tree is in reality nothing but Mould, wonderfully compounded with Air and Water. And from theſe Plants, when they die, juſt the ſame kind of mould is formed as gave them birth. By this means Fertility remains continually uninterrupted: whereas the Earth could not make good its annual Conſumption, were it not conſtantly recruited.

In many caſes, the *cruſtaceous Liverworts* are the firſt Foundation of Vegetation. Therefore however deſpiſed, they are of the utmoſt conſequence in the Œconomy of

Nature. When Rocks firſt emerge out of the Sea, they are ſo poliſhed by the force of the Waves, that hardly any Herb is able to fix its habitation upon them. But the minute cruſtaceous Liverworts ſoon begin to cover theſe dry *Rocks*, tho' they have no Nouriſhment but the little Mould and imperceptible Particles, which the Rain and Air bring thither. Theſe Liverworts dying turn into a fine Earth, in which a larger kind of Liverworts ſtrike their roots. Theſe alſo die and turn to mould: and then the various kind of Moſſes find nouriſhment. Laſtly, theſe dying yield ſuch Plenty of mould, that Herbs and ſhrubs eaſily take root and live upon it.

THAT Trees, when dry or cut down, may not remain uſeleſs to the world, and lie melancholy Spectacles, Nature haſtens on their Deſtruction, in a ſingular manner. Firſt the Liverworts begin to ſtrike root in them, afterward the moiſture is drawn out of them, whence Putrefaction follows. Then the Muſhroom kind find a fit place to grow on, and corrupt them ſtill more. A particular ſort of Beetle next makes himſelf a way between the Bark and the Wood. Then a ſort of Caterpillar and ſeveral other ſorts of Beetle bore numberleſs holes thro' the trunk. Laſtly, the Woodpeckers come, and while they are ſeeking for Inſects, ſhatter the tree already corrupted, and exceedingly haſten its return to the Earth from whence it came. But how ſhall the trunk of a tree, which is immerſed in Water, ever return to Earth? A particular kind of Worm performs this Work, as ſea-faring men well know.

BUT Why is ſo inconſiderable a Plant as Thiſtles, ſo armed and guarded by Nature? Becauſe it is one of the moſt uſeful Plants that grows. Obſerve an heap of Clay, on which for many years no Plant has ſprung up: Let but the Seeds of a thiſtle fix there, and other Plants will quickly come thither, and ſoon cover the ground. For the thiſtles by their Leaves attract Moiſture from the Air, and by their roots ſend it into the Clay, and by that means not only thrive themſelves, but provide a ſhelter for other Plants.

I SHALL add only one Obſervation more, concerning the Difference between *Natural* and *Artificial* things.

things. If we examine the fineſt Needle by the Microſcope, the Point of it appears about a Quarter of an inch broad, and in figure neither round, nor flat, but irregular and unequal. And the Surface, however ſmooth and bright it may ſeem to the naked Eye, is then ſeen full of raggedneſs, holes and ſcratches, like an Iron Bar from the Forge. But examine in the ſame manner the Sting of a Bee, and it appears to have in every Part a Poliſh moſt amazingly beautiful, without the leaſt Flaw or inequality, and ends in a point too fine to be diſcerned by any Glaſs whatever. And yet this is only the outward Sheath of far more exquiſite Inſtruments.

A SMALL piece of the fineſt Lawn, from the diſtance and holes between its threads, appears like a lattice or hurdle. And the threads themſelves ſeem coarſer than the yarn wherewith ropes are made for Anchors. Fine *Bruſſels* lace will look as if it were made of a thick, rough, uneven hair line, intwiſted or clotted together in a very awkard and unartfull manner. But a Silkworm's Webb on the niceſt Examination appears perfectly ſmooth and ſhining, and as much finer than any ſpinſter in the world can make, as the ſmalleſt twine is than the thickeſt Cable. A pod of this Silk winds into nine hundred and ſixty yards. And as it is two threads twiſted together all the length, ſo it really contains one thouſand eight hundred and ſixty; and yet weighs but two grains and an half. What an exquiſite Fineneſs! And yet this is nothing to the ſilk that iſſued from the worm's mouth when newly hatched.

THE ſmalleſt dot which can be made with a Pen, appears thro' a Glaſs a vaſt irregular ſpot, rough, jagged and uneven about all its Edges. The fineſt Writing (ſuch as the Lord's Prayer in the compaſs of a ſilver Penny) ſeems as ſhapeleſs and uncouth, as if wrote in *Runic* Characters. But the ſpecks on Moths, Beetles, Flies and other Inſects, are moſt accurately circular. And all the Lines and Marks about them are drawn, to the utmoſt poſſibility of Exactneſs.

OUR fineſt miniature Paintings appear before a Microſcope, as mere Dawbings, plaiſtered on with a trowel. Our ſmoopheſt Poliſhings are ſhewn to be mere Roughneſs, full of Gaps and Flaws. Thus do the works of Art

Art ſink, upon an accurate Examination. On the contrary, the nearer we examine the Works of Nature, even in the leaſt and meaneſt of her Productions, the more we are convinced, nothing is to be found there, but Beauty and Perfection. View the numberleſs ſpecies of Inſects, what Exactneſs and ſymmetry ſhall we find in all their Organs? What a profuſion of Colouring, azure, Green, vermillion; what Fringe and Embroidery on every Part! How high the finiſhing, how inimitable the poliſh we every where behold! Yea, view the Animalcula, inviſible to the naked Eye, thoſe breathing Atoms, ſo ſmall, they are almoſt all Workmanſhip: In them too we diſcover the ſame Multiplicity of Parts, diverſity of Figures and variety of Motions as in the largeſt Animals. How amazingly curious muſt the internal Structure of theſe Creatures be. How minute the Bones, Joints, Muſcles and Tendons! How exquiſitely delicate the Veins, Arteries, Nerves! What multitudes of Veſſels and Circulations muſt be contained in this narrow Compaſs! And yet all have ſufficient room for their ſeveral Offices, without interfering with each other.

The ſame Regularity and Beauty is found in Vegetables. Every ſtalk, Bud, Flower and ſeed, diſplays a Figure, a Proportion, an Harmony, beyond the reach of Art. There is not a Weed whoſe every Leaf does not ſhew a multiplicity of Pores and Veſſels, curiouſly diſpoſed for the conveyance of Juices, to ſupport and nouriſh it, and which is not adorned with innumerable Graces to embelliſh it.

But ſome may aſk, To what purpoſe has Nature beſtowed ſo much Expence on ſo inſignificant Creatures? I anſwer, This very thing proves they are not ſo inſignificant, as we fondly ſuppoſe. This Beauty is given them either for their own ſake, that they themſelves may be delighted with it: Or for Ours, that we may obſerve in them the amazing Power and Goodneſs of the Creator. If the former, they are of conſequence in the account of their Maker, and therefore deſerve our Regard. If the latter, then it is certainly our Duty, to take notice of, and admire them.

In ſhort, the whole Univerſe is a Picture, in which are diſplayed the Perfections of the Deity. It ſhews not only

only his Exiſtence, but his Unity, his Power, his Wiſdom, his Independence, his Goodneſs. His Unity appears in the Harmony we cannot but ſee in all the Parts of Nature; in that one ſimple End to which they are directed, and the conformity of all the Means thereto. On every ſide we diſcern either ſimple Elements or compound Bodies, which have all different Actions and Offices. What the Fire inflames, the Water quenches: what one Wind freezes, another thaws. But theſe and a thouſand other Operations, ſo ſeemingly repugnant to each other, do nevertheleſs all concur in a wonderful manner, to produce one effect. And all are ſo neceſſary to the main Deſign, that were the Agency of any one deſtroyed, an interruption of the Order and Harmony of the Creation muſt immediately enſue.

SUPPOSE, for inſtance, the Wind to be taken away, and all Society is in the utmoſt Diſorder. Navigation is at a ſtand, and all our Commerce with foreign Nations deſtroyed. On the other hand the Vapours raiſed from the Sea, would remain ſuſpended juſt where they roſe. Conſequently we ſhould be deprived of that uſeful Covering the Clouds, which now ſcreens us from the ſcorching Heat: Yea, and of the fruitful Rains. So our Land would be parched up, the Fruits of the Earth wither, Animals die, thro' Hunger and Thirſt, and all Nature languiſh and droop. All the Parts of Nature therefore were conſtituted for the Aſſiſtance of each other, and all undeniably prove the *Unity* of their omniſcient Creator.

HIS *Power* appears in the whole Frame of Creation, and his *Wiſdom* in every Part of it. His *Independence* is pointed out in the inexhauſtible Variety of Beaſts, Birds, Fiſhes and Inſects: And his *Goodneſs*, in taking care of every one of theſe, *opening his hand, and filling all things living with plenteouſneſs.*

EVERY thing is calculated by divine Wiſdom, to make us wiſer and better. And this is the ſubſtance of true Philoſophy. We cannot know much. In vain does our ſhallow Reaſon attempt to fathom the Myſteries of Nature, and to pry into the ſecrets of the Almighty. *His Ways are paſt finding out.* The Eye of a little Worm is

is a ſubject capable of exhauſting all our boaſted ſpeculations. But we may love much. And herein we may be aſſiſted by contemplating the Wonders of his Creation. Indeed he ſeems to have laid the higheſt Claim to this tribute of our Love, by the Care he has taken to manifeſt his Goodneſs in the moſt conſpicuous manner, while at the ſame time he has concealed from us the moſt curious Particulars, with regard to the Eſſences and Structure of his Works. And to this our Ignorance it is owing, that we fancy ſo many things to be uſeleſs in the Creation. But a deep Senſe of his Goodneſs will ſatisfy all our Doubts, and reſolve all our Scruples.

The End of the Firſt Volume.

ERRATA.

PAGE 7, for *Plythagoras*, read *Pythagoras*, and so P. 14—P. 9, r. *Thales Milesius*, without a ,—P. 12, r. illustrated—P. 13, r. *Torricellius*—P. 14, r. *Tycho*—P. 29, for the , after the *Cornea*, put a . —P. 30, r. stronger on black. r. acutely. r. Vibration—P. 32, for Term r. Form—P. 35, r. Yet this is not by the Teeth properly—P. 40, for disjointed, r. jointed—P. 41, r. Microscope—*ib.* r. of the Head first, in the Note, l. 6—P. 42, r. ossified—P. 44, for peculiars r. peculiar—P. 47, r. *Nocera*—P. 49, l. 2, *dele* in—P. 53, r. limpid, r. Collision—P. 55, r. Exercises—P. 59, l. 1, r. prevents—P. 62, for short r. soft—P. 63, r. *Teeth*, the —P. 65, r. Mesentery—P. 68, r. Effluvia. r. Supplement—*ib.* r. Gift—P. 69, r. Dexterity—P. 76, r. constitute—P. 78, r. receding —P. 83, r. *Fluids*—P. 84, l. 3, r. spring. r. Schirrhus's. r. the Animal Spirits—P. 96, r. Microscope—P. 100, r. Structure—P. 104, r. timorous—P. 108, r. violence—P. 110, r. Materials—P. 112, r. Year 1738, r. were—P. 113, r. *Marcgrave*—P. 116, *dele* to and fro—P. 118, r. timorous—P. 119, r. solid—P. 120, r. 11. It—P. 129, r. shews, r. better. They—P. 132, for fincones r. fir-cones—P. 133, l. penult, r. lose—P. 138, l. 1, r. Microscope —P. 139, l. 5, for his r. Him—P. 141, *dele* 7—P. 151, l. 5, r. Materials—P. 155, l. 12, r. is thus—P. 159, l. 8, r. unnecessary. l. 9, r. reflection. l. 24, for and r. At. r. Microscope—P. 161, r. will know—P. 162, r. swim. r. Polar—P. 172, l. 34, r. contain —P. 173, l. 1, r. flattest—P. 179, l. antepen, r. Incision—P. 180, r. before. The—P. 185, r. down a thread—P. 186, r. attach— P. 188, l. 7, r. in it,—P. 189, r. *Hartsoeker*. r. Pea-colour—P. 192, for their r. your—P. 196, r. is that—P. 199, r. surprizing to see —*ib.* r. silk enter into.—P. 200, l. 7, *dele* the—P. 203, l. 10, r. Microscope,—*ib.* l. 16, r. Tufts—P. 204, Notes, r. he soon inferred —P. 206, l. 31, for their r. its—P. 209, l. 5, for a , put a .—*ib.* l. 10, r. in the Shape—*ib.* l. 19, for longer r. larger—P. 218, l. 17, r. Sorts—*ib.* l. 32, r. Cold—P. 219, l. 15, r. but as they—P. 221, l. 6, r. include—P. 224, l. 11, r. artificially—P. 225, r. Lustre— P. 228, l. 32, for should r. shall—P. 237, r. Fibres—P. 238, r. some of the woody Parts—P. 239, for two thick r. too thick—P. 242, r. Microscope—P. 243, l. 27, for serve r. save—P. 246, r. Autumn—P. 249, l. 35, for a ? put a ,—P. 256, Notes, l. 5, r. move at ease—*ib.* l. 10, r. in the Fluids—P. 257, r. Kernels—P. 261, r. excretory—P. 267, r. coralline—P. 271, l. 13, for These r. The—P. 273, l. 21 and 22, for it r. they, and for its r. theirs— P. 274, l. 11, for within r. with—*ib.* l. 39, *dele* the—P. 275, r. Principles. r. dissolution—P. 276, l. 28, for These r. the—P. 278, l. 27 and 29, for Stamina r. Stigmata.