Natural history of nutrition, life, and voluntary motion : containing all the new discoveries of anatomist's, and most probable opinions of physicians, concerning the oeconomie of human nature ; methodically delivered in exercitations physico-anatomical / by Walt. Charlton, M.D.


CHARLETON
NATURAL
HISTORY
LONDON
1659.

NATURAL HISTORY

OF { NUTRITION, / LIFE, and / VOLUNTARY MOTION.

Containing
All the *NEW DISCOVERIES*
of *ANATOMISTS*, and most probable
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Concerning the
OECONOMIE OF HUMAN NATURE;
Methodically delivered in
EXERCITATIONS PHYSICO-ANATOMICAL.

By WALT. CHARLTON: *M. D.*

LONDON,
Printed for *Henry Herringman*, and are to be sold at
his shop at the *Anchor* in the lower walk in the
new *Exchange*. 1659.

TO THE
RIGHT HONORABLE
THOMAS, VICOUNT
FAUCONBERGE.

My Lord,

IT *was the ſaying of a learned, wiſe, and great Man, of our Nation, that* Books of Uſe ought to have no Patron, but Truth and Reaſon; *And whether or no I have obſerved this* Rule, *in devoting this* Book *to* your Lordſhip's Patronage, *will not be much diſputed by Any, who have the Hap-*

pinesse and Honour to Know you well. For, whoever understands your general insight into all Kinds of Learning, your exact Judgment in distinguishing Truths from Falshoods, however subtily concealed and plausibly delivered, and your strict Reasonings in all Arguments offered to your Consideration; doth need no other proofs to convince him, that, if You are not Truth and Reason it selfe Animated, *yet (at least) you have them in you, in so eminent a degree, that it can be no Flattery to say, You are therein a* Grand Exemplar *to Others: nor will the most Scrupulous refuse to embrace, as Authentique and Current, whatever Position hath once received the stamp of your Assent and Approbation. So singular a Felicity it is, to render* Nobility *more illustrious with* Learning; *to have long cultivated a fertil* Mind, *with select* Precepts, *and usefull* Observations *of Men and Manners; and alwayes to make mature* Deliberation *the Harbinger to* Belief, *as well as to* Action.

Besides, the Argument *of this Discourse*

course, which now humbly seeks your Lps. *Countenance, is much more proper and fit for Your Cognizance, than vulgar Eyes perhaps may judge, when they first glance upon the* Title *of it. For (to omit, that it leads to the most excellent of all Human Knowledges; the Knowledge of* Ones self, *which is the ground-work of* Civil Prudence *) it explaineth the most probable* Oeconomy of Nature *in perfect* Animals; *and especially the most perfect and noble of them,* Man: *A piece of Science, certainly, so far from being Unnecessary to a* Statesman, *that I dare affirme,* None can ever attain to any competent proficiency in the Mysteries of State-principles, or the Art of Governing Men, who is not in some measure conversant in the Mysteries of Human Nature, *as well those which concern the* Constitution *and* Fabrique *of the* Body, *as those which belong to the* Inclinations *and* Passions *of the* Mind. *And, the* Reason *hereof is obvious and plain; since the* Maximes *of sound* Policy *ought to be*

deri-

derived from the Lawes *of* Nature, *at leaſt by way of Analogie and Imitation: & the beſt way to underſtand, how to preſerve Men in* Societies, *is to obſerve,* How Nature *at firſt produceth, and afterward conſerveth them in their* ſingle Perſons, *or* individual Beings. *Certainly, My Lord, the higheſt pitch, to which* Human Wiſdome *can aſpire, is, to imitate the works of* God *in his Creatures: and the moſt perfect* Model *or* Form *of Government, is that, which comes neereſt to the Idea of the* Divine Conſtitutions, *either in the larger Volume of the* Univerſe, *or in the exact Abridgment of it, the* Body of Man. *This made* Pythagoras *call Man, the* Meaſure of all things. *This makes the greateſt* Politicians *ſo frequently conſult the oraculous Aphoriſms of our perpetual Dictator,* Hippocrates; *and transferre His Rules of curing* Diſeales *of the* Body, *to the compoſing* Diſorders, *and rectifying* Diſtempers *in the* State. *This* Menenius Agrippa *found a happy truth; when He, in a moment, appeaſed the ſeditious and mutinous*

tinous Commons of Rome, only by a speech, wherein He compared the several Members *requisite in a well-ordered Common-wealth, to those in the Body of Man ; and shewed the* Offices *of* Those, *to be as necessary as the* Functions *of* These. *And, this that incomparable Sophy, the* Lord St. Alban, *seems to have reflected upon, when He said,* It was without president, that any Government had been disastrous in the hands of Learned Governours ; *and doubted not to call those,* Empirique *States-men, who are ignorant in* Natural Philosophy. *I could, My Lord, exspatiate in this noble and ample Theme, and permit my* Pen *to run into a* Parallel *betwixt the several* Parts *in a Body* Politique, *and those in the Body* Natural ; *and demonstrate the neer* Affinity *and* Correspondence *of them, in their respective* Uses, Actions, *and wayes of subministring to the Health and Conservation of the whole : but that I here speak to a* Person, *to whom such speculations are so familiar, that I should dero-*

gate

gate from the Vastnesse of his Parts, to imagine it needfull for me onely to put Him in Mind of them, or (indeed) of any thing else suitable to that place of Eminency, and Condition of Dignity, to which his Virtues have advanced Him.

Now, My Lord, these my Exercitations being thus, in a Twofold Respect, capable of your Lordships Favour; their Ambition in seeking to acquire to themselves more of Value and esteem, from the Knowing and Ingenious part of Mankind in our English World, by carrying your illustrious Name in their Front; is not only Excusable, but also Commendable, as being grounded on the Law of Decency, which forbad them to addresse to any other Sanctuary; and which evinceth, that this their applying themselves to your Lordship, was upon due Regard, not upon Facility.

And, for my Own part; that I have taken this way of Testifying the extraordinary Respect and Honour I bare to your Person and Virtues: this is to be imputed, partly

partly to the Humility of my Condition; *which permits me not to be so happy, as to have any better Means, or Opportunity of expressing my Devotion; and partly to my* Gratitude, *for the many singular Favours Your* Generosity *long since conferred upon me, which alwayes urgeth me, in the best manner I am able, to acknowledg my selfe,*

My most Honoured Lord,

Your Lordships

Most humble, and most entirely devoted Servant,

Walt. Charleton.

The

The Stationer to the Reader.

THat you might be acquainted with the Occasion of the Author's writing this discourse, his Design therein, and the Motives that induced Him to consent to the Publication of it; I have obtained leave of him, to Print also this following Epistle of his to that Excellent Person, Dr. Ent, to whose peircing and impartial judgment, he thought fit to submit his own, as well concerning the Verity and weight of what his Papers contained, as concerning the fitnesse of their Constitution to endure the publique air. And this Favour I was the more importunate with him for; both because it might evidence his Modesty, in distrusting his own Exactnesse: and because it might appear, it was not only his Inclination, that brought this Book into my hands, and so into yours. Besides, I was not so improvident of my own Advantage, as not to understand, how much of Reputation the Booke hath acquired to it self, by passing the Examination of a Man, whose Universal Learning, and admirable Perspicacity in things of Nature, have conspired to render him as competent a judge of such Treatises, as the World affords. This I say, not to assure you, that Dr. Ent found nothing in these Papers, from which He thought fit not to dissent; because, the subjects of Philosophers speculations and Enquiries, being usually very obscure in themselves, it is no rarity to meet with Diversity of Opinions among Them, as well as among the Vulgar: but, thus much I dare avouch, that He dissented but in very few points, and those only concerning such difficulties, that are not yet cleerly determined by Anatomical Observations; and that nevertheless, He pronounced the whole work to have been undertaken upon mature Consideration, and done with singular Care, Industry, and Circumspection. And I doubt not but you also will be of the same Opinion, when you have attentively read the booke; in which confidence I commend it into your hands, being not a little glad of so good an opportunity to manifest my devoir toward the advance of Knowledge, and service of the Publique.

Hen. Herringman.

Clarissimo Atque Ornatissimo
Viro.

D. GEORGIO ENT,

M. D. &,

Celeberrimi Medicorum *Londinensium*
Collegij, Socio dignissimo.

ANnus jam fermè elapsus est (*Præclarissime Vir*,) ex quo è Magnatibus *nostris Quidam* (*insignis quidem* Hippocraticæ *familiæ Fautor*, *& cujus, in cæteris omnibus quæ ad veram Sapientiam spectant, eruditissimo Animo singularem res etiam* Physicas *altiùs contemplandi aviditatem, à juventute usque infuderat Ipsum* Naturæ Numen) *quotidiana, mihique prorsus ineluctabili precum importunitate, à me efflagitabat; ut, sepositis aliquantisper, quibus tunc temporis totus incumbebam, studiis, nupera* Anatomicorum *Inventa, simul cum celebrioribus* Medicorum *super iisdem Sententiis, maximè quæ* Arti *nostræ & luminis & augmenti plurimum attulisse hodie censentur, breviter Sibi, atque ex ordine, enarrarem. Neque enim (ut aiebat) otii tantum à severioribus Reip. negotiis surripere potuit, quantum satis esset perlegendis omnibus, quæ de re* Anatomicâ *novi quid, supraque Vulgarem Genium sublimis, in se continerent, Recentiorum Voluminibus.*

Ipse

Ipse autem, quò illustris adèo Viri, mihique verè Patroni, imperio, quantum in me esset, obsecundarem; ne tam laudabilem, quâ flagrabat heroïca Mens, in reformatæ Anatomes *mysteria inquirendi sitim, diutiùs inexpletam relinquerem: quam demandare placuit, provinciam in me libenter suscepi. Mox itaque ad Authorum eorum, quorum seu* Industriæ, *seu disquisitionum* Felicitati, *nuperas in Medicorum Scholâ* Novitates *debemus, iteratam lectionem seriò me accinxi; atque ex iisdem denuò quæcunque Mæcenatis mei expectationi satis facere posse judicabam, fideli calamo exscripsi: nec vadimonium datum ante deserui, quàm* Ἀποσπάσματα *simul in unum (qualis de* Oeconomiâ Animali, *juxta recentes in* Anthropographiâ *Hypotheses, ingenuè Philosophantem decere videretur) continuum* Tractatulum *consuissem; adjectis hìc illìc quibusdam* Ratiociniis, *quæ ad cæterorum sive elucidationem facerent, sive connexionem.*

Cæterùm, Chartulas haud citiùs perlegerat Nobilissimus Dnus *quin, ipsas, non Sibi modo, sed & aliis utiles fore, generosa quadam* Humanitatis *exsuperantiâ, existimans; ulteriùs adhuc sui in me arbitrii experimentum capere adnixus sit, adque operis* Divulgationem *ardentissimè me solicitaverit. Recusavi sæpius; utpote non ignarus, quàm exigui essent pretii hæ Lucubrationes, apud perspicaciores Sophiæ cultores; quámque nihili sit ista Laudis messis, quæ ex* Rhapsodicâ *Scriptione, utcunque fideli elaboratâque, acquiritur: & quò meipsum meliùs tueri possem, varia in contrarium adduxi argùumenta. Dixi nimirum, quæ scripseram, in privatum solummodò Ipsius oblectamentum collecta fuisse, stylique impolitioris stamine contexta; ideóque summè temerarium fore, si extra privatos cancellos in publicum divagari permitterentur: pleraque ex contentis, licet Ipsi forsan novitatis specie arriderent, aliis tamen, maximè*

è Doctiorum

è Doctiorum *censu, jam obsoleſcere: me denique occurrentibus in operis ſerie aliquibus* Difficultatibus, *quas vel omninò intactas reliquiſſent, vel ſenſu planè diverſo explicâſſent* Emunctiores) *eâ interdum uſum Conjectandi libertate, cujus me deinceps, poſt ſecundas cogitationes, forſitan meritò pœniteret. Sed plane fruſtrà fui: Is enim, concepti ſemel deſiderii pertinax, contra excuſationem omnem aures occluſerat. Quid agerem igitur? Hinc Viri* Dignitas, *&* Amicitiæ *Sacra premebant; illinc* Tenuitatis *meæ conſcientia: Contra hanc peccare, temeritatis eſſet, atque inſolentiæ; nefas autem illa violare. Hôc Dilemmate obſeſſus, diu anceps ſum animi, donec tandem ea conditione inter nos conventum eſt, ut cordatum aliquem ex Æſculapii Myſtis, in rei deciſionem, ilicò appellaremus. Acceptâ itaque ſemel utrinque æquiſſimâ iſthâc lege; pronum erat, Quem è Noſtratium Doctiſſimis in* Arbitrum *ſeligeremus.*

TE enim, Vir Excellentiſſime, *quem eſſe eum omnes meritò agnoſcunt, in quo Eruditioni ſummæ (ſine fuco dicam) ſummus acceſſit Morum candor, in ingens* Medicinæ *decus,* Nominiſque Tui *immortalitatem; Quis aut* Cordatior, *aut* Æquior *poterat nominari in judicem? Tuum itaque penes arbitrium jam eſt, ut vel ſecuris Muſæoli mei tenebris, vel petulantis, inque Eruditorum ſcripta, ſupra quàm decet, ſeverioris Vulgi Cenſuræ, adjudicetur Hicce, talis qualis eſt, de Humani Corporis Oeconomiæ,* Diſcurſus: *quem in eum finem ad* E. T. *nunc miſi, vacuis horis (ſaltem niſi moleſtum nimis fuerit) evolvendum; non opinionem, ſed Oraculum habiturus, quicquid ſuper eodem è Delphico tripode reſponderis. Spero autem interim, antiquam tuam, & toties feliciter à me expertam, in Tuî Cultores* Humanitatem, *mihi excuſationi ſuffecturam, quòd ſublimiores Tuas, atque in* Artis *noſtræ (quam* Dijs *ipſismet adeò cognatam meritò agnoverunt Veteres) Compendium*

dium usque defixas, Contemplationes, nugis meis tam diu interpellare ausus sim: Teque etiam, utut in hac re sim importunus, facile tamen posse exorari, ut amare pergas

Virtutibus Tuis addictissimum

Londini, 12. *Junij*
M. DC. LVIII.

Gualtrum Charletonum.

Postscriptum.

ESt & aliud adhuc, quod ab. E. V. *summoperè rogare velim; nimirum, ut, sicubi à verô aberravero, in viam reducere dignetur; nec Censoriâ, ubicunque videbitur, virgulâ abstineat. Mihi siquidem, exilitatis meæ semper conscio, volupe admodum est, à* Tali *Viro corrigi, docerique,*

——Unum Tritonia Pallas
Quem docuit, multâque insignem reddidit Arte.

Galen.

OF NVTRITION.

Exercitation the First.

Of Nutrition.

THe *Platoniſt*, though He holds the Deity, and the world to be co-eternal, doth yet allow the World to have been created by God: and to ſolve the ſeeming contradiction, ſaith, that *Priority* was not [κατὰ χρόνον] in reſpect of *time*, but [κατὰ φύσιν] in reſpect of *Nature*; as the Sun and light are coævous, though the one be the Cauſe, the other the Effect. This, certainly, might be more juſtly ſaid of the *Generative* & *Nutritive* Faculties (if at leaſt, they be not one and the ſame); by one of which an Animal is *produced*, and by the other *conſerved*. For, though the *Formative* Virtue may ſeem to precede in its operation; yet are the *Stamina*, or rudiments of the Embryo ſcarce delineated, or adumbrated, when the *Nutritive* begins to augment and perfect them: So as that it may rather be ſaid to go hand in hand with the Plaſtick's faculty, than to follow after it; and what priority there ſeems to be in their o-

Article 1. *Nutrition* and *Generation*, one and the ſame Act of the ſoul or Formative virtue.

perations is rather in respect of Nature, than of time. To forme, and nourish, are not only acts of one and the same soul; but so alike, that it is no easie matter to distinguish betwixt them. For, *Generation* and *Accretion* are not performed without *Nutrition*; nor *Nutrition*, or *Augmentation*, without *Generation*. To nourish, is to substitute such and so much of matter, as was decay'd in the parts, namely flesh, nerves, veins, arteries, *&c.* And what is that in reality, but to generate flesh, nerves, veins, arteries, *&c*? In like manner, *Accretion* is not effected without Generation; for all natural bodies, upon the accession of new parts are augmented, and those new parts are such of which these bodies were first composed: and this is done, according to all the dimensions; so that, to speak properly, the parts of an Animal are encreased, distinguished, and organized all at once. Farther, this is necessary both in respect of the *Efficient* cause, and of the *Matter*. The *Former*, because *idem esse principium efficiens, nutriens, & conservans in singulis animalibus, necesse est; nisi aliam formam in puero, aliam in adolescente, et in sene aliam constituamus.* The *Latter*, because all Animals (such as are produced *per Epigenesin*, of which is our discourse; not of such Insects, as are produced *per Metamorphosin*) are corporated of one part of the matter prepared by the Formative Spirit, and nourished and augmented by the rest. For, Nature doth nourish and amplify all parts of an Animal with the same matter, or humour (not

As well in respect of the *Matter*, as of the Efficient.

(not with a diverſe) out of which ſhe conſtituted or framed them at the firſt. Becauſe, whatſoever is ſuperadded to the parts, during their growth, ought to be of the ſame ſubſtance, with what was præexiſtent, and ſo muſt conſiſt *ex congenere materiâ* : their Renovation as well as firſt Corporation being effected by *Epigeneſis*, Aggeneration, or ſuperſtruction. So that we may well conclude, that Nutrition is nothing elſe but *continual Generation* : and as neceſſary to the Conſervation of every individual nature, as Generation it ſelf is to the conſervation of the Univerſe.

2. The neceſſity of *Nutrition*, two-fold, viz. *Augmentation* & *Conſervation*.

To make this Neceſſity the more evident, we are to conſider; (1) That foraſmuch as an Animal cannot performe all the functions, of which its nature is capable, whilſt it remains in the minute parts, and rude beginnings, in which it is firſt formed; therefore, there muſt ſucceed a Nutrition, that may dilate and amplify thoſe ſlender *ſtamina*, by interweaving and aſſimilating ſo many other congenerous parts, as ſerve to advance and augment the Animal to a convenient magnitude: (2) That ſince the chief principle of life in every Animal, is a certain indigenary Heat (analogous to pure flame, ſuch as the moſt rectified Spirit of Wine yeelds, upon accenſion) which by continuall motion and activity agitating the minute and exſoluble particles of the body, doth diſſolve, and conſume, or diſperſe them; of neceſſity, the whole Fabrick would ſoon be deſtroy'd, unleſſe there were a continuall re-

novation or reparation of those decayes, by a substitution and assimilation of equivalent particles, in the room of those dispersed and absumed. So that, we see, the Necessity of Nutrition is *Two-fold*; one in respect of *Augmentation*, the other in respect of *Conservation*.

As to the continuall *Decay*, or *Depredation* of the substance of our bodies, wherein the latter necessity of Nutrition doth consist; that we may the better understand the manner how it is effected, we are to enquire into the Causes thereof, *viz.* the Agent or Depredator, and the Matter or substance depredated.

3. The Efficient cause of the consumption of the parts, is the *Vital Flame*

The *Agent* or *Efficient* Cause, with all Philosophers, we hold to be the *Naturall Heat*, or *Vital Flame*, at first kindled, by the vegetative soul, or Plastick spirit, in the blood, constantly burning in the Heart, as in its fountain, or primary *Focus*, and thence by diffusion of it selfe through the arteries, warming, cherishing, and enlivening all parts of the body. This *Lar familiaris* is called ἔμφυτον πῦρ, *ingenitus ignis*, by *Hippocrates*; ἡ ἐν τῇ καρδίᾳ τῆς ψυχῆς ἐμπύρωσις, *Accensio animæ in corde*, the Kindling of the soul in the heart, by *Aristotle*; and generally known by the name of *Calidum innatum*, the innate Heat. The principle of life, therefore, being a certain Fire, certain it is that the same cannot subsist or endure one moment of time, unless it be perpetually maintained or fed with some convenient ὑπέκκαυμα, *succendiculum*, or Fewell; which is thereby indefinently consumed: for, all Fire whatever (that Elementary Fire,

Fire, which the *Ariſtotelians* conceive to be ſo pure, as to need no *pabulum* or aliment, being a meer Chimera) doth conſerve it ſelfe onely by the deſtruction of the matter, in which it is generated. So that, indeed, we have one and the ſame Cauſe both of our Life, and of our Death; or (to ſpeak more properly) our Life is nothing but a continuall Death, and we live becauſe we dye. For, ſo long we live, as this Veſtall-Fire is kept glowing and ſhining in the ſacrary of our heart: and when the ſame is put out, either by ſuffocation, or want of ſuſtenance, life is inſtantly extinguiſhed. And perhaps, it was to this *Euripides* alluded, when he ſaid; *Quis novit autem, an vivere hoc ſit emori: An emori, hoc ſit quod vocamus vivere?*

4. The *Matter* thereby conſumed, not the ſubſtance of the ſolid parts, but the *Fluid*, and cheifly the *Blood* and *Spirits*.

The *Matter* or *ſubſtance* conſumed, we conceive to be the *Fluid* parts of the body, eſpecially the Blood and ſpirits, which having in them ſomething of the nature of oyle or ſulphur, are the principal *ſuccendiculum*, or Fewell of the vital Flame: and not the ſubſtance of the *ſolid* parts, at leaſt not in that large quantity vulgarly ſuppoſed. For, experience teacheth, that ſundry Animals, as Bears, Dormice, Swallows, &c. do ſleep all the winter long, without receiving any ſupply of aliment: and yet have all their ſolid parts of their bodies, as large and firme, when they awake again in the ſpring, as when they firſt betook themſelves to their dens or dormitories; nay, if we may credit Naturall Hiſtorians, they grow fat in this time of their long abſtinence. Which doubtleſſe

leſſe is to be aſcribed to this, that the flame in their heart, all that time, being but gently moved, and burning quietly, doth conſume very little of their ſpirits and blood. In like manner, we have examples of *Leucophlegmatique* virgins, who upon a decay of Appetite, have endured long abſtinence from all ſorts of aliment: and yet have not been emaciated in any proportion to their ſo diuturn faſting. So that it is more than probable, that there is not ſo rapid and profuſe an exhauſtion of the ſubſtance of the ſolid parts, by the activity of the vital Heat, as Phyſicians have vulgarly imagined. In many diſeaſes, we confeſſe, the habit of the body is much extenuated; but that is only a ſubſidence or flaccidity of the Muſculous fleſh, cauſed by the defect of ſpirits and blood, by which the ſame was formerly diſtended and plumpt up; not by any deperdition of the ſubſtance of the ſolid parts.

5. The *Manner* how they are conſumed, is by cont nual *Diſperſion.*

Laſtly, as for the *Manner* how the blood and ſpirits (and, if you pleaſe to have it ſo, alſo the leſs fixed and more eaſily exſoluble particles of the ſolid parts) are abſumed by the vital Heat; it may be familiarly explicated by the example of the oyle conſumed by the flame of a Lamp. Flame (as reaſon defineth it) is a ſubſtance luminous and heating, conſiſting in a perpetuall *Fieri*, *i.e*, an indeſinent accenſion of the particles of its pabulum, or combuſtible matter, and periſhing as faſt as it is generated: ſo that fire is made fire, and again ceaſeth to be fire, in every, the ſhorteſt moment of time;

and

and when there remain no more particles in the combuſtible matter, wherein it may generate it ſelfe anew, it inſtantly periſheth. Continuall *Diſperſion*, therefore, being the proper effect of Fire; the matter or ſewell, whereon it ſubſiſteth, cannot but be in perpetuall flux or decay. In like manner (that we may accommodate this to our preſent purpoſe) the *Lamp of life* conſiſting in a continuall accenſion of vital ſpirits in the blood, as that paſſeth through the heart; thoſe vital ſpirits, tranſmitted by the arteries to the habit of the body, no ſooner arrive there, but as they warme and vivifie the parts, ſo do they immediatly fly away, and are diſperſed into the air, carrying with them many aqueous parts, and (perhaps) ſome ſulphureous exhalations. Moreover, there being in all parts of the body certain ſweet and balſamicall, or conſerving ſpirits, as it were affixed unto and concorporated with them; the vital ſpirits meeting with and acting upon them, do by little and little render them volatile, and at length wholly diſperſe them: whereupon the minute particles, in which they did reſide, become mortified, &, as excrements of the body, are ejected together with the exhalations of the blood. And this is (as we conceive) the reaſon and manner of the depredation made upon the parts, by the vital heat.

6. And in what *Quality.*

If your Curioſity extend yet further, and you would enquire into the *Quantity* of Aliment daily devoured by this *Biolychnium*, or Lamp of life; the acute *Sanctorius* will tell you, that,

that, according to his ſtatique obſervations, men commonly avoid as much by inſenſible perſpiration, in one day, as by ſtool, in fifteen. But ſo great is the variety among men, in reſpect of temperament, diet, age, exerciſe, the ſeaſon of the year, and other circumſtances; as that no definite compute can be made of this diſpence. And yet we may be certain, that the proportion of blood and ſpirits daily exhauſted by the flame burning within us, is very great: and that the moſt part of the matter of occult tranſpirations, is the vital ſpirits, which are continually generated, and continually diſperſed.

From the conſideration of the Cauſes and Reaſon of the Deperdition of ſubſtance in Animals, we may opportunely progreſſe to an enquiry into the Cauſes and Manner of the *Renovation*, or Reſtauration of it, by Nutrition.

7. The Efficient *Principle* of the *Renovation* of the parts, what.

The *Efficient* principle (or ἀρχὴ κινητικὴ ἢ διεξαγωγὴ, as *Ariſtotle* calls it) certainly, is the very ſame with the Generant, or Formative; becauſe, as we ſaid afore, Generation cannot be without Augmentation, and Augmentation is Nutrition. Not that we are of their judgment, who hold that Life and Nutrition are different, not *in re*, but onely *in ratione*; for, the Embryo is nouriſhed, before the *Empſychoſis*: but that we conceive, that Life doth conſiſt in a continuall accenſion of vital ſpirits out of the blood, which is the pabulum of the Lamp of life; and that Nutrition doth conſiſt in the reſtauration of what is conſumed, by an Appoſition

sition and Assimilation of consimilar or congenerous matter.

The *Material*, or Constitutive principle, we take to be a certain sweet, mild and balsamical Liquor, analogous to the white of an egge, out of which the chicken is formed. For since all Animals are nourished with the same, out of which they were at first fabricated, according to that common Axiom, *iisdem nutrimur, ex quibus constamus*; and that of *Aristotle*, *eadem materia est, ex qua augetur animal, & ex qua constituitur primùm*; and since they have their origine *ex Colliquamento*: we may well conclude, that the *Succus Nutritius* is in all qualities respondent to the Colliquamentum of the white of an Egge. Nor are they in the right, who thinke, that the parts of the body being diverse, those of the Aliment ought also to be equally diverse. As if Nutrition were nothing else but a selection and attraction of fit aliment; and that there were not required in every part a concoction, assimilation, apposition, and transmutation. For, the Aliment of all parts is common, and similary, such as the white of an egge; not heterogeneous and composed of diverse parts: and it is the work of the Vegetative soul, as to forme all parts out of one and the same homogeneous matter at first, so afterward to augment and repair them out of the like, by transforming that into the substance of each part, which is potentially all parts, and actually none. As from the same rain all sorts of plants receive

8. And what the *Material*.

their increment; becauſe the water, which was potentially life to them all, is now made actually life to each, being tranſmuted into the ſubſtance of each. Whereunto the *Philoſopher* had reſpect, when, oppoſing the opinion of *Anaxagoras*,

Principium rerum qui dixit Homæomeſiam,

De gen. Animal. l. 2. c. 4. He ſaith; *Diſtinctio partium non, ut quidam opinantur, propterea fit, quia ſimile ſuapte natura ad ſimile fertur: nam præter alias multas, quas ratio iſta habet difficultates, accidet, ut quævis pars ſimilaris ſeorſim creetur. Verbi gratia, oſſa per ſe, & nervi, & carnes; ſi quis eam cauſum approbet*, &c.

9. And the *Manner* how they are renorated. Laſtly, as to the *Manner* how the parts are refected, or inſtaurated; it is moſt probable the ſame is effected by *appoſition*, *agglutination*, and *aſſimilation* or *tranſmutation*; all which muſt in order ſucceed each other, before the act of Nutrition can be compleat. For, the *ſuccus nutritius*, being firſt prepared in the ſtomach and other organs thereunto inſervient, muſt be brought and appoſed to all the parts, that are to be nouriſhed; then from contiguity by appoſition it muſt be advanced to continuity, by agglutination; and laſtly made of the ſame ſubſtance with them, by aſſimilation or tranſmutation, which is the perfection or ultimate term of Nutrition.

10. *Conſectary*, of the *twofold* Expence of the *Chyle*. From what hath been ſaid, it eaſily appears, that the expence of the Aliment (at leaſt of the Chyle extracted from it) is *Twofold*; one part thereof, being converted into the *ſuccus nutritius*,

nutritius, for the instauration of parts : the other being converted into *Blood*, both for the fewel of the vitall flame, and for the confection of Spirits. That we may, therefore, the better understand the processe of Nature in both these Operations; it is fit, we enquire into the method of *Chylification* first, and afterward into that of *Sanguification* : that we may comprehend the whole history of Nutrition from the beginning to the end.

OF CHYLIFICATION.

Exercitation the Second.

Of Chylification.

Article 1.

The *Order* of the Meat in the stomach.

WHen we eat, whatsoever of solid Aliment is detruded into the Ventricle or stomach (for Deglutition is by way of detrusion) doth for a while observe the same order, in which it was swallowved dovvn; vvhat vvas first taken, lying undermost, and vvhat last, uppermost : unlesse it chance, through intemperance, that an excessive quantity of drink so distend the stomach, as that the meat be set afloat ; and then that order is changed into confusion.

2.

The *Posture* of the stomach, in Concoction.

When our hunger is satisfied, and repast finished, the stomach doth dilate it self more or less, according to the proportion of meat and drink received, so as to imbrace the same

closely and strictly on all sides; and then shut both its upper and lovver orifice; the upper, that vapours may not ascend to the brain, and that the concoction may be the more perfect; the lovver, lest any of the meat should descend into the guts, before it be converted into perfect chyle. Yet the lovver seems not so strongly contracted, as the upper; because it hath been observed, that upon even a gentle compression of the body of the stomach, it easily yeelds to the pressure of the yet half-concocted meat, and permits it to pass into the guts. And sometimes the stomach is so vveakned, by surfeits and frequent distension, as that neither of its orifices is dravvn together so closely, as it ought to be; and in such case the Concoction is alvvayes imperfect.

3. The *Dissolution* of the Meat, by an *Acid* humor found in the stomack.

The meat thus received into, and embraced by the stomach, is by and by moystned and diluted, partly by the drink, partly by a certain *Acid* humor contained in the stomach. Which being endovved vvith an incisive, penetrating, and dissolving faculty, doth as it vvere cut, and dissolve the solid meat into very small pieces, and (like an excellent menstruum) extract all the laudable and alimentary parts of it, *ad modum Tincturæ*. But vvhether this Acid juice be ingenite in the stomach it selfe, or sent thither either from the Spleen (as hath been vulgarly believed) or from the cæliacal arteries (as is most probable) vve shall hereafter professedly enquire. In the mean vvhile, certain it is, that this Acid liquor (or spirit, as some

ſome have named it) is ſo neceſſary to the ſtomach, as that it cannot happily performe its Office of Chylification vvithout it. For (to omit hovv much the ſame conduceth to excitement of Appetite) vvhen it is vvanting, the concoction is rendred ſo imperfect, as that the meat is avoided vvhole, as it vvas ſvvallovvcd dovvn; vvhich *Hippocrates* ſeems to intimate, in the 1 *Aphor.* 3. *ſect.* vvhere he ſaith, *In longis inteſtinorum lævitatibus, ſi tactus acidus fiat, qui prius non erat, ſignum bonum eſt.* Certain it is alſo, that this Acidity, as it is not excited but by a moderate heat, ſo it is diſcuſſed and deſtroyed by an exceſſive. Which is the reaſon, vvhy the appetite is vveak and languid in phlegmatique conſtitutions, and cold diſtempers of the ſtomach; and in Fevers, and hot diſtempers, vvholly taken avvay. Like as bread is very hardly leavened, in a cold place, and in an Oven not at all. But, we return from our digreſſion.

4. Which cauſeth a certain *Fermentation* of the Chyle therein.

The mixture of the ſolid and liquid parts of the aliment, being by this time advanced *uſque ad minima*, ſo as the vvhole appears to be, one and the ſame fluid ſubſtance; in the next place ſucceeds a *Fermentation*, not unlike the motion ariſing in vvine, vvhile it defæcates it ſelf. Which *Fermentation* vve underſtand to be a certain Heat and agitation of all parts of the liquor, ariſing from a conteſt or ſtrife betvvixt the Spirits and craſſer parts, vvhile the Spirits endeavour to expand themſelves, and flye avvay, and the groſs parts oppoſe

pose and hinder that their endeavour. Now this is that motion, which being equivalent to long Elixation, doth so fully impregnate the potulent part of the Aliment, with the spirits and virtues of the solid, as that it puts on the form of a whitish juice, in colour and consistence not much unlike the Cream of barly, generally called the *Chyle*, as the function or action of the stomack, by which it is so confected, is called *Chylification*.

5. All parts of the Aliment, not Chilified at once, but successively: and the first Chylified, first discharged into the Guts.

But, here we are to advertise, that all the meat doth not receive this commutation equally soon; it having been observed in dissections, that some parts have been perfectly converted into chyle, and that chyle detruded into the intestines and milky-veins; while the rest have remained wholly crude. Nor is it reasonable, that the whole mass of Chyle should be detained in the stomack; or that what is already concocted, should there stay and expect the perfection of what is not concocted: but that as fast as the chyle is made, so fast should it be discharged out of the stomack.

6. The *Time* required to perfect Chylification, various, according to divers respects.

We are to advertise also, that as to the *Time* wherein the work of Chylification is wholly consummated, there is no small variety; as well in respect of mens individuall temperaments, as of quantity and quality of meats they eat, and also of the time of their meals, with other circumstances. For, in some men the digestion is compleated in 3, 4. or 5. hours space; while in others it extends to 8. 10. nay

13. which certainly is to be aſcribed chiefly to the abundance of heat and Acidity in the ſtomacks of Thoſe, and to the decay of them in Theſe. Again, by how much the greater *quantity* of meat is devoured, by ſo much the ſlower is it digeſted. The ſame likewiſe may be ſaid of the *quality* thereof; becauſe the groſſer, tougher and harder the aliment is, by ſo much the more difficulty is it comminiſhed, cutt, diſſolved, and fermented; and conſequently the longer before it be concocted. Moreover, concoction is performed in the *day* much ſooner, than in the night; notwithſtanding the vulgar opinion, of the receſſion of the naturall heat towards the ſtomack, in ſleep, for the promotion of Chylification: becauſe in the day, by reaſon of motion and exerciſe, the Circulation is more free and ſwift, and ſo the diſtribution of the Chyle more expedite. Laſtly, *Maſtication* of the meat in the mouth is ſo neceſſarily præcedaneous to concoction; as that by how much the ſmaller the morſels are, and the better chewed, by ſo much the ſooner are they digeſted. Nay, among the parts of the ſame meat, there is no leſſe variety; ſo that ſome parts of bread and fleſh commonly remain unaltered, a good while after others more tender and exſoluble are transformed into perfect chyle, and protruded into the gutts. So that no certain time can be aſſigned to Concoction in all men. But Nature it ſelf hath given us a ſigne, by which every ſingle perſon may know, when this chylification is finiſhed in his ſtomack;

mack; and that is a ſenſe of emptineſſe, and appetite to a ſupply or recruit of Aliment.

THE JOURNEY OF THE CHYLE

Exercitation the Third.

Article 1. The traduction of the Chyle, from the ſtomack and inteſtines, into the common *Receptacle*, through the *venæ Lacteæ*.

THe Chyle, being, according to the manner declared, perfectly concocted, is by degrees (the ſtomack gently and gradually contracting it ſelf) expreſſed or detruded into the Guts; and not attracted by them, as hath been commonly taught. The Guts being filled with this liquor, and by a certain periſtaltique motion, or undulation, like that of worms creeping, contracting themſelves ſucceſſively from the firſt to the laſt; tranſmit the ſame downward. And as it paſſeth through them, there is a ſeparation made of the profitable or alimentary part, from the unprofitable or excrementitious: the latter to be excluded by ſtool; the former to be protruded into the *Venæ Lacteæ*, or milky veins. Which opening themſelves by ſmall orifices or inletts, in infinite number, into the coats of the inteſtines; and running in continued channells from thence into the Meſentery: carry the Chyle into a certain common Receptacle or Gulph (called *Receptaculum Pecqueti*, from the inventor) conſiſting of a membranous ſubſtance, ſituate at the root of the meſentery, upon the *vertebræ lumborum*,

lumborum, and filling the ſpace betwixt the Muſcles *Pſoæ*. From this common Receptacle there are derived other *ductus chyliferi*, which running upwards, neer the ſpine of the back, through the Thorax, and propagated quite home to the ſubclavian branches of the *vena Cava*, neer the external jugular veins, exonerate themſelves into them; ſo as the Chyle being there commixed with the blood, is by the aſcendent trunk of the *vena Cava*, ſoon imported, together with its new aſſociate, the blood, into the right ventricle of the heart. And this, according to the late invention of *Perquet*, and anatomical experiments of the moſt accurate Diſſectors ſince, is the true Traduction of the Chyle from the ventricle to the heart: at leaſt of ſo much of it, as is to be converted into blood, for the fewell of the vital Flame, and confection of vital ſpirits.

That we may, with the more exactneſs and certainty, trace the footſteps of the Chyle in all its progreſs through theſe various and obſcure Meanders; we are to obſerve, from Anatomicall Demonſtrations, two things concerning the Chyliferous Conduits. *Firſt*, that there are (beſides the Common Receptacle, and channells from thence aſcending to the cheſt and ſubclavian veins) two kinds or ſorts of the venæ Lacteæ; one ariſing in ſlender capillary roots from the Inteſtines themſelves, and thence delated through the Meſentery to ſome glandule or other, ſituate either in the Meſentery it ſelf, or not far from it in ſome o-

2. Of which there are two kinds, *one* ariſing from the Inteſtines; the *other* from the Glandules, in the *Abdomen*, into which the former ſort exonerate themſelves.

ther part of the Abdomen, and there disseminated into capillary furcles: the other taking its origine out of that very Glandule, into which the former sort exonerate themselves. *Secondly*, that the Glandules in the Abdomen are not seated in the same places in all men; but are variously posited, here in some there in others, according as Nature (sometimes affecting variety in the same species, where conveniency admits thereof) pleaseth to fix them; and this without incommodity to the body: and that from the incertainty of the position of these Glandules, the Distribution of the venæ Lacteæ comes to be also various and incertain. For, Anatomy sensibly atteſteth, that all the small furcles of the *venæ Lacteæ* of the former sort (arising from the intestines) do constantly tend to some one Glandule in the lower belly; and are distributed into the same, before they arrive at the Common Receptacle, or disembogue themselves into any vein; yea (as was newly said) that they produce another race of Capillary branches in the Glandules, in which themselves were terminated; and that many of those small rivulets concurring and uniting, make one greater channell, before they lose themselves either in the Common ocean, or any branch of the *vena Cava*. Now, from the foresaid various position of the Glandules, it comes to pass, that the Distribution of the venæ Lacteæ into their substance, and their new propagation out of them again, are so uncertain, as that it hath given occasion to some

Anatomist

Anatomists to suspect, that the *venæ Lacteæ* are disseminated into very many parts of the body; when, indeed, they only come neer those parts, and then passe by them, without effusing any part of the Chyle into them.

Now, from these observations, it is very-probable, that all the *venæ Lacteæ* (before the Chyle loseth its milky colour) do exonerate themselves either into the vena Cava, or some branches of it. And as for the *Lacteæ Thoracicæ*, our sense demonstrates, that they empty themselves into the subclavian or Axillary veins (branches of the *Vena Cava*); so that none disgorgeing their fraught or chyle into any branch of the *vena Portæ*; it is most manifest, that no part of the Chyle is imported into the Liver (as was long believed and taught), there to be converted into blood; and consequently that the office of the Liver is not Sanguification.

3. But none of either kind tend to the Liver.

Whether any of the *venæ Lacteæ* are distributed into the *Paps*, and *womb*; in women; though highly probable, is yet in dispute: no Anatomist having hitherto been so happy in his searches, as to discover by what secret wayes or passages they tend to either. We say, highly probable; for, according to that judicious saying of *Hippocrates*, *Licet visum oculorum effugiant, ea tamen mentis acie comprehendantur*; though they have thus long concealed themselves from the eye of the body, yet are they obvious to the eye of the Mind: and the acuteness of our Reason may herein supply the dullness of our sense. Now, to evince the proba-

4. That the Milk in the Papps is not made of Blood, but of meer Chyle brought thither by some peculiar vessels: because

bility of this Opinion, let us consider the sundry and weighty Arguments, that seem to assure, that *the Milk in the paps is not made of blood; but mere Chyle brought into them by some peculiar vessells.* Which though a seeming Parergy, is yet fully pertinent in this place.

5. There are no convenient conduits, by which Blood can be brought into the paps, in sufficient quantity.

First, there are *no convenient wayes or conduits*, by which Blood may be, in a due quantity, imported into the Paps, there to be whitened into Milk. For (1) the *Arteriæ Thoracicæ* can adferre but a small tribute of blood into the treasury of the Paps; and what they bring in, is soon exhausted and carried off again by the veins; according to the apodictical doctrine of the Circulation of the blood. But, did the blood remain in them; yet would it hold no reasonable proportion to the large quantity of milk usually effused in a day (which in healthy Nurses commonly amounts to two pints). Because the Arteries disseminated into the Paps, are exceeding small, as our eyes witness, and *Vesalius*, long since well observed, where He saith, *Exiguæ aut ferè nullæ arteriæ adeunt mammas, quod in mammarum cancro affectarum allatione constat, ubi paucæ aut ferè nullæ arteriæ sanguinem fundunt, cùm tamen venarum magna copia sit.* (2) The Arteriæ Hypogastricæ cannot be thought to convey blood into the Paps; because they are terminated in a part far distant from their confines, and empty themselves where their streams are soon swallowed up and returned into the vena Cava by the Hypogastrick veins. (3) The same may be said

Examin. observat. Fallop. pag. 89.

of

of the Epigaſtrick arteries and veins. So that in reſpect of wayes importing blood into the Paps, it appears altogether unlikely, that that ſhould be the matter of Milk.

Secondly, *Blood is not a fit, nay not a poſſible matter for the generation of Milk.* For (1) if blood ſhould be imported into the paps, in ſufficient quantity, and there extravaſated; certainly it would be converted rather into *pus*, than into milk, as is frequently obſerved in Inflammations and Apoſtems of the Paps. (2) To what end ſhould nature convert blood into milk, when that milk is to be ſoon converted again into blood, in the infant ſucking it? (3) How is it poſſible, that the Chyle, which loſeth its whiteneſs and other qualities, when it is transformed into blood; ſhould reſume them again, as ſoon as it becomes milk; *a privatione ad habitum*, is repugnant to Nature? (4) Meat and drink cannot be ſuddainly changed into blood, and that blood changed into milk; but experience teacheth, that the paps of nurſes are filled ſoon after their repaſts, and many women feel their milk flow ſwiftly into their breaſts, almoſt as ſoon as they have drunk. (5) Women that are ſomewhat fat, have greater plenty of milk, than ſuch as are lean: but, if blood were the matter of milk, the lean would afford more milk, than the fat; becauſe the lean have larger arteries and veins, and ſo more ſtore of blood. (6) If blood were the matter of milk, then would the bodies of Nurſes fall into dangerous ſickneſſes, from exceſs

6. Blood is not a fit, nor poſſible *Matter*, for the generation of Milk.

of

of blood, soon after they cease to give suck; because being long accustomed to the generation of so profuse a quantity of blood, for the supply of their milk; and that daily evacuation thereof ceasing, the whole body must needs be oppressed with that redundancy: but, they seldome complain of any *Plethora*; therefore &c. (7) If blood, not chyle, were the matter of milk, then were it impossible the milk should retain the odour and qualities of the meats eaten; since no manifest quality of the meat can be deprehended in the blood, much less in what is generated of blood, as being one remove further from it: but the Milk doth frequently retain the odour and other qualities of the meat and drink; Ergo. This is attested by the experience of Physicians, who give purging medicaments to Nurses, when there is cause to purge their children. *Prosper Martianus*, the best Commentator upon *Hippocrates*, hath an observation of a woman, who having taken a purge, soon after gave her child suck, and thereby endangered the childs life, a superpurgation ensuing in the child, while herselfe felt no effect of the medicament at all. No obscure argument, that the Milk deriveth its purgative faculty from the Chyle, not from the blood; for if it were to be carried so long a journey, as through the heart and arteries, and therein undergoe so many and great changes: doubtless the virtue of the medicine would be much weakned and dulled; nor could it be derived into the paps, so soon after it was first

Comment in lib. Hippocr. de nat. pueri.

received

received into the ſtomack. Here may we ſeaſonably recite that ſaying of *Ariſtotle*, *Si lactans pilum cum cibo aut potu ingerat, ad mammas pervenit, & in earum papillis conſiſtens, morbum inducit, qui* τελχίασις *nominatur*: and that rare obſervation alſo cited by *Martianus*, of a piece of a root of Cichory eaten in ſallade by a nurſe at night, and taken out at one of her nipples the next morning. But, above all, this Experiment is moſt convincing. Let a nurſe drink a good draught of milk tincted with Saffron; and within an hour or two after expreſs the milk out of either of her paps, into a glaſſe or other ſmall veſſell: and that milk ſhall have the odour, ſapour, yea and the very colour alſo of Saffron. (8) Nor is the Milk made of the Menſtruous blood, as ſome Philoſophers have dream't; becauſe many bruit Animals have milk, that never ſuffer the monthly flux; becauſe moſt new-born infants have ſome milk in their paps, as *Dr. Harvey* hath well remarked; and becauſe even Men themſelves have been found with good plenty of milk in theirs alſo. *Schenchius* affirms, that he knew one *Laurentius Wolfius*, who from his youth to the 50 year of his age, had aboundance of milk flowing out of his duggs every day. The like is aſſerted of a certain Flemming, by *Wallæus*; and of divers others by *Cardan*, by *Benedictus*, by *Aquapendens* and other credible Authors. Nay, Hiſtorians report, that in *America* there are whole nations, among whom the men generally abound with milk, and ſuckle their children.

7. *De hiſt. Animal. cap.* 11.

Loco citat.

De gen. anim. exercit. 55.

dren. To which we may adde, that many nurſes have their Termes, while they give ſuck, and yet find no diminution of their milk, at thoſe times, more than at others. So that we ſee, how unreaſonable it is to conceive, that bloud is the matter of Milk.

7. *Milk* and *Chyle* agree in all their manifeſt *Qualities* and are reciprocally convertible.

Thirdly, Milk and Chyle ſeem to be one and the ſame thing; as may appear both by their mutuall agreement in all their qualities, and by their eaſie reciprocall convertibility. As for their *reſemblance in manifeſt qualities*; (1) They both have a fatty ſubſtance: otherwiſe neither could be fit either to ſuſtain the Lamp of life, or to inſtaurate the parts; nor can the bloud contain any ſuch fatty ſubſtance in it, but what is derived from the Chyle. (2) As Milk doth conſiſt of two parts, the *ſerum* and *craſſamentum*; ſo likewiſe doth Chyle, whoſe *ſerum* is dreyned away by the kidneys, and *craſſament* by the guts. (3) As Milk, if kept over-long, eſpecially in a warm place, or corrupted by any Acid juice, doth turn ſowr; ſo alſo doth the Chyle, and in the ſtomach of Calves is found a certain ſowr ſerum, which houſwives uſe for the coagulation of their Milk; in like manner the ſame is frequently generated in the ſtomachs of men, which being ejected by vomitting, ſets the teeth on edge; having acquired that ſowrneſſe either by corruption from exceſſive heat, or by the admiſtion of a melancholy juyce. (4) They are equally ſweet in taſt; which is the reaſon, why many brute Animals lick up

the

the milky liquor flowing from the ſecundines, when they bring forth their young, which is indeed the nutriment of their young, while remaining in the womb. (5) They reſemble each other in colour, being both white; as the ſenſe teſtifieth. (6) They both contain certain ſmall Fibers, that ſeem to be educed from the more viſcous and glutinous parts of the aliment. And theſe, doubtleſs, are thoſe Fibers, which ſenſibly uniting themſelves in the ſuperfice of bloud let forth into a cold veſſel, appear in form of a whitiſh film, or thin skin; long miſtaken by Phyſitians for cold, viſcid and phlegmatique matter commixt with the bloud: and if the red parts of the bloud be gently waſhed away from them, they become diſtinctly viſible. And as for their *reciprocal Convertibility*; that is clearly proved by this, that Chyle is eaſily converted into milke, in the Nurſe; and that milk again converted into Chyle in the ſtomach of the Infant that ſucks it. Now theſe many reſemblances conſidered, we may ſafely conclude, that they have much more of reaſon on their ſide, who conceive Milke to be nothing but meer Chyle brought from the ſtomach to the Paps, by peculiar paſſages; and therein promoted to ſomewhat more of perfection: than they, who think it to be made of bloud whitened in the glandules of the paps.

8. That Chyle is imported alſo into the *womb*, in pregnant women.

Having, with ſo great veriſimilitude, brought Chyle from the ſtomach to the Paps, for the ſuſtenance of the infant, after he is born;

it remains now that we see, whether any portion thereof be deduced also to the *womb*, for his nourishment before he is born. First, therefore, let us seriously consider, what light hath been anciently given to this obscure disquisition, by that Genius of Nature, *Hippocrates*; who hath sundry pregnant Texts to this purpose.

9. From the Authority of *Hippocrates*, &

lib. de Natur. pueri.

Uterum fœtu grandiorem (saith He) *comprimere mulieris ventrem, & quod in cibo potuque est pinguissimum & candidum, magisque uteri calore dulcoratum, in mammas tendere, & in uteros quoque exiguam portionem per easdem venas deferri.* In which words the reverend Author toucheth upon two things very considerable and pertinent. (1) That the fat, white, and sweet Chyle is carried up to the paps, by *compression of the Venæ Lacteæ*, and *the common Receptacle* of the Chyle; the swoln womb being incumbent upon them, and pressing the Chyle upwards. For, that Compression cannot be understood of the veines and arteries in the lower belly, as if they were thereby urged to disgorge their bloud into the paps, for the generation of milk; because, a compression of those veins and arteries, that are neer the *Vertebræ Lumborum*, would necessarily hinder the course and recourse of the bloud, requisite to the work supposed. But, as *Perquet* will have the weight of the Liver, moved up and down in respiration, to conduce to the compression of the stomach, *venæ lacteæ*, and receptacle, from the upper part of the abdomen: So will *Hippocrates*

pocrates have it, that, from the lower part, the compreſſion of the womans belly by the greatneſſe and weight of the child, doth cauſe the Chyle to alter its courſe (his words, in another place, being, *convertitur ad mammas, quod eſt dulciſſimum ex humido*) and flow upward to the paps. Thus the Scythians, as *Herodotus* reports, had a trick to blow up the wombs of their Mares, by certain ſufflatoria oſſea, like pipes, to the end that their bellies being compreſſed by the ſwelling of their wombs, the greater abundance of Chyle might be protruded into their udders, and ſo their milke encreaſed. (2) Since by reaſon of the ſame Compreſſion, the paſſage of the Milk, by veſſels tending from the paps to the womb, is not ſo open and free, as while the burthen of the womb was leſſe; thence it comes, that ſo ſmall a quantity of the Chyle is imported into the womb, as will not ſuffice to the nouriſhment of the *Fœtus*. Much Chyle, therefore, flowing to the paps from the *Venæ Lacteæ*, and the Common Receptacle; and ſome milk alſo reflowing from the womb to them, by reaſon of this Compreſſion mentioned: it is no wonder, if the paps at that time ſwel above meaſure;

lib. de Mulier.

A ſecond memorable place of *Hippocrates*, to this purpoſe, is that; *Ad mammas enim & uterum ejuſmodi venulæ, & conſimiles, ferantur. Cumque ad uterum pervenerit, lactis formam habet, eoque exiguo puer fruitur: mammæ verò, ubi lac exceperint, attolluntur & implentur.*

libr. citat.

A third, to the same effect, is this ; *Fœtus quod in sanguine dulcissimum est, ad se trahit, simulque aliquantulâ lactis portione fruitur.* Where He hinteth the true cause, why it is unwholesome and dangerous for Infants to suck women with child, *viz.* because the best of the milk is attracted by the Fœtus, in the womb, and the worst is carried to the paps. Which He more expresly declares in these words, *Dum mammæ exsuguntur, venæ quæ ad eas tendunt ampliores redduntur, & ampliores effectæ quod pingue est è ventre attrahunt, & in mammas transmittunt* : giving the reason, why the fat and richer parts of the milk do not ascend to the paps, till after the birth of the child, who by frequent sucking doth dilate and amplifie the vessels (formerly too small) through which the milk is to pass from the womb to the paps, and so make them more capable of the thicker liquor ; and hence, doubtlesse is it, that the milk in womens breasts is alwaies much thinner and wheyish, while they are with child, than after their delivery.

10. Of Dr. Harvey.

From *Hippocrates* the First, let us go to *Hippocrates* the Second, the immortal *Dr. Harvey* ; who, by frequent dissections of prægnant and suckling Animals, discovered that there is Chyle or milk imported into the womb. For, describing the *Cotyledones* or *Acetabula* of the womb, He saith ; *Cavitates istæ spongiæ majoris loculamenta magnitudine non excedunt ; inque singulas earum, totidem vasorum umbilicalium ramuli tenuissimi profundè penetrant : quippe in iisdem*

Exercit. de Uteri membranis & humoribus.

dem alimentum fœtui reconditur; non quidem sanguineum, sed mucosum, ovique albumen crassius planè referens. Unde etiam manifestum est, bisulcorum Animalium fœtus (ut & alios omnes) sanguine materno non ali. And, in the subsequent paragraph, He adds, *coarctatis hisce acetabulis, non sanguis, sed albugineus liquor emanat; eodemque expresso, illa statim contracta, albidiora, & flaccida conspiciuntur; ac demum mammarum papillas, aut verrucas pensiles majores referunt:* And a little after, *Opinor, caruncula omnes (uberum modo) non sanguinem, sed succum albumini similem concoquere, eundemque fœtui subministrare.* Again, in another place, tracing the way of this milky juice more accurately, He saith; *ab utero per cotyledones pertingit ad caruncula placentæ; quas quidem si digitis compresseris, ex earum una aliqua (tanquam ex papilla) succi istius alibilis facilè cochlearis mensura emulgetur: idque nullo apparente sanguine, quem attractu etiam valido, numquam elicueris; quinetiam caruncula sic emulcta atque inanita, compressæ spongiæ instar contrahitur & flaccescit; plurimisque foraminibus pertusa cernitur. Adeò ut omnibus indiciis pateat, carunculas istas esse ubera uterina, sive albuminis nutritii conceptacula.* And a little after, He expresly affirms, *succum illum in Gravidis ante partum, in acetabulis conservari; post partum verò, ad mammas deferri.* Than which nothing can be more plain, more positive.

II. And from the *sympathy* betwixt the womb and the paps.

To the Authorities of these great men, let us adde the consideration of that great *Sympathy* or consent betwixt the womb and paps, so

ſo frequently obſerved in women. Which Conſent cannot be cauſed by nerves, nor by veins, nor by arteries, nor by ſimilitude of ſubſtance, nor by contiguity of ſituation; and therefore moſt probably, by mediation of theſe preſuppoſed Chyliferous veſſels tending from the paps to the womb. (1) Not by *Nerves*; becauſe the paps derive their nerves from the fourth intercoſtall pair, or the fifth pair of the thorax: and the womb is ſupplied with ſenſe from the nerves of the *os ſacrum*, and alſo from the ſixth conjugation of the brain. (2) Not by *veins or arteries*; becauſe they are, both, deſtitute of ſenſe, as *Galen* himſelf affirms. (3) Not by *Similitude of ſubſtance*; becauſe the paps conſiſt moſtly of Glandules, and the body of the womb is membranous. (4) Not by *Contiguous ſituation*; becauſe the paps and womb are far diſtant each from the other. It being, therefore, moſt certain, that all ſympathy betwixt parts of the body, doth ariſe either *ex Vaſorum Communione*, or *ex operis ſocietate*, or both; and that betwixt the paps and womb there is no communion of veſſels, unleſſe it be of ſome chyliferous veſſels derived from thoſe to this; and that there is a ſociety of office betwixt the paps and womb, both containing the Aliment of the child: it is highly conſentaneous to truth that there are ſuch veſſels (though yet undiſcovered) by which the Chyle is carried from the paps to the womb, while the infant remains therein, and back again from the womb to the paps, after he is born. This being granted, we

may

may cleerly understand the wayes and manner of the ascent of the milk from the womb to the paps; and the reflux of it from the paps to the womb, so frequently mentioned by *Hippocrates*. We may understand also, how the good or evill affections of the womb are communicated to the paps; and how it comes, that a Cancer cured in the paps, doth revive and grow again in the womb, and *vice versâ*. And thus may we understand those Aphorisms of *Hippocrates*; *Si gravidæ mammæ graciles fiunt, repente illa abortit; si gravidæ lac multum è mammis effluat, fœtum imbecillum significat; si solidæ mammæ, fœtum saniorem*. In respect of these vessels, are we moreover to interpret that Rectitude of consent betwixt the papps and womb, intimated in that Aphor. *Gravidâ gemellos gerens, si dextera mamma fiat gracilis, marem; si verò sinistra fœminam abortit: fœtus enim mares in dextris, fœminæ in sinistris magis.*

12. A conjectural description of the *Chyliferous vessels* tendin from the paps, to the womb.

To conclude this Disquisition, therefore, since it is manifest that there are some such Chyliferous vessels, or *ductus*, by which the paps and womb have a reciprocall commerce; it is not improbable, they are derived from the extremities of the Chyliferous veins of the thorax, where those enter into the subclavian veins, or the branches of the *vena cava*; being disseminated on each side one, to each pap; whereunto so soon as they have insinuated themselves, and dispersed several small surcles, to lead a long the chyle to the nipples, they may be conceived to emit others branches

ches downward along the abdomen, that insert themselves into the womb, on each side one; and perchance some one also into the bladder, it having been observed, that Chyle hath been avoided by urine. But, what need we thus anticipate, by conjecture, when we dayly expect the discovery of the wayes through which they passe, by Anatomists, who now a dayes exercise themselves in strict enquiry after them?

OF SANGUIFICATION.

Exercitation the Fourth.

Of Sanguification.

Article 1. The most part of the Chyle is converted into blood.

FRom the smaller and lesse conspicuous Rivulets of the Chyle, we now come to survey the grand and plainly visible Current thereof; which being imported (as we formerly declared) into the subclavian veins, from them into the *vena cava*, and thence immediately disembogued into the right ventricle of the heart, is therein converted into a liquor of a different colour and nature, *viz.* Bloud, for the fewell of the vital Lamp, and the continual refection of spirits vital. And here we are (for method's sake) in order to consider (1) The *Mutation* which the Chyle ariving at the heart, doth therein suffer, or the Action its

ſelf, called Sanguification; (2) *The Agent*, or principal Efficient of that Mutation; (3) The *Manner* how it is effected; (4) The *Uſes* of the Bloud, after it is made; (5) The *Motion* of the ſame, in order to thoſe uſes.

Concerning the *FIRST*, viz. *the Action of Sanguification*; we advertiſe, that it is not an Organical action, or ſuch as depends upon the peculiar conſtitution, or fabrique of any Organical part of the body; but meerly a *Similary* one. For, ſince the bloud, when made, is a ſimilar body; and the Chyle of which it is made, is likewiſe a ſimilar body; and that the Chyle doth not become bloud, by ſeparation of any one or more parts of it, from any other (as the Urine and Bile are made) but only by a kind of Exaltation of its nature, or an advance of thoſe Natural ſpirits it containeth, into vital or more ſublimed and active ones, while the vital ſpirits, præexiſtent in the Ventricles of the heart, do enkindle the ſame heat, and cauſe the ſame diffuſive or expanſive motion in the Natural, which themſelves have formerly acquired: we ſay, conſidering theſe things, it is manifeſt, that the work is done by *ſimple Aſſimilation*; and conſequently that Sanguification is an Action *ſimilar*, not Organical, as hath been long erroneouſly affirmed.

2. Not by an Organicall, but a *Similary* Action.

Concerning the SECOND, *viz.* the *Efficient*, let us firſt examine what that cannot be; and ſo we ſhall the more eaſily and certainly find what it muſt be. The prime Agent, or Author

of the work of Sanguification, is not either the *Liver*, as *Galen* and his Sectators conceived and taught; or the *veins*, as some Anatomists have dreamed; or the substance of the *Heart*, as *Aristotle* and his Disciples have asserted; or any other organ of the body.

3. Whose Primary Efficient, is not the *Liver*;

To be more particular; we affirm, the *Liver* not to be the Agent in the work of Sanguification; and that for sundry reasons. (1) No part of the Chyle is brought to the Liver, by any one or more of the Venæ Lacteæ: they in the lower belly generally exonerating themselves into the Common Receptacle; and those in the Thorax being terminated in the subclavian veins: and therefore it is impossible the Liver should transforme chyle into blood, when no chyle can arrive thereat. (2) There is blood to be seen in an Embryo, before even the very rudiments of the Liver are delineated; and what hath beeing before, cannot be the effect of what hath no beeing till afterward. That the blood hath priority of existence, is manifest from the observations of *Dr. Harvey*, who expressly affirms, *Sanguinem dari, antequam quicquam corporis reliqui existat; esseque eum, præ cæteris omnibus fœtûs partibus, primogenitum; & ab ipso, tum materiam, ex qua corporatur foetus, tum nutrimentum, quo augetur, procedere; esse denique (si modo ulla fuerit) primam particulam genitalem.* (3) After the Chick is perfectly formed in the egg, and hath its veins and arteries repleniſhed with blood; yet doth the Liver still remain pale and whitish,

de gen. Animal. exercit. 18.

not

not without some small tincture of yellow, which observation doth of it self alone demonstratively depose the Liver from the office of Sanguification, and conferre that dignity upon some other Agent. For, how can the Liver, supposing the Chyle were brought to it, give a deep redness thereunto, while it self yet continueth white? Can any thing give that to another, which it self hath not? This also is certified by the experience of *Dr. Harvey*, who thereupon firmly concludes; *jecur & calorem, & colorem suum à sanguine mutuatur; non autem sanguis à jecore.* From hence it may be observed, that the native colour of the Liver is not red, but pale, with a faint mixture of yellow; and that, what redness it doth afterward acquire, is communicated to it from the blood continually percolated through the parenchyma of it. Both which may more plainly appear by this, that in a Chick not yet excluded from the shell, that yellow paleness of the Liver is visible, even the very last day of the Hens incubation; though at that time the same begins to incline toward some degree of redness, which is more and more augmented every day after the chick is hatched. Again, if you fill a bladder with warm water, and through a slender pipe inject the same, by the trunck either of the vena Cava, or vena Portæ, into the Liver; and so rinse out the blood remaining in the vessels and substance thereof; you shall sensibly perceive the redness of the Liver to vanish away, and a certain duskish or sooty yellowness succeed in

exercit. de gen Animal. 51 sub finem.

the room. Which obscure yellowness, doubtness, hath its original meerly from the tincture of Choler. However, most certain it is, that the Liver hath natively no redness at all; and what it afterward contracteth, is adventitious, and from the blood. To this purpose is that easie experiment of Dr. Harvey; *imò verò jecur, lien, renes, pulmo, & cor ipsum (si sanguinem inde omnem expresseris, cujus præcipuè gratia viscera dicuntur) expallescunt illicò, & partibus frigidis accensenda sunt.* So that we may with good warrant conclude, that the office of Sanguification was, by the Galenists, assigned to the Liver, rather upon inconsiderate partiality, than any right at all.

Exer. jam citato.

4. Nor the veins.

(2) Of the *veins* also the same may be said. For, if that rule of *Galen* holds true (as certainly it doth); *Quod mutatur, in ejus speciem, à quo mutatur, facessit*; the veins can never be thought fit, to transform the Chyle into blood. For, their Colour is white and somewhat translucid; their substance viscid, membranous, and bloodless; they have no parenchyma, and very little either of heat or spirits of their own: whereas, on the contrary, the Blood is of a deep red, not translucid, of a substance fluid and interminate, and abounds with heat and spirits. And, therefore, it were vain to expect an Assimilation, where the supposed Agent and Patient are of natures in all things so incompatible, so contrary. We deny not, that the veins in some respect conduce to the *Conservation* of the blood; but how? Only as they

are

are Organs, inſervient to the defence of it from external injuries, and the reduction of it from the parts upon which it was newly affuſed out of the arteries. And as for any ſimilar Action of the veins upon the blood; they have none at all: yea, their office of Conſerving it doth conſiſt chiefly in their inactivity, *i.e.* in this, that they are not apt to alter or deprave it; as Glaſs-veſſells are the beſt to conſerve liquors in, becauſe they neither communicate any ill qualities of their own, nor permit the like to be communicated from others to them. But, that which doth principally conſerve the blood in the purity of its nature, is the very ſame thing that makes it from the beginning, *viz.* the *vital Heat and Spirits derived from the Heart*, which by their enlivening warmth, and continuall motion, do not only vindicate the blood from corruption, but alſo all the ſolid parts of the body, and ſo even the veins themſelves alſo, as long as the Lamp of life continueth burning. And that being once extinguiſhed; how ſoon, alas! do all parts of the body yeeld to the quick tyranny of corruption?

5. Nor the *Heart*: but the *vital ſpirit*, reſiding in the blood.

(3) Nor hath the Heart more right to this noble office of Sanguification. For, that borrowes all its vital heat and activity meerly from the vital blood contained in its ventricles, and diſtributed into its ſubſtance by the Coronary arteries. Of which vital influx were the Heart deprived, but for ſome few moments; it would ſoon become as torpid and motionleſs, as any other part of the whole body; ſo far

far is it from exalting the Chyle into so noble a Nectar, as the blood is, by any similar action of its owne. To assure this, please you, take out the yet-panting Heart of any the strongest and soundest Animal, and having with warm water rinsed all the blood out of the ventricles, fill them again with warm Chyle or Milk; and see whether it will be able to convert the same into blood. Certainly, you shall find none the least change to be wrought upon the liquor infused. Yet the Heart is a solid and strong part; and one would scarce think it probable, that that action, which it is supposed to performe, by reason of its solid substance, should be intercepted in so short a space of time. Forasmuch, therefore, as the Heart doth, in a moments time, surcease its activity, and desist from the work of changing Chyle into blood, as soon as the vital blood is effused out of its ventricles; it is as manifest, as certain, that the virtue Generative of blood, is not radicated in the solid substance of the Heart, primarily, but in somthing else, *viz.* in that very thing, upon whose absence immediately that virtue is destroyed, which is the vital Blood. Again, the dissection of Living Animals teacheth us, that the vital Heat is much greater in the ventricles, than in the substance of the Heart: and Reason biddeth us thence to inferr, that the same Heat is originally in the ventricles, and but at second hand, or by way of communication, in the parenchyma. Now, if the Activity of even the Heart it self, be derived

rived originally from the vital Blood; and that the vital Blood be more powerfull than the Heart: we can hardly deny the ſame to be the Primary Cauſe, or Agent of Sanguification; unleſs (at leaſt) it ſhall appear, that the vital blood is leſs apt for ſuch a work, than the Heart. But, comparing the agreeableneſs of the Heart to ſuch an office, with that of the vital Blood to the ſame; we ſhall quickly perceive which of the two hath the greater. For, the vital Blood is of the ſame ſpecies with the thing to be made or produced; but the ſubſtance of the Heart is far different from it. It being, therefore, canonical, that all Naturall Agents endeavour, according to their energy, to aſſimilate to their own nature the thing, upon which they act: it ſeems of equal certainty, that the activity of the vital Blood, is moſt properly conſigned to the work of Sanguification. A further evidence of this, may be drawn from hence, that the Chyle and Blood are moſt *intimately mixed* together in the ventricles of the Heart; while the Chyle doth only *ſuperficially* and *in tranſitu* touch the ſides of them. To which may be added, that the Chyle makes but a very ſhort ſtay in the Heart: but remains conſtantly commixed with the Blood, untill it be thereto perfectly aſſimilated. Laſtly, the blood flowing in the heart, arteries, and veins, doth exceed the Chyle of one meal, in quantity at leaſt ten times, and in ſtrength or activity, an hundred; (for, what is more potent, then that ſpirit, which enliveneth the whole body;

what

what softer, gentler, and more easily superable, than Chyle?) and therefore, no doubt but the Bloud doth easily obtain the victory over the Chyle, and over-run it with his own nature.

7. which alone formeth the blood in a chicken, out of the *Colliquamentum.*

To secure this Assertion from all doubt whatever, let us have recourse to the observations of *Dr. HARVEY* (the true Oedipus in all abstrusities of this kind) of the progress of Nature in the generation of the parts of an Animal successively one after another; and we shall soon be satisfied, that the First Bloud is made by the vital spirit. That great man attesteth, that the white of the Egge doth for some dayes after the Hen hath sat a-brood upon it, retain its native whiteness, and that out of the Colliquament, or White, made more thin and fluid, the Chick is generated, without the addition of any other matter. The Question then is only this, *How that white colour in the Colliquamentum, or so much of it as the Plastique faculty converts into blood; comes to be changed into red?*

Certain it is, this cannot be effected by any thing that was red before; because there is no part of the Egge of, or inclining to, that colour; and the yelk remains intire a good while after there is bloud to be seen in the *punctum saliens*. Nor is it the Fleshy parts, that communicate this vermillion tincture to the bloud, because they remain white after the bloud is made out of the Colliquamentum: and it is much more reasonable, that the fleshy parts derive

derive their redneſſe wholly from the bloud, perpetually irrigating and waſhing them in its Circulation. For, their redneſſe grows upon them by degrees, and that ſooner or later, according to the degrees of Heat impreſſed upon the Egge by the Hen, and according to the greater or leſſe quantity of bloud arriving at them. Some parts, which are but lightly touched by the bloud, never become red; in which account are the coats of the Eyes, the Ligaments, Tendons, Membranes, Bones, *&c.* Others obtain a certain paleneſſe daſhed with a ſparing mixture of red; as the Glandules which as they are furniſhed with greater or ſmaller arteries (reſpective to their magnitude) ſo are they tinged with more or leſſe of redneſſe. The Muſculous fleſh is more deeply died with ſcarlet, than the Glandules; as being irrigated with greater ſtreames of bloud. The Kidneys, Liver, Spleen, Lungs, and Heart, are all waſhed with full ſtreams of bloud; and therefore have a deeper dye of redneſſe, than any other parts: and yet are much leſſe red, than the bloud it ſelf. Now it is more reaſonable to conceive, that the Greater ſhould communicate its virtue to the Leſſer, than on the contrary, the Leſſer to the Greater. For, how can any Natural Agent operate beyond the ſphere of its activity, *i. e.* the meaſure of its power? or communicate that to another, which it ſelf wanteth? Again, nothing can have an activity, before it hath a beeing: and conſequently the ſolid parts cannot give a red-

neſſe to the bloud, becauſe they are not in beeing, till after the bloud. Nothing, therefore, remains to be the Efficient of the Bloud, but the *Vital Spirit*, kindled originally in the pureſt part of the ſeminal matter, or *Colliquamentum* which we may well denominate the *Vital Liquor*.

8. The *Manner* how bloud is firſt generated in an *Embryo*, by that *Vital Spirit*.

Concerning the *THIRD* conſiderable, *viz.* the *Manner* of this grand operation of the Vital Spirit; though it be very obſcure, yet doe we not think it altogether inexplicable, if we deduce the bloud from its firſt Origine, the newly mentioned *Vital Liquor*. This *Vital Liquor*, before it aſſumes the colour and forme of Bloud, doth begin to ſeparate it ſelf from the other parts of the Egge (to which it is at firſt promiſcuouſly admixed) and to runne its ſelfe out into certain ſlender rivulets, or branchings, which afterward become Veins. Theſe rivolets concurring in a point, meet altogether at the centre of the *Colliquamentum*; which centre being the principal ſeat of the Plaſtique ſpirit, and acquiring a certain mication, or pulſation, is then called *Punctum Saliens*? And all this is done, before there is any the leaſt appearance of bloud in the Egge. So ſoon, therefore, as theſe Rivulets are conjoyned, the Flux of the *Vital Liquor* is, for ſome time, ſo hindred by, and repreſsed in them, as that being indefinently agitated by the *Spirit of Life*, it æſtuateth, and indeavours to expand it ſelf and enlarge its bounds: and ſeeing that it cannot flow back againe toward the circumfe-

rence,

rence, by the same passages, which brought it toward the centre, by reason of fresh supplies of *Vital Liquor* pressing it forward continually in the course begun; it is compelled to force it self again into the seminal matter, from whence at first it began its motion, through other slender conduits newly for that purpose formed, and then it begins to flow in a round. For, this appears to be the true reason of the *Circumgyration* of the *Vital Liquor*, from the very beginning. Soon after this, the Rivulets or pipes first made, and leading from the circumference to the Centre, become *Veins*; and the others made in the second place, and leading from the centre to the cicumference, become *Arteries*: which (yet others disallow, in respect of the fabrick of the valves) and then in the poynt of their concourse or confluence, the *Heart* is framed. Through which Heart, and the conduits annexed or (rather) continued unto it, the one sort tending toward, the other from-ward the centre; the *Vital Liquor* doth (while life lasteth) perpetuate its motion: and at the same time irrigate and vivifie all parts of the matter, which it continually washeth in that its circular course. Now this *Circulation* is begun, for some time before the Vital Liquor is excocted into bloud; as may be conceived from hence, that when the motion of the *Punctum Saliens* is plainly visible, there is no bloud, but only a clear, transparent liquor, or (as the Learned *Harvey* call's it) the *Colliquamentum*: and also from hence, that while

the *Seminal Matter* is yet thin and fluid, the Vital Liquor can easily disperse its channels through the same ; there being then no impediment to that its expansive motion, and operation : but, if it should defer its dispersion and making of rivulets, til after the solid parts were made; 'tis hard to conceive, how it could be able to shoot it self forth into branches, and make its way through them.

9. and in what *part* of the Conception it is first generated, viz in the *Chorion*.

This *Dance of Life* being thus begun, though no Bloud yet appears, yet soon after it doth appear ; the Vital Liquor, while continually (though slowly) circulated, by little and little assuming the form of Bloud. And the place in which the bloud first shews it selfe, is the *Chorion* ; not the Heart. For, seeing that the *Chorion* ought to be made solid and firme, before any other of the parts of the Conception, insomuch as it serveth as well for the safeguard, as nourishment of all the other parts ; and that to this end, there is no moysture comming from without, that might hinder its being made solid ; and that the Chorion, as involving the whole conception, is the first part that receiveth the warmth of the Hen, during her incubation : we say, from hence it comes, that the vital Liquor doth first of all obtain the forme of Bloud in the Chorion. And this is effected the sooner, because the vital Liquor doth more easily emit its exhalations, in that place, as being in the circumference, than in any other more remote from it : and unlesse those exhalations were freely emitted, the

Spirits

Spirits of the *Vitall Liquor* would inevitably be soon extinguished. It is moreover probable, that at this time, the Vital Heat is more potent and active in the exteriour parts of the Conception, than in the Centre ; and so, that the First Bloud is made in the Chorion, where it first discovers it self to the sight of the inspector. Hence also we may observe, that because there is no bloud to be discerned in the *Punctum Saliens*, for many hours together after bloud is discernable in the *Chorion* : therefore, must the Circulation of the bloud be exceeding slow in the begining; for, as soon as the bloud, that is in the *Chorion*, performing its circular motion, arriveth at the Heart, it cannot but be discerned in the *Punctum Saliens*.

10. In the generation of Blood, what are the Concurrent Extrinsecal Causes : and what the Accessary Organical.

Now, these observations being undeniable, we may safely assert ; that the *Vital Spirit* in the *Seminal matter*, being excited and assisted by the external heat of the Hen sitting upon the Egge; and by degrees becoming active, and infusing heat into the vital Liquor, wherein it doth reside: doth thereupon, in processe of time, induce the colour of bloud ; and that only by means of its vital Heat and Motion ; and that no other part is to be reputed for Principal Agent, in the work of Sanguification. Nevertheless, we do not hereby exclude *Concurrent extrinsecal Agents*, or *Causes* : but into that account readily admit the Hen, whose warmth at first both excited and assisted the Vital Spirit in the work of Sanguification; and

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the substance of the Heart it self, which afterward conduceth in some sort to the same. Nor do we repudiate *Accessory Organical Causes*; as the *Fabrick of the Heart*, the *Arteries* and *Veins*, all which are inservient to the continual motion of the bloud. Only we affirme, that *the Vital spirit, by reason of its Heat and Motion, hath a just right to the dignity of Principal Agent, in making of Blood.*

11. The Conversion of the *Colliquamentum* into Bloud, by the heat and motion of the Vitall Spirit; illustrated by sundry analogous *Experiments*, and *Observations.*

We say, *By reason of its Heat and motion.* For, that Colours frequently are advanced from a white, or pale, to several kinds of Red, meerly by Heat and Motion; is demonstrable by sundry easie and familiar Experiments. Our Confectioners well know, that long boyling of Quinces and other Fruits doth give them a ruddy colour. So likewise Fruits baked in an oven, are more inclined to redness, than while they were raw. The same is true also even of Flesh, and Bread, which by baking or rosting, acquire redness in their superficial parts: and some Chymists affirme, that a Tincture of Bread will assume a certain degree of redness, after long digestion. This is not, we acknowledge, common to all Liquors, especially simple ones; for simple waters, and such as are destilled, suffer little or no change of colour, upon decoction, though long. But generally all Compound Liquors, especially if they contain any Nutritive juice, in competent quantity, and have besides any touch of salt, or Acid spirits in them: are observed to acquire a sanguine tincture, by decoction. Upon which fertile hint,

as

as we conjecture, that highly Learned, Industrious, and Acute Person, Dr. ENT, seems to have grounded that ingenious opinion of his; that the Redness of the Blood ariseth *ex Aciditate spiritus vitalis salinei*, from the *Acidity of the vital spirits*, having their original from a certain seminal salt. However, we have good reason to perswade our selves, that all *vital Liquors*, *i.e.* such wherein the vital spirits of Animals do reside, are apt to acquire more or less of redness; provided they obtain sufficient Heat, and agitation or strife in their motions. This is evident in all Sanguineous Animals, in which the Chyle is first white, and after changeth into bloud. And as for Exsanguious Animals, they also give some testimony of this truth; as may be instanced in Oysters, in which bloud is frequently found (and yet without a prodigy) in summer time, by reason their vital Heat seems then to be augmented: and in winter, when their Heat is again lessened, below what is requisite to induce redness, their vital juice is alwayes whitish. To return to sanguineous Animals; as they are generally hotter of constitution, than Exsanguious; so are their Sanguine parts alwayes hotter, than their pale and white parts. In like manner, in cold diseases, as the Green sickness, Cachexy, Dropsy, and in all Phlegmatique constitutions, the bloud is paler, than in hot diseases and constitutions. Again, the venal blood, as it loseth the heat, which it had acquired in passing through the heart and arteries; so doth it

in Apolog. pro circulatione sanguinis, adverſ. Pariſan. p. 119.

propor-

proportionately by little and little loſe that florid and deep ſcarlet dye, that it had in the heart and arteries. For, blood let forth of a vein, appears blewiſh, and comes ſhort of that lively freſh ſcarlet, that is obſerved in bloud effluxed from an Artery. All which clearly ſhew, by whoſe efficiency it is, that the vital juice (in Sanguineous Animals) is excocted into Bloud; and what conſerves the ſame in its primitive purity and luſtre: *viz.* the *vital ſpirit* continually renewed in, and enlivening the blood; for, that being once extinguiſhed, how ſoon doth the bloud degenerate into *Cruor*, and loſe its freſh ſcarlet tincture?

12. That the ſame *Agent*, which maketh the firſt blood in an *Embryo*, doth make it ever after in an *Animal*, during life.

Having thus inveſtigated what that is, which makes the *Firſt* Bloud in an Embryo, by converting the *vital Liquor*, from a white, into a purple Nectar: we cannot be long in exploring what that is, which in *Animals* maketh bloud all the life after, by converting the *Chyle* likewiſe, from a white into a red liquor. It is an infallible rule, you know, that the *identity of Effects dependeth upon the identity of Cauſes*; becauſe an effect is not ſuppoſed to be, untill it hath obtained exiſtence from its proper cauſes: and at the ſame time the cauſes give that exiſtence, they cannot but give alſo the identity belonging to it. All which is imported in that common Axiome, *Idem, quà idem, ſemper facit idem.* For, though *Free* and *Arbitrary* Cauſes may act at liberty, and, by varying the manner of their operating, vary alſo their effects: yet *Natural* ones are bound up to a determinate

mode

mode of energie, and muſt, as long as they continue the ſame, act after one and the ſame way, and ſo produce invariably the ſame effects. Foraſmuch, therefore, as the Efficient of the Firſt Blood, is an Agent *Natural*, and not Arbitrary; if it continue the ſame in an Animal, while the Animal lives, it muſt of neceſſity continue the ſame operation. That it doth continue the very ſame, during life, is moſt certain; becauſe it is the Principle of life, nor can life ſubſiſt for ſo much as one moment without it. Nor doth this Efficient of Bloud only perſiſt the ſame in the body, that it was at the firſt conception; but growes every day more vigorous, potent and fit for the work, untill the Animal hath attained to the flower of his age: and to imagine that an Agent Natural (ſuch as the Vital Spirit) ſhould at any time become idle, intermit its operation, and not exerciſe all its forces; is groſſely abſurd. Conclude we therefore, that the Vital Spirit, as it is the Efficient Cauſe of Sanguification, in the Embryo from the firſt Conception; ſo is it conſtantly Author of the ſame work, untill the Animal dieth.

OF THE USES OF THE BLOOD.

Exercitation the Fifth.

Article. 1. That the Bloud is not the General Nouriſhment of the body. Becauſe

IT followeth now, that we enquire, *To what End Nature* hath conſigned ſo continuall a province, as this of Sanguification, to that ſubtile Agent, the Vital Spirit; or, more plainly, of what *Uſe* the Bloud is, in Sanguineous Animals. Concerning this, there are (for ought we know) but *Two opinions* extant; the *One*, that *the Blood is the general Nutriment of the body*, or Matter by which the ſubſtance of the parts is daily inſtaurated; the *Other*, that *it ſerveth both for the maintenance of the vital Flame, which cannot ſubſiſt without a perpetual ſupply of convenient fewell; and for the refection of vital ſpirits.* The *Former*, though very antient, and generally embraced; yet (in our judgment) deſerveth to give place to the *Latter*: becauſe though the Latter be new, and as it were of but yeſterdayes ſtanding, yet it hath much more of probability, as may be evinced by theſe enſuing Arguments.

2. The contrary opinion is ſubject to ſundry both inexplicable *difficulties*, and irreconcileable *incongruities.*

(1) It is well known, that *Ariſtotle*, in many places of his works, hath earneſtly contended, *Sanguinem eſſe ultimum totius corporis alimentum*, that the bloud is the ultimate, or moſt perfect Aliment of the whole body: and that the whole School of *Phyſicians* hath given its ſuffrage

frage to verifie that his Tenent. And yet many things, not easie to be explicated, and lesse easie to be reconciled one to another, may be observed to attend thereupon. For, *Physicians*, when, in their Physiological discourses, they treat of the nature of the Bloud and endeavour to make good, that it serveth to no other use, but only to afford Nutriment to the body; they suppose it to be a substance, not simple and homogeneous, but mixt and compounded of Four several juices, promiscuously flowing together in the same streams: deducing their principal argument hereof, from the Combinations of the Four First Elementary Qualities (as they call them) and accordingly teaching, that the ingredients of bloud are the two sorts of *Bile*, or *Choler* (*viz.* the yellow, and the blackish) *Phlegme*, and *Blood* properly so called. Further, of each of these different humours; They make some *Nutritive* (as assuming the whole body to be made up of them) others *Excrementitious*: and then They decree, that the bloud doth consist of those diverse Nutritious humors, as of Heterogeneous parts. After, though they allow the Phlegme to be the colder and cruder part, and so capable of conversion into good and laudable blood, by more intense heat, and longer concoction; and likewise allow the Choler to be convertible into Melancholy, by adustion; and blood to be convertible into both choler and melancholy, by the same means: yet will they by no means admit of a regression of either Choler or Melancholy

into blood. Now, if theſe things be true (as may well be doubted) and that there is no poſſible regreſſe of Melancholy into Choler, nor of Choler into laudable Blood : then will it inevitably follow, that all the other three juices are but only in Order to Melancholy : and that Melancholy is the principall and moſt perfectly concocted Aliment. Nay more, They muſt grant two ſorts of Blood ; the one, the whole maſſe of blood contained in the veines, and compoſed of thoſe four humours : The other, the more pure, more florid, and more ſpiritual part thereof, which in a ſtricter ſenſe they call blood, and which ſome will have to be contained only in the heart and arteries, apart from the venous blood, as deputed to peculiar and more noble Uſes. Now, according to this diſtinction, it is manifeſt, that not the pure arteriall bloud is the nouriſhment of the body, but the baſer, compoſed of diverſe juices, or rather chiefly the Melancholy ; to which as to their ultimate term, or perfection the three others tend. And how incongruous it is, to conceive, that the body is nouriſhed, either with impure juices, or with Melancholy a cold dry and earthly humour as they define it: is obvious to men of even the ſhalloweſt underſtandings.

3. There are ſundry parts, into whoſe ſubſtance the blood is not admitted.

(2) If the Blood were the Univerſal Aliment of the body, then certainly no part could be nouriſhed, at which the blood doth not arrive : but we ſee that many parts are nouriſhed, as the Brain, Bones, Nerves, Ligaments, Teſticles,

Teſticles, &c. to which notwithſtanding the blood is not ſo brought, as to be admitted into their ſubſtance: and therefore the blood is not the Univerſal Nouriſhment. We ſay, ſo as to be admitted into their very ſubſtance; for though blood be found in thoſe parts, yet doth it not penetrate deeply into them, as the Nutritive juice ought to do: *alimenti enim vis* (ſaith *Hippocrates*) *ad oſſa uſque pervenit, & oſſium partes.* The blood doth, indeed, touch upon thoſe parts, in its running round the body; and but only touch them; and for this reaſon, that all the parts may be cheriſhed and enlivened by the Vitall Spirits, which it carrieth along with it. Thus, in the Brain, veins are no where found, but diſſeminated upon the Membranes, that are their ſupport; the *Plexus Choroides* and ſome other few places excepted. Which perhaps is the reaſon, why *Ariſtotle* denyed any blood to be contained in the brain; becauſe it is not effuſed into the ſubſtance thereof, as it is into the fleſhy or muſculous parts.

lib. de Alimento.

1 *Hiſt. an. c.* 16.

(3) Men that are fat and plump, have but little blood; and ſuch as are ſpare and lean, have abundance: which could not be, if blood were matter of nouriſhment. And becauſe Lean perſons have much blood; therefore are they more lively, couragious, and active, as abounding with Spirits, in proportion to their great quantity of blood. Hence is it alſo, that Lean perſons bear large evacuation of blood, without detriment of health; becauſe their fleſhy

4. Fat men generally have the leaſt blood, and Lean the moſt.

fleſhy and muſculous parts, as being firme and ſolid, drink up the leaſt quantity of bloud in their pores, and ſo there remains the more for the fewel of the Vitall Lamp. Whereas, on the contrary, groſſe and fat perſons, ſuffer great dammage by large effuſion of bloud; becauſe the habit of their bodies being deſpoyled of Spirits and hotter bloud, is filled with ſerous humours, and ſo eaſily degenerateth into a Cachexy. In like manner, in a groſs body, where are more parts to be nouriſhed, there ought to be the more bloud to nouriſh them: but groſſe men, for the moſt part, eate much leſſe, than lean; becauſe they have leſſe veins, and being inclined to ſedentary and unactive lives, they conſume but few Spirits. For it is but a ſmall portion of the Chyle, that is, converted into the *Succus Nutritius* (the diſſipation of the ſubſtance of the parts, being neither ſo ſuddain, nor great, as hath been vulgarly conceived, as we formerly explicated) and the reſt, after its unprofitable parts are ſeparated, being brought to the heart, is moſtly conſumed in Spirits. Such things, therefore, as relieve the Spirits, ſuddainly ſatisfie our hunger; as good wine. Whence that Aphoriſm of *Hippocrates*; *Famem, vini potio ſolvit*: becauſe vvine revives the Spirits.

a *Sect. Aph.* 36.

5. Men periſhing by famine, have their arteries and veins full of bloud.

(4) In Animals dying of famine, and men dying of Conſumptions; good ſtore of bloud hath been found in the veines and arteries. Which were impoſſible if bloud were the nouriſhment of the body: for, then no Animal could

could periſh by famine, while it had any bloud in its veſſels : nor could the body be ſo emaciated, in conſumptions, while the veins contain ſo plentifull a ſource for the reſarcition of the parts. Which reaſon, among others, induced *Dr. Harvey*, to conclude ; *etſi ſanguis ſit pars corporis, non tamen huic nutriendo ſolum deſtinatur. Enimvero, ſi huic duntaxat uſui inſerviret, nemo fame periret, quamdiu ſanguinis quicquam in venis reliquum habetur : quemadmodum & lucernæ flammula non extinguitur, quamdiu inflammabilis olei in eâ vel minimum ſuppetit.* *de gener. Animal exercit. 52.*

(5) If the bloud were changed into *Ros & Cambium*, as they call them ; then, certainely, in the habit of the body, and capillary veines, it would appear white, or inclining to whiteneſſe : but our ſenſe aſſureth, that it is no leſs red and florid in thoſe places, than in the centrall parts of the body.

6. The bloud continueth red and florid, in the habit of the body.

(6) *Hippocrates* hath a ſingular obſervation, of a certain man, a patient of his, who being much emaciated, and every day more and more conſuming, notwithſtanding the moſt reſtorative aliment he could take ; was at length cured, only by a very profuſe eduction of bloud out of the veins of each arme, after all other means had been in vain attempted. Which would not have hapned, if the bloud were the nutriment of the parts. The reaſon of this admirable cure ſeems to be this. There is (as we have more than once declared) a twofold expence of the Chyle : one part goes to the inſtauration *libr. 5. Epidem. t. 25.*

7. *Hippocrates* cured a man of extream Leanneſſe, only by profuſe Phlebotomy.

ſtauration of the parts, as being, or conſtituting the *Succus Nutritius* ; the other ſupplyes the Vitall Spirits, under the form of blood. Now when one of theſe exceeds, the other languiſhes ; and the too plentifull exhauſtion of the Chyle, upon the blood being the cauſe of this mans Leanneſſe, his recovery ſucceeded upon a turning of the ſtreame of the Chyle upon the parts for their ſufficient Nutritive juice.

8. The blood is obſerved to be leſs unctuous and glutinous, in the Arteries, that carry it to the parts ; than in the veins, that return it from them.

(7) If the blood did nouriſh ; then would Fat, unctuous, and glutinous blood be moſt accommodate to that uſe : for, the ſerum hinders the appoſition of the blood, and therefore Ichorous and weeping Ulcers are ſeldome conſolidated. Now, the blood is obſerved to be more unctuous and glutinous in the veines, than in the arteries, in which it is commonly more diluted, and full of ſerum : but the blood is carried to the habit of the body by the arteries, and from thence brought back again by the veines. Which, certainely, is a very weighty argument, againſt the Blood's being the nouriſhment.

9. There is a manifeſt *Diſſimilitude* betwixt the blood, and ſundry parts of the body.

(8) Betwixt the thing nouriſhed, and its nutriment, there ought to be a certain Analogy, or ſimilitude ; according to that old ſaying, *Partes quaslibet alimento ipſis maximè conſimili enutriri* : but betwixt the blood and ſeverall parts of the body, inſtead of this requiſite reſemblance or affinity of qualities, there is in many things a perfect Diſſimilitude or diſparity. For, if we compare the blood, with the brain,

brain, the Horny coat, or Humors of the Eyes, the Bones, tendons, and other the like parts, we ſhall find little or no proportion, or reſemblance betwixt them. In an Appolexy, where the brain is overflowed with bloud effuſed into the ſubſtance of it, all the ideas or marks of things formerly known, are quite obliterated, nor doth any perception of them remain. Likewiſe when the eye is bloud-ſhodden, the perſpicuity of the coats of the eye is changed into opacity, and the tranſmiſſion of the viſible ſpecies through them hindered. The bones alſo are ſo many wayes diſcrepant from the bloud, that it ſeems impoſſible they ſhould be conſtituted thereof. And of the tendons, Nervs, membranes, *&c.* the ſame may be ſaid.

10. The progreſs of Nutrition, is from crudity, to fuſion and volatility; not retrogade from volatility to fixation: and ſo the Aliment ought to be more crude, or fixed, than the parts to be nouriſhed.

(9) The Manner of Nutrition, is a certain promotion of the aliment from the ſtate of crudity, to the ſtate of concoction, or an Exaltation of its Spirits to a further degree of activity. And therefore, the aliment muſt of neceſſity be more crude, than the part therewith nouriſhed. For, that promotion is not by any degradation, or Fixation of the Spirits of the aliment; but by an Exaltation or reduction of them neerer to volatility. Foraſmuch therefore, as the Spirits already in the bloud, are approached or advanced neerer to the ſtate of volatility, than thoſe contained in the parts above mentioned: certainly, the bloud cannot be thought a convenient nouriſhment for them. The redintegration of thoſe parts ought

to be expected from ſuch nutriment, as is more fixed than themſelves are: Otherwiſe how could it ſuffice to the ſolidation or firmation of them? But, the blood is of a more rough and grating nature, and its ſpirits more advanced toward volatility, than thoſe reſiding in the ſolid parts: and in that reſpect is wholly unfit to nouriſh them. Moreover, it is neceſſary, the Nutritive juice ſhould be ſequeſtred from the blood, before it can be opportunely broughtand apponed to the parts: if ſo, to what end was it admixt to the blood at all? ſhall we believe, that Nature (rather than ſeem idle) doth make any thing, only that ſhe may unmake it again afterward?

11. The blood is it ſelf nouriſhed, and doth conſume the ſubſtance of the ſolid parts: and ſo cannot be their nouriſhment.

(10) What is it ſelfe nouriſhed, cannot (without abſurdity) be thought to be the nouriſhment of another: nor can that which is the cauſe of the exhauſtion of the ſolid parts, be the matter of their redintegration. That the blood is it ſelf nouriſhed, is manifeſt from the large acceſs of Chyle to it, after every meal: and that it is the cauſe of the exhauſtion of the ſolid parts, is alſo manifeſt from hence, that the Vital Heat, whoſe *ſubjectum inhæſionis* is the blood, is the only conſumer or depredator of the ſolid ſubſtance of the body. For, whatever be the effects of the Vital Heat, reſiding in the blood, as its proper and original ſubject; the very ſame may be juſtly imputed alſo to the Blood itſelf. For, albeit we ſometimes aſcribe the actions of things to their Qualities, or Faculties; thereby indicating the Formal

Formal Reaſon,or Manner; by which the ſubſtance operateth: yet we cannot deny, but it is the very ſubſtance it ſelf,to which thoſe Qualities are inherent, that really performeth the action. It is the blood it ſelf, therefore, which by reaſon of its inherent Heat, doth unceſſantly prey upon the ſubſtance of the ſolid parts, and cauſeth them to make proviſion for their reparation, even after they have attained to their perfect magnitude. Nor doth it only ſo, but it moreover, in caſe of famine, converts the ſolid ſubſtance of the parts into its own, ſupplying its defects out of their decayes. This is manifeſt,in long abſtinence from meat,when though the habit of the body be extenuated, yet (provided the perſon take water,or ſome other thin liquor, that may be a vehicle of the Humours) do the arteries and veins continue full of bloud. Thus alſo in Fevers, though the ſtomack be ſo weake, as to abhorr all things but ſmall beer,or cooling Juleps; yet doth the blood all that while repair it ſelf, by colliquating the ſubſtance of the ſolid parts, and converting it into its own. For, how otherwiſe could the ſtreams of blood be dayly repleniſhed? And, that they are repleniſhed, is evident from hence,that though the quantity of blood be diminiſhed (proportionately to the ſtrength of the patient) by Phlebotomy, in the beginning of the Fever: yet will it be again, in a day or two after, ſo encreaſed, as to require a ſecond, and perhaps a third diminution; and that, notwithſtanding the ſick perſon hath

received little or no nouriſhment all that while. An undeniable argument, that the bloud, in that defect of ſupplies from the Chyle, doth repair it ſelf out of the ſpoils of the ſolid parts. Now, ſince the bloud doth exhauſt and depredate the ſolid parts; how can it conſiſt with reaſon, that it ſhould be their nouriſhment?

12. The Firſt Matter, of which the parts are made, is not Blood; but a certain liquid juice, very like the white of an Egge.

(11) The Aliment of the parts ought to be in all things like that matter, of which they were at firſt compoſed. For, what is ſuperadded to the parts, as they are augmented, is of ſimilar ſubſtance with that, which was præexiſtent in them, and ſo of neceſſity muſt be conſtituted *ex congenere materia*. Now, the *Materia prima* of all the parts, is not bloud, but a certain liquid juice, perfectly reſembling the White of an Egg, of which the Chicken is formed; only with this difference, that in viviparous Animals that Liquor is more thin, and like the *Colliquamentum* in Eggs, after the Hen hath ſitten upon them ſome days. For even Viviparous Animals conceive a kind of Egg in their wombs, which is involved in a thin membrane, and containeth a certain viſcid humour, very like the White of Eggs, attenuated and melted by the warmth of the Hens incubation. And this Liquor is the very matter of which the Embryo is firſt formed: but very unlike the bloud, in ſubſtance, colour, and all other qualities. As therefore the parts are not made up of bloud, at firſt; ſo are they not augmented or nouriſhed by it afterward.

We

We said, That the bloud is not the *General Nutriment* of all the body; thereby admitting, that it may be the *Particular* nutriment of some parts. For, as to the *Parenchymata Sanguinea*, the parts whose substance is chiefly Sanguineous; forasmuch as they seem to consist mostly of the thicker parts of bloud coagulated in them, and affixt to their vessels and fibers; and that they have no Nervs derived unto them, through which the *Succus Nutritius* might be imported into them: we conceive, that the decay of their sanguineous particles, is dayly repaired by the fresh opposition and affixation of the like particles of the bloud. And in this accompt, we reckon the *Liver*, *Spleen*, *Kidneys*, *Heart*, *Lungs*, and *red parts of the Muscles*. Yet in all these, whatsoever of *Fibers*, *Membranes*, or *Vessels*, is found commixt with their *Parenchyma* or Sanguineous substance; all that is to be excluded from the capacity of being nourished by the bloud. But, as for all the Fibrous, Membranous, and Nervous parts of the body, and all the *Parenchymata Sanguinea*, as the Brain, Spinal Marrow, the Humours of the Eyes, Teeth, Bones, and Glandules; it is most probable (from the reasons alleadged) that they are nourished, not by the bloud, but by some sweeter, softer, and milder liquor, congenerous to the spermatick matter, or *Colliquamentum*, of which they are originally constituted; which is dayly brought and effused or instilled into their substance, out of the Nervs inserted into them. But of this distribution of

13. Nevertheless the blood may be the Nourishment of such parts, whose substance is mostly sanguineous: and what those are.

of the *Succus Nutritius*, by the *Nervs*, we shall have opportunity to discourse more particularly hereafter.

14. The manner, how the *Vital Heat* is conserved; and the *Vital Spirits* continually recruited, *ex sanguine*.

VVell then, of what Use is the bloud? Why truly (according to the latter opinion recited) we conceive it to serve both as the Pabulum, or Fewel of the Vital Flame, and as the Matter of which the Spirits Vital are confected. Concerning the manner, how Flame is maintained by its Fewel; we have already plainly, though succinctly, discoursed. And, as for the Manner *how the Vitall Spirits are continually recruited, ex Sanguine*; we may understand it to be thus. The Spirits, contained in our solid aliment, being at their first admission into the stomach, crude or in the state of *Fixation*; are soon after, partly by admistion of Liquids, and partly by Fermentation, promoted, from the state of *Fixation*, to that of *Fusion*. In this state, the richer or more nutritive parts of the solid aliment, being, by way of Liquation, throughly commixed with the drink; there resulteth a certain milky juice, called the *Chyle*; which is a Liquor abounding with sweet, mild and delicate Spirits. Now these Spirits, so soon as they are brought to the Heart, and there commixt with the Vitall blood; are by little and little exalted to a third state, *viz.* that of *Volatility*; and so become fit subjects to entertain the Vitall Heat, and want only another recourse to the heart, to be therein, as it were by accension, advanced to the heighth and dignity of perfect vitall Spirits. For, the

Vital

Vitall Spirits differ from the Spirits contained in our aliment, no otherwiſe than in the gradual preparations and exaltations now mentioned. We are to advertiſe moreover, that the Heart, in its Syſtole, is not contracted ſo cloſely or ſtreightly, as to expell all the blood contained in its Ventricles, at once: but leaves a good part thereof remaining in them, after the contraction is ended. And that this remaining blood doth heat and kindle the portion of blood next effuſed out of the veins into thoſe ventricles; and by that means exalt it to the condition of Vital blood. We further obſerve, that in the Spirits of the blood, there are ſundry degrees of volatility; ſo that ſome attain to the higheſt degree of volatility much ſooner, than others; and none, untill they have undergone ſeverall Circulations, and as many freſh Accenſions in the Heart. For, in every Circulation they grow more and more ſubtile and agile; and ſo muſt at length be brought to the requiſite height of volatility. To which having once attained, in the very next Circulation (though they are reſtrained and kept in, by the ſides of the heart, and coats of the arteries, while they remain therein) being diffuſed upon the outward parts of the body, as they warm and vivify thoſe parts, ſo do they ſoon flye away, and diſperſe themſelves into air. And while theſe thus flye away, other Spirits leſſe volatile are, by the colder temperament of the parts, by which they paſs, ſomewhat repreſſed: ſo that the force of their expanſive

panſive motion is much abated, the Mication or panting of the bloud interrupted, and the bloud wherein they are, of Arterial, or vital bloud, is made venouſe or Natural; and ſuch it continueth, untill the next circulation bring it again to the heart, there to be kindled afreſh, and exalted to the due heat of vitality. Which once acquired, it recovers its intermitted motion of Mication, or riſing and falling alternately, and yeeldeth a freſh ſupply of ſpirits vital; which being tranſmitted to the habit of the body, are ſoon diſperſed, like the former.

15. The Reaſon of the *Mication*, or panting motion of the Blood, in the arteries.

And thus is the vital Flame kept alive, at no leſſe expence, than a continual diſſipation of the moſt votatile ſpirits of the blood. For, that vital Heat ariſeth from within, and the moſt ſubtile ſpirits are the firſt Movers to the excitement thereof: the motion by which they do it, being their indeavour to expand themſelves, and to dilate their bounds, while the other groſſer elements, or ingredients of the bloud, oppoſe them therein. And this *Strife*, or *Counter-activity* of the ſpirits, on one part, and of the groſſer ingredients of the blood, on the other, doth exhibite the *general Eſſence of Heat*. To which may be added this ſhort obſervation, that in this Contention, one while the ſpirits prevailing, do lift up, or ſwell the maſs of bloud; another while the groſſer elements (the contraction of the Heart and arteries aſſiſting them) prevailing, countermand and interrupt that expanſive motion: and that by this

this alternate conqueſt of theſe Antagoniſts, is made the *Mication* or *Riſing and Falling of* the blood, the one in the Dilatation, the other in the Contraction of the Heart and arteries. Forasmuch, therefore, as the vital Heat doth conſiſt in the rarefactive motion of the ſpirits, and the renitence of the groſſer parts of the bloud; and that the ſpirits, for the moſt part, at leaſt alternately, obtain the victory and dominion over their opponents: it ſeems moſt conſentaneous to truth, that *this vital Heat cannot be preſerved, without a perpetual expence of the moſt pure*, i. e. *the moſt volatile ſpirits of the blood*; and conſequently neceſſary, that during life, *freſh ſpirits muſt be perpetually minted out of the blood*, to defray that vaſt and continual expence. And this we conceive to be the true progreſs of Nature, from the firſt reception of the ſpirits contained in the Aliment, to their eduction into the Chyle, their ſublimation in the heart, their gradual exaltation to the higheſt degree of volatility, and laſtly their diſſipation through the skin into aer: upon which depends the Conſervation of the vital Heat, and the continual Generation of the vital Spirits.

OF THE MOTION OF THE BLOOD; ITS CONDITIONS AND CAVSES.

Exercitation the Sixth.

Of the Motion of the Blood, its Conditions and Cauſes.

1. The Method of the Chapter.

NAture (which in all her works, hath the End, and Means conducing to that End, alwayes cloſely connected in one idea) having ordained the perpetual generation of this vital Nectar, the Blood, in Animals, for the Uſes, in the precedent Chapter recited: that ſhe might not be deficient in the means requiſite to fulfill thoſe Uſes, hath alſo ordained, that the blood ſhould be carried from the Fountain to all the parts, in living ſtreams, by a certain admirable *Motion*, neceſſary to its diſtribution through the whole body. Now, that we may fully underſtand the nature of this Motion, we are to conſider (1) the *Manner*; (2) the *Conditions*; (3) the *Cauſes* of it.

2. That the Motion of the blood is Circular;

Concerning the FIRST; we obſerve, that the blood is continually carried, or rather driven from its fountain, the Heart, in the centre of the body, by the Arteries, to the circumference; and back again from the circumference, to the centre, by the veins, irrigating, cheriſhing, and vivifying all the parts, as it paſſeth along: and that therefore, this Motion was, by the

the glorious Inventer of it, *Dr. Harvey*, called the *Circulation* of the blood; *quòd*,

Ejus enim semper redeat labor actus in orbem.

For, in the first place, the blood is effused out of the vena Cava, into the right ventricle of the Heart; as may be evidently seen in living Animals dissected, especially in Coneys. For, if the trunck of the vena Cava be bound with a ligature, both above and below the heart; you may perceive all the blood contained in the space betwixt the ligatures, to be speedily discharged into the right ventricle of the heart, to which the vena Cava is conjoyned.

3. From the Vena Cava, into the right Ventricle of the heart.

From the right ventricle of the heart, it is (the heart contracting it self) expelled into the vena arteriosa, and so into the Lungs; but not through the septum transversum, or middle partition of the heart, as some have imagined, conceiving the same to have some certain obscure passages from the right into the left ventricle; only because they could, without much violence, thrust a style, or probe through it: when, indeed, those passages are not made by Nature, but by the point of the probe; the flesh of the heart being so tender, as that it is easily penetrated, by any hard and pointed instrument though but gently intruded.

4. From the right Ventricle, by the Vena arteriosa, into the Lungs:

Passing through the vena arteriosa into the very substance of the Lungs; the bloud is immediately returned into the venosa arteria, and through that into the Left ventricle of the Heart.

5. From the Lungs, through the Arteria Venosa, into the left Ventricle:

Heart. This is demonstrable thus. Having made a ligature upon the great branch of the Arteria venosa, neer the pericardium, in the lungs of an Animal yet living; you may observe that branch to be soon filled and much distended with bloud, in that part, which is toward the lungs, and that emptied and flaccid, that is next the heart: and upon remove of the ligature, the bloud will flow amain from the lungs to the left ventricle. Now, there being no other way, by which this bloud can flow to the left ventricle, but from the lungs: it must of necessity descend thence, by the Arteria venosa.

6. From the left ventricle, into the great Artery, and thence into the smaller Arteries.

The left ventricle having thus taken in a quantity of bloud, answerable to its capacity; the heart instantly contracting it self, expelleth the same (at least, good part thereof) into the Great Artery (arising from the left ventricle) thence into the lesser arteries, and so into the substance of the flesh; from whence the bloud is intruded into the capillary veins, by them into the greater veins, from them into the vena Cava, and at length into the right ventricle of the heart, there to begin the same circular progress again.

7. From the smallest Arteries, through the substance of the flesh, into the smallest veins.

We say, from the capillary arteries into *the substance of the Flesh*. For, as to those, who will have the bloud to pass out of the small arteries, into the small veins, *per Anastomoses*, by certain inosculations, or open passages from those into these: we challenge them to demonstrate to the sense, any such way of entercourse

or communication betwixt arteries and veins, in the whole habit of the body; and *Dr. Harvey* did the same before us, when He said, *De Anastomosi venarum & arteriarum, ubi sit, & quomodo sit, & qua de causa, neminem hactenus recte quicquam dixisse, suspicari licet.* And why may not the blood be as wel conceived, to permeate through the pores of the flesh, as water through the pores of the earth, the sweat through the skin, the serum through the parenchyma of the Kidneys, or as the same blood through the thick substance of the Liver. *de mot. cord. & sang. cap. 9.*

8. How the New made blood is circulated with the old.

Nor is only that bloud brought back to the heart, by the vena Cava, which passed through it before; but the stream is augmented by the accesse of fresh Chyle also, imported into the subclavian branches of the same vena Cava, and thence into the right ventricle of the heart. For, this is not only easie to be done, in respect of the vicinity of the ascendent and descendent trunck of the vena cava, to the right ventricle: but also necessary, there being no other way for the new supply of bloud to passe; and that it is done, this experiment doth testifie. The vena cava being bound both above and below the heart; all the bloud contained betwixt the two ligatures, will in a very short space be discharged into the right ventricle.

9. That more blood passeth through the heart, in an hour, than can be supplied from the chyle, in several dayes.

Again, the Heart seems to immit more bloud into the Great Artery, in the space of one hour, than the proportion of Chyle can amount to, in several dayes. For, in most men, the Heart makes more than 3000. pulses, in an hour;

hour; and at every ſyſtole it expells ſome bloud out of its left ventricle into the Aorta; as may be ſenſibly demonſtrated by this, that upon a ligation of the Aorta, neer the heart, and an inciſion made betwixt the ligature and the heart, you may obſerve ſome quantity of blood (more or leſſe) to be ſquirted forth by the inciſion, at every ſyſtole, unleſſe the heart be grown weak and languid; and yet even in that caſe, ſome quantity of bloud will iſſue forth at the hole, once in 3 or 4 pulſes. Nay, when the cone or point of the heart is cut off, and the heart held upright; though the ventricles be not then full, yet will ſome bloud be ſqueezed out of them, every time the heart contracts it ſelf, and that to the diſtance of 3 or 4 feet, as *Dr. Harvey* obſerveth.

2 cap. de. mot. cord. & ſanguin.

10. The Neceſſity of the Circulation inferred from three conſiderations, viz.

As for the *Quantity* of bloud admitted into the ventricles of the heart, when it is dilated, and expelled into the Great Artery, when it is again contracted; it cannot be preciſely determined. For, if in the ſame individual perſon, the motion of the heart, being ſometimes more ſtrong and ſwift, and ſometimes more weak and ſlow, doth make the Circulation of the blood more ſwift, or more ſlow proportionately: certainly in the ſpecies, it muſt be impoſſible to commenſurate the quantity of blood paſſing through the heart, at every pulſe; ſince there is great variety among men, in reſpect of their different temperaments, ages, ſexes, diet, exerciſes, paſſions, and the like, all which vary the pulſe, and conſequently the motion of the blood.

blood. However, that some satisfaction may be given to enquirers herein, we are to consider Three things, *viz.* (1) *How much blood may be contained in the heart of a Man, in its Diastole*; (2) *How much may be expelled out of it, in its Systole*; (3) *and How many Pulses*, or Diastole's and Systoles, *the heart doth commonly, in healthy and temperate men, make in an hour.*

the quantity of blood contained in the heart, in its Diastole;

Concerning the *First*; there are different observations. *Harvey* saith, that in a mans heart dilated, he found more than two ounces of bloud. *Plempius* affirms, that he found almost two ounces. *Riolan* will allow scarce half an ounce, in the left ventricle; but somewhat more in the right. And *Hogeland* comes much lower, admitting only one dragme. But, all men generally grant, that the whole masse of blood contained in the body, doth seldome exceed 24 pounds, or pints, and as seldome come short of 15.

the quantity expelled out of it, in its Systole.

Concerning, the *Second*; we say, that in every systole is expelled either the fourth or fifth or sixth, or at least the eighth part of the bloud received into the heart, at the precedent Diastole. *Harvey* supposeth at least one dragme, and proves that his suppositon from the suddain effusion of all the mass of blood, if but the least artery be cut: and because all the blood may be transmitted through the heart, in the space of half an hour, He thereupon concludes for certain, that much blood is expelled into the great Artery, at every systole. *Conringius* also makes the same compute. *Walæus* and *Sleyelius*

Sleyelius admit half an ounce : but compute only from one ſcruple. *Hogeland* acquieſceth in one dragme. And *Thom. Bartholinus* brings it down to only half a ſcruple. But they all agree, that in the contraction of the heart, the ſides of the ventricles are not drawn ſo cloſe together, as to expell all the bloud contained in them.

The Number of Pulſes, in the ſpace of an hour.

Concerning the *Third*, we remember, that *Primroſe* reckons 700. pulſes in an hour; *Riolan* 2000; *Waleus* and *Regius* 3000. *Cardan* 4000; *Plempius* 4450; *Sleyelius* 4876; *Bartholinus* 4400, or thereabouts; and *Harvey* about 2000; each one numbering the pulſes in his own wriſt.

Now, from theſe three things premiſed we may collect how much bloud may be expelled out of the left ventricle of the heart, into the Aorta, in the ſpace of one hour, according to the ſeveral numerations of pulſes *viz.*

From	℈j 3000	times repeated	℔ 10	℥5		Of blood paſſing thorough the heart into the arteries, in one houre.
	ʒj 4000		℔ 13	℥10 ʒ5	℈j	
	℈j 4450		℔ 15	℥3	℈j	
	℈ß 4400		℔ 7	℥7	ʒ5 ℈j	
	ʒj 2000		℔ 20	℥10		
	ʒij 2000		℔ 41	℥8		
	ʒß 2000		℔ 83	℥4		
	ʒj 2000		℔ 166	℥8		

Again, ſetting it down for a ground, that the quantity of blood contained in the whole body, doth amount only to ℔ 15. (for that is according to the moſt modeſt accompt) and allowing

lowing some part thereof to be consumed by the Lamp of life, and as much to be supplied out of the Chyle: we may inferre these 4 necessary Conclusions.

(1) That more blood is transmitted through the heart, once in every hour, than can be supplied out of the Chyle, in many hours.

(2) That all the blood in the body is transmitted through the heart, once in a quarter, or half, or a whole hour, or in two hours at most.

(3) That so much is not required to the conservation of the vital Flame, and the confection of vital spirits.

(4) That, since the vessells are not broken, that the blood cannot return back out of the heart, nor be any wayes dissipated: it is absolutely necessary, that the blood must return to the heart again by the veins, or be Circulated perpetually, as the immortall *Dr. Harvey* hath demonstrated.

11. That the Circulation is *Universal*, in all the Arteries and veins of the whole body.

Nor is this Circulation of the blood only Particular to some Arteries and Veins (as some have inconsiderately imagined) but *Universal*, or common to them all, throughout the whole body. For though it be, indeed, more demonstrable to the sense in the Limbs, where the vessells being ample and conspicuous, admit of ligatures more conveniently, than those in the Inwards: yet doth observation teach us, that the motion of the blood is the very same in the very *Entralls* also. In particular (that we may deduce it through the most conspicuous Arte-

ries and veins of other interior parts, beſides thoſe already mentioned) the blood is carried in the

- *Abdomen*, to the
  - *Teſticles*, by the ſpermatick Arteries: from them, by the ſpermatick veins, into the left Emulgent and vena Cava.
  - *Inteſtines*, by the Meſenterick Arteries: from them, by the Meſenterick veins, into the *Ramus* Meſentericus, and thence into the vena Portæ.
  - *Spleen*, by the left Celiacal Artery: from it, by the Ramus ſplenicus, into the vena Portæ, and thence directly into the Liver.
  - *Stomack and Omentum*, by other branches of the Celiacal Artery: from them, by the Gaſtrick and Epiploical veins, into the Ramus ſplenicus; thence into the vena Portæ, and ſo to the Liver.
  - *Kidneys*, by the Emulgent Arteries: from them, by the Emulgent veins, into the vena cava.
- *Thorax*, to the
  - Outſide of the Heart, by the Coronary Artery: back again, by the Coronary vein, into the vena Cava.
  - Pleura, by the Intercoſtal Arteries: from it, by the veins thereof, into the vena Azygos, and thence into the vena Cava.

Head,

Head to the *Membranes of the Braine*, by the Carotides and Neck-Arteries (which tend to the four Cells of the brain, but are not therein terminated, as some Anatomists have thought): from them, by the jugular veins, into the ascendent trunck of the *VENA CAVA*.

All which is discoverable to the sense, by binding those vessels, in Animals cut up alive. For, the swelling, caused in either vein or Arterie, by the flux of bloud there arrested, will alwayes appear on that side the ligature, from whence the blood flowes.

12. But, after a peculiar manner in an Infant unborn.

Here we are to advertise, that in the *Fœtus*, or Infant-unborn, the manner of the Circulation of the bloud, through the vessels of the Heart, is different from that we have described. For the blood is not carried from the Mothers womb, into the Umbilical Arteries; but from the *Placenta Uterina* (in which those Arteries are terminated) into the Umbilical vein: which conducteth it along to the Liver of the *Fœtus*, from whence it is transmitted by the Vena Cava into the right Ventricle of the heart. Being brought thither, it is transferred into the Vena Arteriosa: but, because the Lungs are not yet moved, as after the birth, in respiration; and so their vessels are not dilated and contracted alternately, and consequently they can neither receive the blood

out of the Vena Arterioſa, nor impell it into the Arteria Venoſa: therefore hath the providence of Nature contrived and framed Two peculiar paſſages, the one a conduit or pipe, conveying the blood from the Vena Arterioſa, into the Great Arterie; the other a certain foramen, hole, or inlett, by which the bloud paſſeth from the Vena Cava into the Arteria Venoſa, thence into the left Ear of the heart, and ſo down into the left Ventricle. From thence (as well as that from the Vena Arterioſa) it is infuſed into the Great Arterie. So that in an unborn Infant, Nature uſeth the two Ventricles of the heart, as if they were but one: and this, leſt the infant ſhould have his Blood too hot and aduſt, while he wants the ventilation of the air, and expulſion of fuliginous exhalations, through the Lungs. From the Great Arterie, the bloud is ſent into the Umbilical Arteries, which return it to the *Placenta Uterina*; where permeating the ſubſtance thereof, it is again infuſed into the ſmall branches or (rather) roots of the Umbilical vein, by them into the trunk, and at length into the Liver, Vena Cava, and Heart, as before.

13. This Motion of the blood, is

Having thus explained, by what wayes the blood is moved in a round; it follows, that we conſider the *CONDITIONS* of that its motion. Concerning which, we obſerve that the Circulation of the blood is,

Continual;

(1) *Continuall.* For, ſince the Heart is continually in motion, and takes in blood, in its Diaſtole

Diastole, and dischargeth the same again, in its Systole, never intermitting that its proper action, but in great swooning fits, or in the very article of death: it is necessary, that the motion of the bloud be likewise continuall.

(2) *Vehement*; as may be inferred from the hardness and distension of an arterie, or vein bound with a ligature. For, nothing can be distended to great hardness, by a thin and liquid matter, especially upward, unless that matter be with vehemence impelled into, and retained in it. But, this vehemence of the motion is greatest neer the heart, and is afterward diminished by degrees, according to the severall degrees of distance from the heart; so that the extream arteries have but little pulse, unless it happens, that the impellent force of the heart be encreased, as in Fevers, Inflammations, Violent exercise, some passions, *&c.* Which is also the reason, why the veins have no pulse, the impulse of the blood being less in them, than in the smallest arteries. 14. vehement;

(3) *Swift.* For, an artery or vein being compressed by ligature, will swell up and be distended, as it were in a moment; and the blood may be observed to flow in its course very swiftly, so soon as the ligature is removed. But how swiftly, is not easily determined; there being so great variety of Causes, Natural, Non-naturall, and Preternatural, that accelerate or retard the flux of the blood: only thus may be inferred from the precedent compute of the 15. swift;

number

number of Pulſes, and the quantity of blood expelled out of the left ventricle of the heart, in every ſyſtole, That the whole maſs of blood doth paſs through the heart once in an hour or two, at moſt. Yet is not the current of blood neer ſo ſwift in its channels, while they are whole, as when one of them (vein or artery) is cut: becauſe in that caſe, the blood ſtreams forth into the free and eaſily-yielding aer, without any reſiſtance; but being confined in its veſſels, it is forced to diſtend them, and drive on the foregoing current.

16. Of equall velocity in the Arteries and veins.

(4) *As ſwift in the Veines, as in the Arteries.* For, though the impulſe be more vehement in the atteries, as being continued to the heart, than in the veins; and therefore it might ſeem reaſonable, at firſt conſideration, that the motion ſhould be proportionately more ſwift in the arteries: yet, conſidering, that the Arteries are ſtill ſmaller and ſmaller toward their extremities, & that the flux of the blood muſt needs be more and more retarded, as it approacheth thoſe extremities; and on the contrary, that the veins grow wider and wider, from their extremities, to the centre of the body, and ſo the blood hath ſtill larger and larger ſpaces to run through, in its return to the heart; we may ſafely conclude (conjecturally) that the velocity of the motion is as great in the veins, as in the arteries. This is alſo confirmed by ſenſe; for, the Vena Cava, in all that tract from the Liver, to the ſubclavian diviſion, may be obſerved to beat, as often as the

Great

Great Artery; and so must import blood into the right Ventricle, as fast as the *Aorta* doth export it from the left. Which doubtless is the reason, why the Vena Cava hath fleshy Fibres upon it, when it approacheth the heart. Nevertheless, we conceive the motion to be swifter in the Arteries, when the heart contracting it self, doth impell the blood into and through them: than when, dilating it self again, it doth intermit that its impulse. Which is true likewise of the blood in the veins, as may be sometimes observed in *Phlebotomy*, when the ligature is not so streight, as to cause much distension of the vein, in which the incision is made: for, in that case, the blood wil flow forth more swiftly, every time the heart is contracted. And these are the *Conditions* of this admirable motion of the blood.

Lastly, concerning the CAUSE of this motion; it is necessary that the blood be moved either by it self, or by some other principle: and if it be the Author of its own motion, then that must be in respect of either an inherent motive-Faculty, or of its Ebullition, or of its Rarefaction, or of its Quantity, whereby the Ventricles of the heart are distended, and so irritated as to discharge the same, by contracting themselves. If the motion be derived from an External principle; then it must be referred either to Attraction, or to Vection, or to Pulsion. Let us, therefore, see which of all these may be the most likely cause of the Motion of the blood.

First,

17. The blood, not the cause of its owne motion, in respect of any motive *Faculty*, inherent in it.

First, That the bloud is not the cause of its own Motion, *ratione insitæ sibi Facultatis*, by reason of any inherent Faculty; may be inferred from hence, that in bloud effused out of its vessels into the body, or any other receiver, no motion at all can be observed: and it is hard to conceive, that it should be so corrupted in a moment, as wholly to lose a faculty essential to it. *Dr. Harvey*, we confess, affirmeth, that he observed a certain obscure motion of the blood, in the right ear of the Heart (where He supposeth the motion of the Heart first to begin, and last to end) after the Ear had ceased to move; but we refer that to the Mication of the blood from the Vital Spirits not yet wholly extinguished.

18. Nor, in respect of its *Ebullition*.

Secondly, That it is not the Author of its own motion, *ratione Ebullitionis* (which *Arist.* calls ζύμωσις) is manifest from these subsequent reasons. (1) No Ebullition can be constantly equall, or of the same tenour: but the Pulse of the heart, and so the motion of the bloud, is, in temperate and healthy men, for the most part equall. (2) As the Ebullition is greater, so would the pulse; but in burning Fevers, the Ebullition is extream great, by reason of the great intension of the heat; and yet the pulse is frequently small, and weak; as also in the beginning of putrid Fevers, as *Galen* long since remarked. (3) The blood suffers no ebullition, as it passeth through the heart. For, if in the dissection of a living Animal, you make an incision either into the left Ventricle of the heart,

heart, or into the Great Artery neer it ; you shall perceive the blood flowing out at the hole, to be pure and such as before it came into the heart, not frothy, boyling, or rarefied; and to continue such as at its first efflux: yea, more, if you receive the blood issuing from an incision of the *Vena Cava*, in one saucer, and that issuing from the left Ventricle, in another; you shall not be able to discern any difference betwixt the one and the other, either soon, or a good while after. An invincible argument against the Ebullition of the blood, first imagined by *Aristotle*, and since defended by many great men, his sectators. (4) The plunging an arme or legg into cold water, would suppress the Ebullition, and consequently the motion of the blood. For, if you apply a close ligature to a mans arme, and then immerge the same into cold water, or Snow; upon solution of the ligature, he shall find the blood returning to his heart, with so great a sense of cold, as very much to offend him. Which cold arising to the bloud, from its being long detained in the extremities of the arme bound ; *Dr. Harvey* will have to be the cause of swooning immediately after blood-letting, in many men; the heart receiving injury from that acquired cold.

19. Nor of its *Rarefaction.*

Thirdly, Not *ratione Rarefactionis* ; because (1) in living dissections, where the heart yet continueth its motion, no man ever hath, or can observe any such thing as rarefied blood to flow from either the left ventricle, or the

Great Artery, if cut; but pure and such as is from the Ears let down into the ventrices. (2) The Heart it self, when cut in pieces, or wounded, may be observed to beat; yet not from any rarefaction of the blood, for then it hath no blood in either of its Ventricles, or Ears. (3) It hath been observed in Doggs, that after the point of the heart hath been cut off, and the remainder turn'd upside down, though the ventricles could not be halfe full, the blood hath yet been squirted forth at the top, even to the distance of three or four feet; which were impossible, in case the rarefaction of the blood were the cause of its motion. (4) The musculous flesh of the heart, is more firme and strong, than to be subject to inflation and detumescence, meerly from the rarefaction of the blood. It must be a more forceible Agent, that moves that great and weighty machine of the heart. (5) If the blood were so much rarefied in the Ventricles, then certainly ought the orifices of the Vena Arteriosa, and Aorta, to have been much larger, because the blood would have required more room for its egress, than for its ingress. (6) The motion of the heart, and of its valves would be confused; for the Diastole of this, and opening of them, would happen at the same time, and consequently the valves would become useless; both which are repugnant to experience. Besides, the opening and shutting of the valves would be co-incident with the Systole of the Great Artery. (7) That the blood

blood should be rarefied in the heart, and in a moment again refrigerated in the arteries; is contrary both to sense and reason: and if the rarefaction should so soon cease; why is it at all?

21. But of its *Quantity* distending the Ventricles of the heart.

It remains, therefore, that if the blood be the efficient of its own motion, it must be so only *ratione Quantitatis*, by reason of its quantity filling and distending the Ventricles of the heart, and irritating them to discharge it, by contracting or shutting themselves. For, the heart being as it were burdened with the blood distending its cavities, doth contract its Fibers and so its Ventricles, to vindicate it self from that oppression; no otherwise than the stomach, guts, bladder, womb, *&c.* which being extended by meat, chyle, wind, urine, and the infant, drive themselves together, by the help of their Fibers, and so exclude that was burdensome to them. And thus is it probable, that the Heart is continually moved by the blood, like a Mill perpetually agitated by a stream of water; which stream being cut off, the motion instantly ceaseth. This may be credited upon the force of this one experiment; if the *Vena Cava* be intercepted by a ligature, so soon as the heart hath disburdened it self of what blood it hath received from thence, it instantly remitteth its motion; and upon letting in the stream again, by removing the ligature, it as suddenly recovers it. Than which there cannot be a more convincing argument, that the quantity of the blood flow-

ing into the ventricles, is a cause of the motion of the heart, and so of its own motion.

21. Th blood not moved by *Attraction*;

We say, *A Cause*; not the only cause: for we shall soon find another efficient as necessary and immediate, to the motion, as the blood in the respect mentioned.

That nothing doth *Attract* the blood either to or from the heart, is evident from hence; that in Nature there is no such thing, as the motion of a body by attraction; as hath been by solid and irrefutable arguments proved by that heroical wit, and most accomplish't Scholar, *Dr. Ent*; and also by our selves, in the beginning of our discourse of *Occult Qualities*, whither (for expedition sake) we referr the unsatisfied.

Apolog pro circulat. sang. adverſ. Pariſan. a pag. 27. ad 49.

22. Nor by *Vection*;

Nor is it moved, *per modum Vectionis*, by way of Carriage. For, nothing can be imagined to carry along the blood in its course, but the spirits; and those would, in respect of their Levity, carry it only upward: but we see that the blood is moved also downward, and *ad latera*.

23. But by *Impulsion* of the heart, endowed with a Pulsifick Faculty.

It remains, therefore, that the blood is moved in round, *per modum Pulsionis*, by *impulsion*, or *protrusion*: and the Impellent can be no other, but the *Heart* contracting it self, and so expelling the blood contained in its ventricles into the Great Artery, from whence it is urged, or pressed forwards into the smaller arteries, by the succeeding current. We conceive, therefore, that the Heart is endowed with a certain Motive-virtue inhærent and essentiall, called the *Pulsifick Faculty*, which is conjoyned,

conjoyned, as a concomitant cause, with the blood it self, in giving it a due motion: whether it be, that this Faculty doth regulate the influx and efflux of the blood, which would otherwise be irregular; or that of it self it produceth the motion, which cannot be afterward continued, in case the flux of the blood be once interrupted. That this Faculty is necessary, may be inferred from these *Reasons*.

(1) As the Pulse, so the influx of the bloud would be alwayes unequall, unless it were regulated by a Faculty. (2) When the bloud is moved vehemently in Fevers, by the intense heat agitating and urging it; and in men at the point of death, *propter extremos naturæ conatus*, by reason of Natures agony and last efforts: yet is the pulse more weak and low, than at other times, because the Pulsifick Faculty is either much oppress, or much weakned. On the other side, though the Faculty continue strong, yet is the influx of the bloud much diminished, after large hæmorrhages, or upon great obstructions of the capillary arteries and veins, in the habit of the body. Which consideration seems to us sufficient to import the necessity of conjoyning a Pulsifick Faculty, with the quantity of the blood distending and so molesting the Heart, as a *double proxime cause* of the bloods motion.

(3) Though the heart be cut in pieces, yet will each piece have a kind of weak pulsation, as long as it continues warme; which in all probability is to be ascribed to the Faculty implanted

planted in all its Fibres, and not yet utterly destroyed.

(4) It would be derogatory to the majesty of that Prince of all the parts, the Heart, to be moved by the violent impulse of an external principle, and it self conduce nothing thereunto.

Notwithstanding these reasons alleaged, we dare not set up our rest in this doctrine of the Ancients, concerning a Pulsifick Faculty implanted in the heart: only we have recited it, as the most probable Conjecture of all others, touching this abstruse Argument, the proxime Cause of the Motion of the blood. Nor shall we adhere to it longer, than untill we shall be so happy as to meet with a more satisfactory solution of that admirable Phænomenon. In the mean time, Modesty commands us to declare, that we find this Knot to be too hard and intricate for the teeth of our weak understanding. And well may we make this acknowledgment, when the subtle *Fracastorius*, after a long scrutiny into the same subject, was at length forced to desist, with *Motum cordis soli Deo cognitum esse opinor*; and that even *Harvey* himself professeth, that He found it *rem arduam & difficultatibus plenam.* We remember the modest sayings of two great Men, upon the like difficulties; the one of *Galen*, *Quo pacto hæc fiant, si scrutaberis; convinceris te non intelligere neque tuam imbecillitatem, neque Opificis tui potentiam*: the other of *Scaliger*, *Quandam humanæ sapientiæ partem esse, quædam æquo animo nescire velle;*

lib. 15. de usu part. cap. 1. exercit. 307. num. 29.

velle; & veram ſapientiam, nolle nimiùm ſapere. And we think, we need ſay no more, in excuſe of this our profeſſed ignorance.

24. The *Fabrique of the heart, a remote* cauſe of the motion of the blood.

Beſides this Two-fold Proxime Cauſe, there is alſo another *Remote* one, *viz.* the *Peculiar Conformation, or Fabrique, of the Heart and its veſſells.* And among all the parts in this curiouſly framed Machine of the heart, thoſe which are moſt official or inſtrumental to the motion, are the *Fibers* and *fleſhy columnes*; which ſerve not ſo much to the ſtrength of the heart, as to the motion of it. For, in the Syſtole, all the Fibers, both ſmall and great, as well thoſe in the inſide of the ventricles, as thoſe in the Septum, or partition-wall betwixt them (like an artificial network made in the forme of a purſe) being contracted, or drawn together; the blood contained in the ventricles, muſt neceſſarily be expelled or preſſed out of them.

25. The *Motion* of the Heart deſcribed; as conſiſting of *two contrary motions*, and a *Reſpite* betwixt them.

The *Motion of the heart*, which is called the *Pulſe*, as being continual, and made partly by the influx of the bloud, partly by the Pulſifick Faculty reſiding in the heart it ſelf; doth conſiſt of 3 things, the *Syſtole*, the *Diaſtole*, and the *Periſyſtole*: all which are to be explained by their proper Cauſes, according as ocular Inſpection, and Reaſon doth dictate them to the underſtanding.

(1) The *Syſtole*, being the proper and natural motion of the heart, is the Contraction or drawing together of the heart to a narrower compaſs, that ſo the blood contained in the right ventricle may be expelled through the

vena

vena arterioſa into the Lungs; and that contained in the left, may be expelled into the Great Artery, and ſo into all parts of the body.

(2) The *Diaſtole*, being a motion only Accidentary to the heart, is a Dilatation, or opening of the heart, that the blood may flow into the right ventricle, out of the vena Cava; and into the left, out of the Arteria Venoſa.

(3) The *Periſyſtole*, is a certain quiet or ſhort reſpite betwixt the Contraction and Dilatation of the heart, during the ſmall time, that the blood is entering into, or iſſuing out of the ventricles. In healthy men, this pauſe is ſo ſhort, as not to be diſtinguiſhed from either of the two contrary motions: but ſufficiently manifeſt in men at the point of death. It is alſo *double*, there being one reſpite betwixt the Syſtole and Diaſtole; and another betwixt the Diaſtole and Syſtole. And this is the natural ſtate of the Heart.

26. And the *Figure* of it in each.

As to the *Figure*, or *Forme* of the heart in thoſe contrary motions; from the diſſection of Animals alive, from the commodity of its motion and quiet, and from the poſition of its Fibers and other parts, we have learned it to be thus.

In the *Syſtole*, it may be obſerved that (1) the point of the heart is drawn upward toward the Baſis of it, in order to the expulſion of the blood; the length of it being diminiſhed, and bredth proportionately encreaſed: becauſe the baſis is immoveable, in reſpect of the cone,

which

which is fastned neither to, nor by any vessells. (2) The *inner* walls, or sides toward the ribbs, are brought neerer each to other; because they are constringed and made narrower, as may be perceived by putting a finger into either of the ventricles, at the time of their contraction: but the *outward*, becoming tumid, seem to be enlarged in latitude, from the contraction of all parts inflated in the tension or stretching. (3) The fore part of the heart is lifted up towards the sternum, and chiefly neer the base; for, where the pulse is felt, there doth the heart strike the breast with its base, that part being lifted up, and brought neer to the sternon: and at the same time (not in the Diastole) is the heart vigorated, and the arteries dilated and filled, and the pulses are felt both in the breast and wrist, the Diastole of the Arteries being coincident with the Systole of the heart. But the Pulse is more plainly felt in the left side, because there is the origine and orifice of the Aorta. (4) The whole heart becomes tense and hard, and contracted to a smaller bulk; as is manifest both to the sight, and to the touch. (5) The heart appears white, especially in imperfect Animals, such as Serpents, Frogs, Eeles, &c. by reason of the expulsion of the blood in the Systole.

In the *Perisystole*, when the heart is soft, lax, and in its proper state, (1) the cone recedeth from the base; and in some Animals, the base also recedeth from the cone: (2) The lateral parts, both the interior and exterior, are

tended toward the ribbs : (3) The anterior face of the heart ſinks down, and the poſterior is depreſſed, eſpecially neer the orifice of the great Artery.

In the *Diaſtole*, which beginns in the middle of the Dilatation, and ends in the middle of the Contraction. (1) the upper ſide is lifted up and diſtended by the blood falling into the ventricles out of the Vena cava, and Arteria venoſa; the ſwelling ſenſibly beginning at the baſe, and progreſſing to the cone. But the baſe doth not then ſtrike the breaſt, becauſe the Arteries at that inſtant are contracted, and the heart ceaſeth from expulſion of the blood. (2) The heart is flaccid and ſoft, becauſe it is then only paſſive, in receiving the blood. (3) The ſides become extenſe, and the cavities enlarged, and therefore if you put your finger into the heart, during the Diaſtole, you ſhall perceive no conſtriction, as in the Syſtole. (4) The heart appears red, becauſe of the tenuity of its walls, and their repletion with blood. (5) The Cone receding from the baſe, makes the heart longer, that it may be more capable of blood. And thus doth the heart vary its Figure, in each of theſe three poſitions.

OF THE DEPURATION OF THE BLOOD.

Exercitation the Seventh.

Of the Depuration of the BLOOD.

FRom the Circulation of the blood, we (as Nature) advance to the *DEPURATION* or Defecation of it, from its unprofitable or excrementitious parts. And here we are to consider (1) the *Generation*, (2) The severall *sorts* of Excrements generated in and to be separated from the blood, (3) The *parts* in which, and (4) The *Manner how* they are separated.

Concerning the *FIRST*, we observe, that the blood being a heterogeneous liquor, consisting of various Elements or material principles (as the Element of which it is generate) and so not capable to be wholly changed into either the fewel of the Vital Heat; or Vital Spirits: when those parts of it, which had their Spirits less closely and firmely united to their grosser Elements, or (which is the same thing) which were most prone to volatility,

I. The Genealogy of the Excrements.

are consumed and dispersed; it cannot be, but that the remains or reliques thereof must thenceforth become not only useless, but also incommodious to Nature, and therefore as soon as may be, to be rejected. For the sweet and inflammable Spirits of the blood being exhausted; to what use can the remaining mass serve? It can be no longer the subject or residence of the Vitall Heat, for the conservation whereof the blood is principally made: nay, if retained in the body, it would rather damnifie and destroy the same noble principle, the Vital Heat. For, the *Sulphur* contained in the blood, doth by reason of the continuall mication and indeavour of the Spirits to fly away and disperse themselves, and of the decocting activity of the Vitall Heat exercised upon it, become aduſt, and contract a manifest bitterness and acrimony; and the *Caput mortuum*, or Terrene and grosser part, conjoyned with the Fixative Salt, is apt to coagulate and to be petrified; and the *Phlegma*, or insipid and viscid part is apt to obstruct the capillary arteries and veins, and so impede the Circulation; and lastly, the *Aqueous* part, or potulent matter, as being apt to render the bloud too dilute and serous, is wholly unprofitable. These parts, therefore, being no longer usefull ingredients of the bloud, degenerate into Excrements; and ought to be sequestred from it.

This Generation of the Excrements of the bloud, may be appositely adumbrated by the Exam-

Example of Wine distilled. For, as Wine is a Liquor consisting *ex Elementis primiceriis*, of Various choyce ingredients, or dissimilar parts: so is the blood. As the Spirits or more fugitive parts of Wine, are easily separable from the more fixed, *viz.* the Phlegme, Tartar, crass Sulphur, *&c.* by heat: so are the Spirits of the blood easily separated from the more fixed parts of it, *viz.* the Phlegme, Salt Tartar, crass Sulphur aduſt, the Aqueous or potulent matter, by the activity of the Vital Heat. As the Spirits of Wine are, by repeated destillations, advanced to that height of Volatility or subtility, as that some of them flye away and are dispersed into air, in every rectification: so likewise are the Spirits of the blood, by repeated Circulations through the heart, brought to that degree of subtility and volatility, as that they cannot be longer contained or imprisoned in the body of an Animal, but penetrating through the pores, are exhaled by way of dry sweat, or insensible transpiration. And as the residue of the Wine, after the Spirits are gone, remains a dead mass, or vappa, consisting only of a Phlegme, Tartar, and crass Sulphur (which by long heat acquireth a bitterness and acrimony:) so doth the residue of the blood, after its Spirits are exhausted and dispersed. For, (as we said afore) the caseous and grumous parts of the blood, being brought to the state of Fusion, by the Vital Heat, make that excrement called the Phlegma: the Saline and earthly parts consociated, make the Tar-

2. Exemplified in the destillation of wine.

tar,

tar, which being dissolved and kept fluid by the potulent matter (to which it is easily mixed) make the Urine: and the crass sulphur, torrified by the Vital heat, and inseparably floating in the serum, makes the Bile, or Cholerick excrement. And this Diversity of parts in the blood is evident even to the sense, in blood let forth of either vein or artery into a vessell. For, there the caseous or grumous parts (which being most elaborate, and brought to a certain degree of Fusion, have thereby acquired a viscidity) swim on the top, in the forme of a whitish filme or membrane; while other parts of the same kind, having not attained to the like degree of Fusion and viscidity, sinck to the bottome; and the serous or watery (impregnated with the Salt, and somewhat of the crass Sulphur adust) flow round about the rest.

3. The Various sorts of those Excrements: and their Definitions.

Concerning the SECOND, *viz. the various sorts, or Kinds of Excrements* to be separated from the blood, in order to its purification; though what we have now said, concerning their Original, may seem to intimate their several Families and specifical Differences: yet will it not be superfluous to observe further, that all of them, being Liquid, fall under two General Kinds. The *First* comprehends the *More Thin* Excrements, which are (1) the *Urine*, impregnated with the *Tartar*, (2) the *Sweat*, (3) the *Tears*, and (4) the thin *liquor* contained in the *Lymphæducts*: The *Other* includes the *Lesse Thin*, which are 1) the *Phlegme* or p-

tuitous

tuituous Mucus: whether it be *Acid*, ſuch as is found in the ſtomach and guts; or *Inſipid*, ſuch as the Rheum diſtilling from the brain by the palate and noſe, the ſpittle, and ſalivous moyſture excerned from the *Glandulæ ſublinguales*; (2) the *Bile*, both that which is collected in the bladder of the Gall, and that depoſed in the cavities of the Ears, called the *Ear-wax*; for theſe two ſeem to be couſin germans, and differing only in conſiſtence.

The *Urine*, is a ſerous excrement, impregnated with Tartar, and tinged with a ſmall portion of the Bile; brought by the Emulgent arteries, into the Kidneys, together with the blood; there ſeparated from the blood, by a kind of percolation, thence diſtilling by the Ureters into the bladder, and at length avoided by the urinary paſſage.

The *Sweat*, is likewiſe a ſerious excrement, impregnated with a ſmall quantity of Salt, expulſed out of the capillary arteries into the habit of the body, and thence excerned through the inſenſible pores of the skin.

Tears alſo are a ſerous and brackiſh excrement, imported by the arteries into the *Caruncuiæ Lachrymales*, or ſmal Glandules, placed in the interior corners of the Eyes; there ſeparated, by a kind of percolation, from the blood; and thence expreſſed, for the moſt part voluntarily, in griefe, and ſometimes in ſuddain and profuſe joy; and ſometimes involuntarily, in pain, fevers, *&c.*

The *limpid Liquor found in the Lympheducts*

(as

(at leaſt a good part thereof) is a mild and inſipid exhalation of the blood in the arteries, ſweating through the coats of the ſmaller arteries, collected by degrees in the Lymphe-ducts, and by them again infuſed into the blood, as well to prevent the coagulation, as to promote the mication thereof; and after various Circulations, avoided by evaporation through the skin.

Among the Leſs Thin Excrements,

The *Phlegmatick mucus* found in the ſtomach, is a thick viſcid excrementitious juice, endowed with ſome Acidity, brought into the coats of the ſtomach, by thoſe branches of the Celiacal artery, which are therein terminated there ſecerned from the blood, and by tranſudation immitted into the cavity of the ſtomach; to the end, that it may ſerve to excite the Appetite, and in place of a Ferment, promote the diſſolution and concoction of the meat.

The *Pituitous Mucus* found in the Guts, is an inſipid excrement ſpewed out of the Meſenterick arteries, into the ſubſtance of the guts, tranſmitted by inſenſible paſſages into the hollow of them; ſerving to defend them from the injuries of the Chyle and excrements of the belly paſſing through them, and at length to be excluded together with thoſe excrements, by ſtool.

That *diſtilling from the Brain*, is a pituitous excrement, ſevered from the blood brought thither by the Arteries, and excerned either by

by the Palate, or noſtrills. Such alſo are the ſputum, which falls down from the pituitary Glandules ſituate about the baſis of the brain: and the ſaliva, which is generated of humours imported into the Almonds of the Ears, the *Glandulæ ſublinguales*, and other ſpongy parts in the jawes and mouth, and therein ſeparated; for the moyſtning of the mouth, and ſoftning of the ſolid meat, in maſtication.

The *Bile*, or *yellow Choler* found in the bladder of the Gall, is a bitter excrement, generated in the blood, of the craſs ſulphur thereof (diſſolved by the ſerum) made aduſt by the vital heat; ſeparated in the Liver, and thence conveyd by convenient veſſells (which we ſhall particularly mention anon) into the Inteſtines, to be excluded with the excrements of the belly.

Laſtly, the *Ear-wax* is a bilious excrement, thick, yellow, and bitter, in ſmall quantity effuſed out of the capillary arteries neer the Ears, and collected in the *meatus auditorius*.

4. The Reaſon, why each particular Excrement is determinately imported into the part particularly comparated for its ſeparation; is

The Material principles, Generation, Differences, and particular Eſſences of theſe Excrements, being thus explained; it followes that we now diſcuſs the Manner of their ſeparation from the blood, in the parts ſpecified, framed by Nature to that end. Which that we may do with the more ſatisfaction and perſpicuity; it is requiſite, that we premiſe ſome ſhort diſquiſition, as well concerning the Reaſon, why ſuch or ſuch Excrements (all being promiſcuouſly blended together, or flowing

 confuſedly

confuſedly together in the arteries with the blood) are yet carried into ſuch or ſuch parts, rather than into any others: as concerning the various wayes Nature hath contrived, for the ſeparation of Humours each from other, in the body. For, theſe Generals being explicated, anticipate the remove of many of thoſe difficulties and obſcurities, that we ſhall encounter in our ſcrutiny into Particulars.

Concerning the *Former*, therefore, we advertiſe; that the Reaſon, why the Acid Phlegme contained in the blood, is imported rather into the Stomach, than into the guts; the Inſipid Phlegme rather into the Guts, than into the ſtomach; the ſerum into the Kidneys, rather then into the Liver; and the Bile into the Liver, rather than into either the Stomach, Guts, or Kidneys: we ſay, the reaſon of this, is not that each particular Excrement is ſo directed, by any Intelligent Faculty, whoſe office is to diſtinguiſh not only the excrementitious parts of the blood from the benigne and profitable, but alſo the excrementitious one from another, and to diſpenſe each to the part ordained for its ſeparation: nor that each excrement is attracted by and to its like, as if the Phlegme preexiſtent in the ſtomach and guts did, by reaſon of ſimilitude of ſubſtance, draw to it ſelf thoſe Phlegmatique particles of the blood, that hold the neereſt analogy to its own nature; and ſo of the ſerum in the Kidneys, the Bile in the Liver, *Porus bilarius*, and bladder of the Gall, &c.

Not

Not by any *Intelligence*, or *distinguishing Faculty*; because the soul, or Mind (whose Function is only to rationate, or think) is conscious to her self of all her actions; but no mans soul is conscious of any such act, as the distinction of Excrements: And to assigne a distinct Faculty to every distinct operation in the body, is (as that wonder for Wit and Learning, *Dr. Ent*, acutely said) *Deos advocare in theatrum, ut solvant nodum fabulæ.* Not, that it is so directed by any *Intelligence*, or distinguishing faculty.

A course frequently taken, and eagerly pursued by many Philosophers even of the highest forme; but, in truth, so manifestly erroneous, as to refute it self. For, those fruitfull imaginations, that first hatched and introduced the *Faculties Attractive, Retentive, Concoctive*, and *Expulsive*; might, if they pleased, have invented and added as many more to preside over each particular humor and Excrement in the body, and multiplied them even to infinity: the difference of those Actions (and indeed of all others done in Animals) arising really from the different constitutions and structures of the organs, wherein they are performed.

5.

Nor by *Spontaneous Cottion*, *or Attraction Similary*; because in Nature there is no Motion by Attraction, but all from Impulsion; and if there were, yet could not one excrement draw another of the same kind, because *Simile non potest agere in simile, quà simile; non magis certè, quàm in seipsum.* To which we may adde, that though many great men have laboured much to assert this opinion of Attraction *propter* Nor that it is *Attracted* by the like Excrement contained in that part:

ὁμοίωσιν, by reason of similitude or familiarity of substance: yet could none of them make it so much as intelligible; and therefore *Regius* did well to say, *Excrementorum attractio & spontanea coitio, sunt rejiciendæ, quia non sunt manifestæ vel intelligibiles, nec probatæ.*

6. But, that there is a certain peculiar *Conformity of magnitude and figure*, betwixt the minute particles of this or that Excrement, and the pores of this or that part constituted for the reception of it.

To what, then, shall we ascribe this so admirable effect? Why truly, according to the most of probability, to nothing else, but the *Correspondence of Magnitude and Figure betwixt the minute particles of this or that peculiar excrementitious humor to be separated from the blood, on one side; and the small passages leading into, and insensible pores in this or that part, peculiarly constituted for the separation thereof, on the other: together with the help of that particular Fermentation, which each humor doth suffer either neer unto, or in the place of its separation*; to Nature nothing being more frequent, than to make use of a certain *Fermentation*, greater or lesser, where she intends a separation of various humors one from another.

For, since each particular Excrement doth consist of particles of a determinate Magnitude, and determinate Figure; and that each separatory organ in the body hath likewise not only a distinct manner of Conformation of its conspicuous vessells, parenchyma, and other sensible parts; but also its insensible particles, passages, and pores, of a particular magnitude and figure, different from those of all other organs, and accommodated only to that Action or Office, for which the same was made: it is highly

highly reasonable to conceive, by way of inference, that the blood being diffused through the arteries, by the impulse of the heart, indiscriminately and equally to all parts of the body; yet each part doth admit and receive only those parts of the blood, which in respect of the magnitude and figure of their minute particles, are most correspondent or agreeable to the magnitude and figure of its slender passages and pores; and exclude the others, wherein is no such analogy or suitableness. And hence, doubtless, is it, that the serous part of the blood is determinately imported into the Kidneys; the Phlegmatique into the stomach, and guts; the Bilious into the Liver, &c. rather than into any other parts: the capillary branches of the arteries, and the insensible pores of the substance of each of those parts, being in magnitude, figure and situation respectively accommodated or adapted to the receiving and imbibing of the humor brought to it.

7. Which is also the Cause of the *separation* of particulas Excrements, in particular parts.

And for the Separation of each of these Humours thus admitted into these or those parts; we conceive it likewise to belong to the very same Cause, as their Reception or Admission doth; *viz.* to the determinate magnitude and figure of the insensible passages and pores in the Parenchyma of this or that part. Because the separation of each Excrement is effected by a kind of Cribration, or Percolation; and in all percolations, the particles of the matter transmitted, ought both in magnitude and figure, to hold an analogy with the pores of the body,

through

through which they are transmitted. Now, that the Parenchymata of the separatory organs named, are endowed with various secret passages and pores of different magnitudes and figures; is manifest from hence, that their component particles are variously contexed, (in one more loosely, rarely and thinly, in another more closely, densly and thickly) and the vessells and Fibers running through them as variously formed, in magnitude, longitude, position, number &c. and where such variety is, it doth necessitate an equal diversity of pores, which are nothing else but the void spaces betwixt the solid particles. And, that these Excrements may be (to omit, that they are) easily transmitted through such narrow and slender passages and pores, however inconspicuous and undiscernable by the sense; cannot appear difficult, or incredible to any man, who shall but observe, how blood will issue forth of the skin, if it be pricked with the point of even the smallest needle. And thus much of the *Former part* of this *previous Disquisition.*

8. The Differences of *Colatures*, used by Nature in the separation of Humors in the body.

As for the *Other*; though the *Colatures*, which Nature hath instituted, for the separation of Humors in the body, be manifold and various: yet may they all be commodiously reduced to *Two Kinds*, all being in order either to *Nutrition*, or to *Excretion*.

Of the *First* Kind, we have an example in the Nutrition of the Fibers and Membranous parts of the body. For, it is most probable, that those parts (if not all the rest) are nourished

riſhed by the *Succus Nutritius*, brought to them through the Nervs ; and that Aliment, being ſomewhat glutinous, like the white of an Egg, cannot eaſily penetrate into their ſubſtance, without the help of a certain thin and watery vehicle ; which having once done that office of introducing the *ſuccus nutritius* into theſe parts, becometh thenceforth unprofitable to them, and ſo is preſently diſcharged by the *Lympheducts* into more ample ſpaces.

Of the *Other Kind*, there are *Three diſtinct ſorts*. Whereof the *Firſt* is, *when the thicker humor is retained, and the thinner rejected*: of which we have an example in the Kidneys, where the ſerum is tranſmitted into the Ureters and bladder, while the pure blood is retained, to be returned into the vena Cava, by the Emulgent veins. The ſame is alſo effected in the ſeparation of Sweat, Tears, and ſpittle.

The *Second* (contrary to the firſt) is, *when the thinner humor is retained, and the thicker rejected*; as in the coats of the ſtomach and guts, where the Mucous Excrement or Phlegme is tranſmitted into their cavities, and the blood retained to be ſent by the veins into the vena portæ : and in the brain, in which the like Mucus is ſeparated from the blood, and deduced into the palate and noſtrills.

The *Third, when two humors of equal conſiſtence or thickneſſe are ſeparated one from the other*, this being retained, and that rejected. And this Colature is performed in the parenchyma of the Liver. For, the Felleous humor, and the blood,

blood, while warm, are very neer of equall thickneſs : and yet hath nature found out a certain way of percolation, which eaſily diſtinguiſheth and ſeparateth them each from other A thing far tranſcending the induſtry of man, who can make no Artificial Colature, by which two Liquors of equall conſiſtence may be ſeparated one from another.

Theſe Conſiderations premiſed in the General, we now at length come to explicate the *Particular Manner*, how each Excrement is ſeparated, in its peculiar place.

9. The Reaſon and Manner of the ſeparation of the *ſerum* from the blood, in the *Kidneys*.

The blood in its Circulation, being, by the pulſe of the heart, impelled into the Emulgent Arteries, flowes along into the ſeveral branches, or ramifications of them, and at length into the ſmaller ſurcles, or capillary arteries, which running out into ſmaller and ſmaller threads, till they become inconſpicuous, loſe themſelves in various parts of the ſubſtance of the Kidneys, infuſing the blood yet commixt with the ſerum, into the ſame. This Parenchyma or ſubſtance of the Kidneys, conſiſting of various parts diverſly contexed and conformed, and having Pores of different magnitudes and figures, and poſitions running through it, whereof ſome pores are more accommodate in magnitude and figure, to the minute particles of the blood, and others more correſpondent to thoſe of the *Serum* : the blood taketh its way through one ſort of pores, into the capillary branches of the Emulgent veins, that lye open and ready to receive it in all

parts

parts of the parenchyma, and thence to lead it along into the Vena Cava; and the Serum taketh its course through the other sort of pores, into the Papillary Caruncles, which being pervious into the branches of the Ureters (in like manner variously dispersed up and down, so as to receive it from the Caruncles) convey the same into the truncks of the Ureters themselves, from whence it spontaneously destilleth into the Bladder, which by contracting of its self expelleth it in Urine. And this we conceive, to be the true manner of the Percolation of the Serum, made in the substance of the Kidneys.

10. Of the *Phlegmatick* Excrement, in the *stomach* and *guts.*

When the Celiacal and Mesenterick Arteries have, by those their branches, that tend to those parts, brought the blood not yet purified from the *Phlegmatique Excrement*, both Acid and Insipid, into the capillary arteries disseminated upon the coats of the Stomach and Intestines: in which there is a diversity of Pores or insensible passages, some direct, some oblique, in a word, some, in respect of their magnitude, figure and position, peculiarly accommodated to the admission of blood; some to the admission of Acid Phlegme; and others to the admission of Insipid: it comes to pass, that by reason of this Diversity of secret passages, the blood is impelled into the pores most analogous to its minute particles and through them into the capillary veins respondent to the capillary arteries, and thence into the larger veins, which soon discharge it into the Vena

portæ; while the Acid Phlegme is protruded forward into those pores, that are most conformable to its minute particles, and through them at length into the cavity of the stomach; and the Insipid likewise is transmitted through those pores, that are most Symbolical to the magnitude and figure of its minute particles, into the cavity of the Guts, there to defend them a while from the injuries of the Chyle and Excrements, and upon the accession of a new supply of the like insipid Phlegm, to be excluded together with those excrements, as we said before. And this we conceive to be the way of percolation Nature useth, for the separation of the Phlegme from the blood, in the stomach and intestines.

II. That the *Bilious* Excrement doth accompany the Phlegmatique, to the stomach and guts; and why.

Thus long doth the *Bilious* Excrement inseparately accompany the *Phlegmatique*, flowing along together with it through the branches of the *Celiacal* and *Mesenterick* arteries, into the coats of the stomach and guts; but, when it once comes there, it leaves its associate, the Phlegme, to be, after the manner expressed, transmitted into their cavities, and being throughly commixt with the blood, is propelled into the extremities of the capillary veins, answering to the extremities of the capillary arteries, that brought it thither; and from thence is carried along into *Vena portæ*, and at length into the substance of the Liver, therein to be segregated from the blood. Nor, indeed, ought this Bilious Excrement to be sooner

sooner dissociated from the Phlegmatique; or conveyed by any neerer way, or shorter cut, in direct vessels tending from the descendent trunk of the great artery, to the trunk of the *vena portæ*; and that for *three* important *Reasons*.

First, it seems necessary that the Bilious humor should accompany the Phlegme, untill it hath brought the same into the substance of the stomach and guts; because the Phlegme, being a mucous and viscid humor, would be apt to obstruct the capillary vessels, and insensible pores of those parts, unless it were made more dilute and penetrative, by the admixture of the Bile, an humor penetrative and detergent, and so fit to prevent obstructions. This reason may receive verification from hence, that Men of a hot and cholerick constitution, and such in whom this Bilious Excrement doth abound more than in others, are seldom or never troubled with obstructions of the stomach and guts, by gross and viscid humors: whereas, on the contrary, these of colder complexions (especially Virgins *Leuco-Phlegmatique* and afflicted with the Green-sickness) in whom less of choler is generated, are commonly oppressed with oppilations of those parts, from abundance of tough and tenacious phlegme.

Secondly, the Bilious humor it self seems to require some certain degree of *preparation*, conductive to its future separation, before it can be commodiously imported into the Li-

ver. For, ſhould it be convey'd into the Liver, directly out of the deſcendent trunk of the great artery; it could not be avoided, but ſome part of the Phlegme would alſo be carried along with it : becauſe thoſe humors, while they remain in the arteries, are never actually ſeparated; and when they are, their ſeparation is made , by the receſs or going off of the Phlegme into the ſtomach and guts. And if any part of the Phlegme ſhould accompany the blood into the Liver ; the Liver would alwayes be inevitably obnoxious to great obſtructions, ſuch as would ſoon render it unfit for the office, by Nature aſſigned unto it.

Thirdly, the Bile certainly is more firmely united to the blood, than the Phlegme; as being eſſentially radicated in the ſerous part thereof, ſo that without ſome further preparation, it cannot be eaſily ſevered from it. And therefore it was requiſite, that the Bile ſhould be carried about by thoſe ambages of the ſtomach and gutts, that by paſſing through thoſe intricate meanders, it might acquire ſome diſpoſition preparatory to its ſucceeding ſeparation. Now, that which gives it this previous diſpoſition, is a peculiar Fermentation, which it undergoes in the veſſels leading it along into the trunck of the Vena portæ : it being moſt undeniable, that the ſpeedieſt means in Nature, for the ſeparation of impure humors from pure, is by Fermentation, as may be ſenſibly exemplified in Wine and Beer, which

are

are soon defecated by the help of Fermentation, but never without it. These Reasons, therefore, make it evident, that Nature was guilty of no oversight or rashness, when she ordained, that the Bilious Humor should be thus carried about through such indirect and long wayes, before it arrive at the Liver; seeing that circulation doth make its separation afterward both the more safe, and more easie.

12. Why the Blood is not carried immediately out of the trunck of the *vena portæ*, into that of the *vena cava*; but through the various meanders in the Liver.

Nor did Nature play the wanton, or supererogate, when she contrived, that the blood should be carried along through all those intricate labyrinths in the Liver; forasmuch as if the blood were to be infused into the trunck of the vena cava, by some vessell immediately and directly tending from the trunck of the vena portæ, the Bilious humor, being not yet separated from it, would necessarily pollute and corrupt the whole mass of blood. To avoid that inconvenience, therefore, was it requisite, that the blood should be first diverted into the Liver, and therein defecated from its remaining impurities, before it be permitted to enter the vena cava.

13. And why it is transmitted through the *Parenchyma* of the Liver.

When it is brought into the Liver, it doth not pass through the capillary branches of the vena portæ, into the extremities of the capillary branches of the Vena cava, immediately or *per Anastomoses*, as was long believed and taught by Anatomists; because we have the testimony of our eyes, that there are no such *Anastomoses*, or mutual Inosculations betwixt the extremities of those vessells: but, it is first

percolated,

percolated through the Parenchyma or very ſubſtance of the Liver. Now, to what end is it ſo percolated? That percolation muſt certainly be in order either to ſome *Alteration*, or to ſome *Separation*. It cannot be in order to any *Alteration*, becauſe no ſuch thing can be imagined to be effected in the Liver, ſince the Liquor paſſing through the Liver, as it came-in blood, ſo doth it go out blood. It muſt, therefore, conduce to the *ſeparation* of ſomething from the blood. And that ſomething can be nothing but the *Bilious Excrement*; becauſe all other Excrements are ſeparated, before the blood arrive at the confines of the Liver: and becauſe no other Excrement can be found therein. Which conſideration is alone ſufficient to evince, that *the Office of the whole Liver, is to receive the blood out of the vena portæ, to purge it from the Bilious Excrement, and to diſcharge it ſo purified into the vena cava, thence to be conveyed into the Heart.*

As for the *Manner* how this excellent work of Purification is performed in the Liver; for the better underſtanding the ſame, we are to obſerve.

14. That the *Parenchyma* is the *Principal* part of all the Liver.

(1) That the *Parenchyma is the Principal part among all thoſe many, that make up that ample and curiouſly contrived organ of the Liver.* In particular, the *Ligaments* of the Liver ſerve only to eſtabliſh, or hold it firme in its natural poſition; the *Coat* inveſteth it; the *vena Portæ* brings the blood into it; the *Capſula Communis* is inſervient to the diſtribution of the ſame blood,

through

through the branches of the vena Portæ; the *Hepatick Artery* and *Nerve* serve partly to the better promotion of the blood into all parts of the parenchyma, and partly to the more quick and easie influx of the Bilis into the Porus Bilarius; the branches of the *Vena Cava* export the blood, after its purification; and those of the *Porus Bilarius* export the Bile, after its separation: so that it is manifest, that all these several parts are in some sort or other, mechanically inservient to the *Parenchyma*; and that the *Parenchyma is the sole part, wherein the separation of the Bile from the blood is made by an admirable artifice of percolation.*

15. And a kind of *Streiner*;

(2) That this *Parenchyma* is a kind of *Streiner*, after a peculiar manner framed by Nature, for that separation, which can be no otherwayes effected, but by Percolation. For, whensoever a mixt Liquor is brought into a part, and in passing through that part severed into two distinct kinds, and so by distinct wayes effused out of it again; we may be certain, that those Liquors were severed each from other by percolation made in that part; and as certain that that part is a Percolatory Instrument. And since the very same is effected in the Parenchyma of the Liver, while the Bile is severed from the blood; we may well conclude, that that separation is made by percolation, and that the Parenchyma is a kind of *Streiner*.

16. Whose particles are contexed,

(3) That this *Parenchyma* being a lax and spongy substance, after a peculiar manner contexed,

texed after a peculiar manner, and pores of divers sorts: in respect whereof, the Bile is therein separated from the blood, *mechanically.*

texed, and having various sorts of *pores*, whereof some are in magnitude, figure and situation, particularly comparated for the reception of the impure blood, effused out of the extremities of the capillary branches of the *vena portæ*; and others in like manner particularly comparated for the reception of the minute particles of the Bilious Excrement, and the transmission of them into the extremities of the capillary branches of the *Porus Bilarius*; and others again particularly comparated for the reception of the minute particles of the pure blood, and the transmission of them into the extremities of the capillary branches of the *vena cava:* we say, these things being so, it is reasonable to conceive, that after the impure blood is brought into the pores of the *First* sort, the particles of the Bile are impelled into those of the *Second*, and through them into the extremities of the capillary branches of the *Porus Bilarius*; and the particles of the pure blood into those of the *Third*, and through them into the extremities of the capillary branches of the *vena Cava*; so as the separation of the Bile from the blood, is made in the parenchyma of the Liver, only by reason of this *diversity of its pores.*

17. The same inferred from 4 considerables: *viz.*

To encrease the verisimilitude of this Opinion, there occur 4. things not unworthy a serious remark, in this place; *viz.*

The equall distribution of the capillary branches of all the vessells in the Liver.

(1) That the Capillary branches of each sort of the vessells mentioned, are distributed equally into all parts of the Parenchyma; so

that

that the Port-vein doth dispense the blood equally into all parts thereof; and the capillary branches of the *Porus Bilarius*, being likewise disseminated through all parts of the same, lye ready to admit the Bilious humor, as fast as it is separated from the blood; and the capillary branches of the *vena cava*, being also dispersed into all parts of the same, are ready to receive the pure blood, as fast as it is defecated from the Bile. Which is some document, that this whole work of purifying the blood from the Bilious humor, is performed in the Liver, only *Mechanically*, and that with the greatest facility imaginable: nor is it possible for the greatest wit of man, to imagine any fabrique more commodious for the effecting thereof, than this of the Liver is.

The Pulsation of the Vena Portæ within the Liver.

(2) That the *Vena portæ*, being entred into the body of the Liver, doth acquire a certain *Pulsation* (though weak and less perfect than that of an Artery) by the benefit partly of the *Capsula communis*, that includeth it, and partly of the *Arteria Hepatica*, that accompanieth it. For, being included in the same common case with the *Arteria Hepatica*, it must necessarily be compressed, in some measure, by the systole thereof; and again be relaxed, in the diastole: and by that means suffer a certain Dilatation and Compression alternately. And being so compressed, it must impell the blood into the parenchyma; and that blood must be driven on by the next succeeding blood: so as that the motion and distribution thereof is necessarily

continued by that impulſe, without the neceſſity of any either *Similary Attraction*, or *Diſtinguiſhing Faculty*.

The aſſiſtance of that Pulſation, by the Hepatick Nerve.

(3) That the *Hepatick Nerve* may be conceived alſo to conduce ſomewhat to that Pulſation of the *Vena Portæ*. For, that Nerve alſo is included in the *Capſella Communis*, and no leſs diſtributed upon the ſame, than upon the branches of the *Porus Bilarius*. And, therefore, when the *Arteria Hepatica* is dilated, this Nerve, as being contiguous to it, muſt be ſomewhat compreſſed; and ſo irritated to make ſome ſmall Contraction of it ſelf: which being impoſſible to be effected, without a proportionate conſtriction of the *Capſula Communis*; it comes to paſs, that the *Vena Portæ* included in the ſame *Capſula*, ſuffereth a conſtriction, at the ſame time.

The Reſuſcitation of *Vitality* in the blood, in the branches of the *Vena Portæ*, within the Liver; and a new *Fermentation* thereof, prævious to the ſeparation of the Bile.

(4) It is probable, that this Pulſatile motion of the *Vena Portæ* within the Liver, doth cauſe ſome new *Fermentation* of the blood, and redintegrate the decayed *Vitality* thereof, in ſuch a proportion, as may be ſufficient to vivify the *Parenchyma* of the Liver, and conduce to the more eaſie and ſpeedy ſeparation of the Bilious impurities therein: eſpecially conſidering that the Spirits of the blood brought in, are hindered from flying away (as they uſually do through the thinner coats of the veins) by the thickneſs of the *Capſula Communis*, and ſo kept together to reſuſcitate the Mication and renew the Vitality thereof. That this is ſo, may be in part inferred from hence, that the

Vital

Vital Spirits can be no otherwise communicated to this Parenchyma; the *Arteria Hepatica* being wholly distributed upon the *Capsula Communis*, and the branches of the *Porus Bilarius*, but never touching the Parenchyma with so much as one small furcle. Now there being no vessel that brings blood into the Parenchyma, but only the *Vena Portæ*; that Parenchyma must of necessity be deprived of all Vitality, unless we allow the blood, brought by the *Porta*, to recover its vital disposition, by the means of the Pulsation caused in the *Porta*, and the excitement of a new Fermentation from the restraint of the Spirits. For, without the influx of vitall blood, no part can be vivified: and certain it is, the Parenchyma doth receive no blood, but only from the *Vena Portæ*. This Resuscitation of the Vitall Spirits in the blood, brought into the Liver, may be adumbrated by the example of the heart of a Viper, or other Animal of like vivacity. For, the Heart being cut out of the Viper yet alive, and placed upon a table, doth a good while retain its pulsation; and as that motion begins to decay, by reason of the consumption of the Vitall Heat, if you but drop some warm liquor upon the then languishing heart, it will instantly revive, and beat again, untill it grows cold. And such doubtless is this small spark of life reenkindled in the blood contained in the *Vena Portæ*, within the Liver: which though but small, may yet be sufficient both to enliven the Parenchyma, and to excite some gentle Fer-

mentation in the blood, conducible to its purification in that place.

Now, to bring all this into a narrower circle; if we reflect upon the Equall Dissemination of all the foresaid vessels through all parts of the Parenchyma; upon the Pulsation of the Vena Portæ, within the limits of the Liver, whereby the motion of the blood is made more strong and quick; upon the promotion of that pulsation, by the Hepatick Nerv spontaneously contracting it self, after every diastole of the Hepatick Artery; and lastly upon the resuscitation of Vitality in the blood, and its renewed Fermentation (which always precedeth the separation of any humor from the blood): we say, reflecting upon these things, we may plainly understand, with how little of difficulty the bloud is impelled into all parts of the Parenchyma, and therein separated from the Bilious impurities, only by reason of the Diversity of Pores in the same Parenchyma, according to a *MECHANICAL* way or method. Which was the difficulty that required to be removed.

18. The various Manners of the *Excretion* of Excrements, after they are separated and collected.

When Excrements are separated, they must be Excluded; and therefore, having investigated the manner of their separation from the bloud, it is requisite that we say somwhat of the Manner of their *Excretion*. For albeit there be no Excretion, but what is effected immediately by *Pulsion*; yet doth that Pulsion arise from *various causes*. In particular, *One* sort of Excretion is made by *simple Propulsion*;

pulsion; as that of the Serum through the substance of the Kidneys, that of the Bile into the bladder of Gall, and into the *Porus Bilarius*, and of the Phlegma into the Guts. *Another* is, from the *Rarefaction of the Excrements themselves*; as when the Serum, flowing together with the blood in the arteries, is rarefied by heat, and breaks forth into the habit of the body, whence at length it is excluded in sweat through the pores of the skin; and when the watery part of the blood is by way of Exhalation transmitted through the coats of the smaller arteries, and collected in the Lymphe-ducts. And a third sort of Excretion is made, meerly by the *Spontaneous Contraction of the Parts Expelling*; such is that of the Bile out of the bladder of Gall, into the *ductus communis*; of vitious humors out of the stomach, by vomiting; and of the Urine out of the bladder, *&c.* So that we see, there is as little need of any *Attraction*, toward the Excretion of Excrements, as there was toward their separation from the blood.

19. The particular Manner of the Excretion of the *Bile*.

To Explicate the Manner of the *Excretion* of the *Bile* somewhat more particularly; we note, that the *Porus Bilarius* is filled with that humor, by its capillary branches disseminated into the greatest part of the Parenchyma of the Liver: and the *Vesicula Fellis*, by its Fibrous roots, that are likewise disseminated into the rest of the parenchyma. And when these two *Receptacles* are thus filled with this humor, even to distention; then, being irritated or molested

leſted by that burden, they contract themſelves, and ſo ſqueez out ſo much thereof, as exceeded their natural capacity: the *Veſicula Fellis* exonerating it ſelf by the *Meatus Cyſticus*, and the *Bilarius Porus* by the *Ductus communis*, out of which the excrement is convaid, by the oblique inſertion, into the Guts. Which *Irritation* and *contraction* of theſe Receptacles, is the cauſe, why the Bile doth not continually and by drops deſtill out of the *Ductus communis* into the Guts, as the ſerum doth into the Ureters: but is as it were eructated *by intervalls*, and in *good quantity at a time*; thoſe concave and membranous parts never contracting themſelves, but only when they are above meaſure diſtended by a redundancy of the humor contained in them; and the efflux of the humor depending wholly upon that their Contraction.

20. And the Cauſe thereof,

That theſe parts do thus *Contract* themſelves, is inferrible from hence, that all ſenſitive parts (among which the *veſicula Fellis* may be accounted, in reſpect it enjoyeth a ſmall Nerve derived from the ſixth conjugation) are capable of *Irritation*: and therefore, whenever they are diſtended beyond their natural rate, or otherwayes moleſted; they begin inſtantly to make ſome reſiſtance, and reduce themſelves to their due laxity, by ex-preſſing what was offenſive to them; and if the parts thus irritated, be concave, membranous, and fibrous, it is neceſſary, that their reſiſtance be made by a Contraction of all their Fibers, whereby their cavi-

ty

ty is leſſened, and ſome part at leaſt of the humor diſtending them, is expelled. The Receptacles of the Bile, therefore, being ſuch parts; they muſt have ſuch a motion of *ſelf-Reſtitution*, upon the like occaſion.

Digreſſion.

Here (me-thinks) I perceive my Reader to put on the cloudy aſpect of diſſatisfaction, and to arreſt me with this *curious* ſcruple, ſaying; *Doth not this Irritation and ſpontaneous Contraction of Membranous and Nervous parts, when they are moleſted, imply a certain ſenſe in them, diſtinct from the ſenſe of Feeling or Touching, and independent upon the Common ſenſe, or Brain?* For, whatever is any wayes moved by it ſelf, in avoydance or reſiſtance of what is offenſive to it; muſt be endowed with a ſenſe, whereby to diſcern that offenſiveneſs: according to that rule, *Quicquid contra irritamenta & moleſtias, motibus ſuis diverſis nititur; id ſenſu præditum ſit, neceſſe eſt.* But we are not conſcious to our-ſelves of any ſuch ſenſe within us (as we are of all our Animal ſenſes) whereby thoſe parts are made ſenſible of their irritations; and therefore it ſeems, you have imagined one ſenſe more than Nature hath made.

21. *PARADOX.* That we have a certain *Natural* Feeling wholly diſtinct from the *Animal*, and independent upon the Brain.

For the ſolution of this Difficulty, therefore, we *Anſwer*; that thoſe Motions and Actions, which Phyſicians call *Natural* (becauſe they are not inſtituted by the Will; but done even againſt it, and cannot be moderated, accelera-

ted

ted, retarded, or ſuppreſſed, *ex Arbitrio noſtro*, at our pleaſure: and ſo have no dependence upon the Brain, that is the Common inſtrument of all the ſenſes) theſe motions and actions, we ſay, are not yet made without ſome *ſenſe*, naturally inhærent in the parts moved. For inſtance; we are certain, that in palpitations, tremblings, ſyncopes, ſwooning fits, and other Cardiacal ſymptoms or affections, the *Heart* doth variouſly move, and agitate it ſelf; as being offended with ſomething preternatural and noxious to it, and irritated to reſiſt and repell the ſame: and this in reſpect only of ſome ſenſe or feeling, by which it diſcerneth what is incommodious and harmfull. The *ſtomach* and *Guts*, in like manner, being oppreſſed and provoked by vicious humors, inſtantly riſe in armes, and raiſe impetuous vomitings, nauſeouſneſs, convulſions, fluxes of the belly, and the like motions, for the expulſion of their enemies: and as we have it not in our power, to excite or ſuppreſs thoſe commotions; ſo have we no particular cogniſance of any ſuch ſenſe, which ſhould extimulate thoſe parts to begin and continue them. Truly, we cannot but wonder, as oft as we obſerve the effects of Antimony infuſed in wine, and taken into the ſtomach. It is not our Taſt, that doth diſtinguiſh the tincture of the Antimony, from the wine; nor are we ſenſible of any diſagreeableneſs therein to our nature, while we are ſwallowing it down: and yet in the ſtomack there is a certain ſenſe, that diſcerns the offenſive-

neſs

neſſe of that draught, and quickly engageth the ſtomach to raiſe and contract it ſelf, and to eject it again by vomiting; nor will it ever ceaſe, till it be wholly diſcharged. Conſider, how even the *Fleſh* it ſelf doth preſently diſtinguiſh a poyſonous puncture, from a ſimple one; and how ſoon it contracteth, condenſeth and fortifieth it ſelfe, to expell the venome, whereupon enſue ſwelling, inflammation, and great pain in the part pricked, as is obſerved in the ſtinging of Bees, and Hornets, and Scorpions, and the biting of Spiders, Vipers, and other venenate Animals; and all this meerly from ſome ſenſe, which teacheth the fleſh that difference, and excites it to make reſiſtence. Conſider further, how the Contorſion, Falling downe, Aſcent, ſuffocation and other violent Agitations of the *Womb* in women; proceed not from the brain, or Common ſenſe, but from a *Natural ſenſe* inhærent in that part, without which it could not be provoked to thoſe impetuous ſtrivings and motions. For, whatever is wholly deſtitute of ſenſe, is wholly uncapable alſo of being irritated to performe any action or motion, in order to its ſafety. Nor can we, indeed, otherwiſe diſcern what is Animate and ſentient, from what is Inanimate and void of ſenſe; but only by ſome *Motion* excited in it, by ſomething moleſting and irritating it: which Motion doth continually both follow and argue ſenſe.

To evince this *Natural* ſenſe yet further, we

ſhall thus reaſon. We find in our ſelves, that we have Five External Senſes, by which we perceive objects without us; but, becauſe we do not perceive our perception, by the ſame ſenſe, by which we perceive objects (for, we ſee with our eyes, but do not by them perceive that we ſee; but by the mediation of another internal ſenſe, or ſenſitive organ, the Brain, by which we judge of all objects offered to the External ſenſes): therefore is it manifeſt, that the common ſenſory is the Brain, which together with all its Nerves, and external organs annexed to thoſe nerves, ought to be held the adequate Inſtrument of ſenſation. And we may fitly reſemble it to a ſenſitive Root, which ſhooteth forth many Fibers or ſtrings, whereof one doth ſee, another hear, a third taſt, a fourth ſmell and the fifth feel.

Nevertheleſs, As Experience aſſureth us, that there are ſome Motions and Actions in us, whoſe regiment or moderation is no ways dependent upon the Brain; and therefore, by contradiſtinction to voluntary or Animal motions and actions, they are named *Natural*: So alſo doth Reaſon teach us, that we have a certain ſenſe of *Feeling*, which is not referrible to the Common ſenſe, nor communicated to the Brain, and of which we take no cogniſance, but by the various effects and commotions that it cauſeth in our bodyes. For, in this Senſe, we do not perceive that we feel; but as it fares with men diſtracted, or otherwiſe agitated with any violent paſſion of the Mind,

who

who neither feel pain, nor take notice of objects offered to their senses: so is it with us in this Sense, which operating without our knowledge, is therefore to be distinguished from the Animal sense, and may be properly enough called a *Sensation without Sense*. And certainly such as this, is that sense observed in *Zoophytes* or Plant-Animals; as the sensitive Plant, the Boramets or Vegetable Lamb of Tartary, Sponges, *&c.*

We know, there are many Animals, that have both sense and motion; and yet have no brain, or Common sense, as Earthworms, Caterpillers, Silkworms, *&c*: and that there are some Natural Actions in us, which are performed without the influence or help of the brain. As Physitians, therefore, teach us to distinguish such actions Natural, from actions Animal: why may not we, with equall reason, distinguish the *Feeling Natural*, from the *Feeling Animal*; so as to refer one to the brain the other not.

We know moreover, that it is one thing for a *Muscle* to be moved or contracted *Spontaneously* (as in Convulsion); and another, for it to be moved *Voluntarily*, or with various regulated contractions and relaxations, in order to the performance of some action intended, as Progression, or Apprehension. The Muscles, certainly, or Motory-Organs, are, in cramps and convulsions, moved spontaneously, upon their irritation by some acrimonious vapours, or other injurious cause; no otherwise than

the body of a Fowl is moved, after the head is cut off. For as the body is tumbled up and down, and agitated by various convulsive motions of the feet and wings, yet such as are wholly confused and irregular, and of no effect either to progression or to apprehension, because the power and influence of the brain is extinguished; by the government and moderation whereof, those motions were formerly regulated either to progression, or flying: so in Convulsions, our Muscles are contracted, and our members variously agitated with irregular and ineffectuall motions; because those motions depend upon a natural sense only, without the regulating influence of the Brain, which taketh no cognizance of the injuries done to the Muscles, nor of the sense which irritateth them.

These things duly considered, Reason adviseth us, henceforth to lay aside that opinion of *DesCartes*, and his disciple, *Regius*, (both great Philosophers, and in many other things worthy to be followed) that the influx *of Animal Spirits by the nerves, is necessary to the performance of all Naturall Motions and actions done in the body:* and to take up this more probable one of *Dr. Harvey*, that *each Natural action is effected by the part doing it, meerly in respect of a certain sense, whereby it feeleth what is troublesome and injurious to it selfe, and so is irritated to excite such motions of it self, as may conduce to its vindication; and this, without any influx or regiment of the Brain, or Common sense, at all.*

We

We might have added further, out of the same *Dr. HARVEY* that all Motions in the body, are derivative from the *Vitall Influence of the Heart*, and wholly dependent thereupon; because, no part is longer capable of this Natural sense, than while it is irradiated and enlivened by the Vitall Spirits or blood flowing from the heart; for no part once mortified, *i.e.* no longer participant of the Vitall influence, can have any sense, or be irritated to motion. Besides, it is not unreasonable to conceive, that the strength or *Tone* of each part doth mostly consist in its enjoying a due proportion of Vitality: and if that Tone or firmeness be vitiated or diminished (as soon it must, if deprived of that requisite influx), that part becomes languid, dull, and hardly capable of irritation But this noble speculation requires to be handled with more exactness, than the narrow limits of a short Digression will admit of: and we have already said more than enough to assert, that all parts of the body have a certain Naturall sense of Feeling, distinct from the Animal, and wholly independent upon the Brain; which was the Probleme proposed. ¶.

OF

OF RESPIRATION.

Exercitation the Eighth.

Of Respiration.

Article 1. THE Chain of Nature, by which she connecteth various Operations conspiring to one and the same End, brings us in the next place to discourse of *RESPIRATION*; betwixt which and the *Pulsation* is a manifest affinity. For, these two Actions or Motions, as they are inservient to the conservation of the Lamp of Life, and the Generation of Vital Spirits; so do they both consist of a Dilatation and Contraction; the one of a Diastole and Systole of the Heart and Arteries, the other of a Diastole and Systole of the Breast and Lungs.

The Connexion of this Exercitation, to the precedent.

Now this *Affinity*, hath given occasion to many Physicians to conceive the Diastole and Systole of the Lungs, to be Synchronical or coincident with the Diastole and Systole of the Heart; and to refer both their motions to the same cause and Original. But, They have grosly erred, in confounding things so manifestly different. For

2. The Disparity

(1) There are many sorts of Animals, that have

have Hearts, but no Lungs. (2) The Dilatations and Contractions of the Heart, are clearly distinct from those of the Breast and Lungs; as is evident from hence, that they are not synchronical, *i. e.* made and terminated in the same periods and times; one complete Respiration taking up more time, then 4 or 5 Pulses: and this in all Animals that have both Heart and Lungs.

betwixt *Respiration*, and *Pulsation*; both as to their *Times* or periods, and as to their *Uses*.

(3) The Motion of the Heart and Arteries is much different from that of the Lungs, as to their Uses.

For, *First*, if the Pulse and Respiration have one and the same Final cause, and that (as these men have assumed) the Arteries take in the ambient aer through the skin, at every Diastole; and exclude it again the same way, together with the Fuliginous Exhalations of the blood, in every systole; and that in the space of time intermediate betwixt each Diastole and Systole, they contain both the inspired aer, and exhalations: then must we renounce both the doctrine of our Master *Galen*, that in the arteries nothing is contained, but the blood; and our owne experience, that confirms it.

Secondly, if the Arteries were (as the Lungs are) filled with aer drawn in by their extremities, and that the quantity of aer attracted, were proportionate to the magnitude of each pulse, or to the greater or lesser dilatation of the arteries: then, if, while the pulse is great, the whole body were immerged into a bath of water or oyle, it would necessarily follow, that the

the Pulse would become much smaller, or much slower; because it is highly difficult, if not wholly impossible, that the ambient aer should pass through the bath, into the pores of the skin, and so into the arteries.

Thirdly, since all the Arteries, as well those that lye deep in the body, as those terminated in the skin, are moved with equal velocity, and at the same time; it is not possible, the ambient aer should as freely and swiftly pass through the habit of the body, into the profoundest arteries, as into those contiguous to the skin.

Fourthly, it is not credible, that Whales, Dolphins, and other Cetaceous Animals, that have Respiration, can draw aer into their arteries, at every diastole, through so vast a mass of waters, as is from the bottom to the top of the sea.

Fifthly, if in their systole, the Arteries expell the fuliginous exhalations of the blood, through the pores of the skin; why should they not expell also the vital spirits, that are far more subtile and fugitive, than those supposed Exhalations can be? Nature certainly hath made no such Colatory, as should retain the thinner spirits, and let the grosser fumes pass through. Nor is it yet sufficiently proved, that there are any such Fuliginous Exhalations generated in the heart and arteries, and afterward excluded partly by the Lungs, partly by the Arteries, in their Contractions; as are vulgarly believed. For, the blood suffereth

only

only a simple agitation, or conquassation in the ventricles of the heart, and a propulsion in the arteries: and that it can produce such an abundance of sooty fumes from the blood, as Physicians have talked of; is not easie to conceive. Truth is, the blood, by reason of its heat and swift motion, doth emit some Halitus, or vapours (which streaming through the coats of the smaller arteries, are received and condensed into a thin limpid liquor by the Lymphe-ducts) but is it therefore necessary, that it should emit Fuliginous exhalations? We confess also, that there is a certain thin Excrement of the blood and humors, which passeth through the habit of the body; but, that it should be discharged in thick clouds of exhalations, in every systole of the arteries, this is plainly impossible: because at that time the coats of the arteries are constringed and compressed, and there might be an easier egress for them, in the Diastoles, when the cavities of the arteries are dilated. So that among these many Arguments, there is not one, but doth clearly detect, and throughly refute the Error of those Men, who have confounded the Uses of the Arteries, and Lungs, of Pulsation and Respiration.

This capital Error eschewed, we may the more safely progress to explicate the nature of Respiration, as a thing in sundry particulars distinct from Pulsation, though perchance instituted by Nature, as in some sort subservient to the vital Faculty. And, that we may pro-

ceed methodically, it is requisite we consider (1) the *Manner* of Respiration; (2) the *Efficient* Cause; and (3) the *Final* Cause, or *Use* of it.

Concerning the First.

3. *Respiration described.*

Respiration [Ἀναπνοὴ] is an Action of the Breast and Lungs consisting of two contrary motions alternately successive, or of two parts, *viz.* (1) *Inspiration* [Εἰσπνοὴ] in which the ambient aer is impelled into the Lungs and chest, at that time dilated: (2) *Exspiration* [Ἐκπνοὴ] wherein the same aer is again expelled out of the Lungs and Chest, those parts spontaneously contracting or compressing themselves.

Concerning the *Inspiration*, the grand Question is, *Whether the Breast and Lungs are dilated, because they are filled and distended with the aer; as a bladder is distended by aer blown into it*: or, *Whether they receive in the aer, because they are dilated; as a pair of Bellowes is filled with aer, only because it is dilated or opened by external force?*

4. The Efficient Cause of *Inspiration*, is the Dilatation of the Breast, impelling the ambient Aer into the Lungs.

To solve this difficulty, in a word, we say, the Breast is first dilated, before it can be filled with aer, and that Dilatation or heaving up of the brest is the cause of the airs rushing in at the mouth and nostrills, down the *Aspera Arteria*, or wind-pipe, into the Lungs. For, since there is no vacuity (at least no Coacervate one) in the world, no body can be moved out of its place, but the next body must give way, and the next to that likewise give back, till such a part

part of space as is adequate to the dimensions of the body first moved, be made to receive it, and the space which it abandoned, be again fully possessed by another body succeeding into it: we say, since this is necessary, it is manifest, that the aer next incumbent on, or contiguous unto, the Breast and Abdomen being urged and impelled by the breast, while that is dilated or expanded, is forced to give back, and press the aer next to it, which likewise drives back the next aer, untill at length the compressed aer wanting room to retreat into, and endeavouring to avoid further compression, (its own Elater ingaging it thereto) rusheth into the breast and there possesseth that room or part of space, which was left by the breast, when it began its motion. So that so much aer is impelled into the breast, as is driven out of its place by the superfice or outside of the breast, during its expansion or dilatation.

As for the *Attraction* of Aer into the Lungs, *ad fugam vacui*; it is a meer dream; as well because all motion is by *Impulsion*, as because Nature doth not abhor vacuity *primario* or *ex se*, but only *ex Accidente*, or in respect of the confluxibility of the insensible particles of Fluid bodyes, as we have elsewhere amply demonstrated.

In Physiolog. Epiarro-Gassendo-Charltoniæ. lib. 1. cap. 5 pag. 40.

And if there were any Cause to be found, that might blow the aer into the breast, as it is blown into a bladder, so as to distend it; or at least, if the aer could be conceived to enter

into the breast spontaneously, or of its own accord, without impulsion, so as to force, or heave up the same: then indeed, would the Comparison betwixt the dilatation of the breast, and that of a Bladder, by wind blown violently into it, hold good, and we should not need to seek further. But, there being no such insufflating cause assignable; and it being ridiculous to imagine the aer should spontaneously move it self, so as to flow uncompelled into the cavity of the Chest (as is manifest not only in dead men, into whose breasts, though their mouths and nostrils are wide open, the aer doth not croud it self: but also in living men, when they at their pleasure keep their breasts compressed, or hold their breath, as the vulgar phrase is), it seemes much more reasonable to explain the reason of Inspiration, by that other similitude of the flux of aer into a pair of Bellows; there being no other difference betwixt the repletion of the Chest, and the repletion of a pair of Bellows, with aer, but only this; that the Bellowes are opened by an externall force, and the Chest is dilated by an internal.

5. And the cause of *Expiration*, is only the spontaneous contraction of the Breast.

And as for the *Exspiration*, that is evidently from the compression of the breast and Lungs, which is the naturall motion of Restitution For, the Dilatation being an action, whereby the parts of the Chest are distended into a position more large, than is natural to them; the Contraction seemes to be nothing else, but a certain falling down or relaxation of the

parts

parts distended, whereby they spontaneously return to their natural position, and such as they hold in a dead body; and this not onely in the Lungs, but also in the Diaphragme, which in dead bodyes is not extended downward to the stomach and guts (as in inspiration) but riseth upward toward the Lungs and Heart. But if it be here demanded, whether Inspiration, or Exspiration be first; we answer that it is necessary that the aer should be first inspired, before it can be exspired; and every ANIMAL dyes *Exspirando*, in Exspiration.

Concerning the *Second*.

6. The Dilatation of the Breast and Lungs, not from any Motive Faculty congeniall to the Lungs.

The Enquiry is, *By what cause the breast and Lungs are so dilated*, as we have asserted? And this, indeed, is a Difficulty not so soon resolved, as proposed; for, besides the obscurity of the thing it self, we find our selves benighted with the various opinions of Authors. Some wil have, that the Lungs are endowed with a certain *Faculty of Dilating themselves*, and so elevating the whole breast: as the Heart hath a pulsifick faculty, by whose virtue the ventricles contract themselves in each Systole. And, hereupon was it, that *Aristotle* (the Author of this opinion) doth compare the Lungs to a pair of Bellowes, as if they did of themselves first attract the aer, and then emit it again. But, though it be true, that the Lungs are filled with aer, and emptied again, or elevated

and

and depressed alternately, as Bellowes are ; yet is it doubtfull, whether (as the hand which moves the bellowes, by opening and shutting them, is the cause both of the influx and efflux of the aer in them) there be not some other part of the Chest, besides the Lungs, which being first dilated and contracted, is the cause, why the Lungs are opened and shut ? or more plainly, *whether the expansion of the Lungs be from an ingenite Faculty?* And, that the Lungs have no such Ingenite Motive-Faculty, is sufficiently manifest even from hence, that their motion is alwayes conforme to that of the Diaphragme, and from hence, that we can suppresse, accelerate, or retard our respiration, as we please.

7. Nor from the impulse of the blood out of the heart into the Lungs.

Others derive the motion of the Lungs from the *Heart*, or rather *the blood expelled out of the right ventricle of the heart, through the Vena arteriosa into the Lungs, and so lifting them up.* But this is erroneous, because (1) the efflux of the blood out of the right ventricle is caused by an ordinary motion purely natural to the heart; whereas (as we said even now) Respiration is sometimes arbitrary : (2) the cause of pulsation and Respiration would then be not onely one and the same, but those motions also would agree in their times and periods ; whereas scarce four, nay six, pulses are equal in time to one single Respiration : (3) the blood doth not stay long enough in the vessels of the Lungs, to keep them elevated all that while they are distended ; but is in continual motion,

tion, and in a moment circulated by the Arteria venosa, into the left ventricle of the Heart: and where it is retarded in its course, by any misaffection either in the capillary vessels, or in the substance of the Lungs (as it many times happens, in the disease vulgarly called, the Rising of the Lights) it causeth extream difficulty of breathing: (4) in great Apoplexies, while the pulse continueth good and regular, the Respiration many times ceaseth.

8. Nor from the motion of the Muscles of the Thorax.

Others will have it, that the Lungs borrow their motion from the *Thorax*, or *Chest* containing them; but the reason which detaine us from assenting thereto, is, that after the chest is cut quite open, the Lungs continue their motion for a good while, and strongly: which were impossible, if they derived their motion from the chest.

9. But from the *Diaphragme* moved by a congenite Faculty.

Now it being evinced, that the Lungs are not moved either by themselves, or by the Heart, or by the Thorax; it remains, that they must be moved by some other part in the Breast, in which as in the first original, the motion of Inspiration doth begin: and this part seems to be no other, but the *Diaphragme*; and that for these reasons. (1) In wounds, or perforations of the breast, the Lungs instantly falling together, as it were close themselves (for some short space) while the Diaphragme is still elevated and depressed alternately, contracting and againe relaxing the ends of the spurious ribbs, and cartilages to which,

which it is annexed: whence it comes, that the aer rusheth violently into the cavity of the chest, and upon the elevation of the Diaphragme, is driven out again, through the wounds with impetuosity sufficient to blow out a candle. (2) Every man, in Inspiration, feels the Thorax to be dilated, and the whole Abdomen lifted up, and the ends of the lower ribs to be drawn inward: the Diaphragme being extended downward, with its middle part crowding down the stomack, liver and guts, and with its circumference or extream parts contracting the ribs.

(3) Allowing the Diaphragme to be the *primum Movens*, among all parts infervient to inspiration, we may easily understand, why the Respiration becomes more frequent and remiss, when the stomach is full, and when the Aer is made more dense, than ordinary, by fogs and thick exhalations. For, in the former case, the Diaphragme hath not room enough to expand it self downward, as it ought, and so is compelled to compensate the smallness of its motion, by the frequency of it; and in the latter, the Lungs are so prepossessed with gross vapours, as that they cannot admit much aer at a time, and therefore the Diaphragme is necessitated to repeat its motions so much the oftner. (4) In Apoplexies (unless they be fatal) though the Respiration be almost insensible, yet the motion of the Diaphragme is continued; as may be perceived by the gentle motion of the Chest. (5) Respiration is more

perturbed

perturbed and vitiated, by diseases of the Diaphragme, than by those of any other part of the breast: and it hath been observed by *Vesslingius* that a *Steatoma* grown upon even the carneous part of it, caused extreme difficulty of breathing. Now, these are the Reasons that have induced us to believe, that the *Motion of Respiration begins in the Diaphragme*; which being a kind of Muscle of a peculiar figure, substance, position, and action, may as well be conceived to be extended by virtue of a certain peculiar and *ingenite Faculty*, as the Heart is by a Pulsifick Faculty: so that we may conclude the same to be the prime and principal instrument of Respiration Natural or Gentle. *Syntagm. Anatom. p. iij.*

We say *Natural or Gentle*, by contradistinction to Respiration *Violent*, or *Arbitrary*. For, allowing of *Galen's* triple difference of Respiration, *viz. Free and Gentle*, *violent*, and *more violent* or *sublime*: we conceive the *First* to depend upon the Diaphragme alone; the *Second*, to require a concurrence of the Intercostal Muscles, of which the interior serve to contract, and the Exterior to dilate the Chest; and the *last* to be effected by the Diaphragme, Intercostal, and Pectoral Muscles, all being set a work, and combining together to the motion. And, as for Respiration *voluntary*, such as we can at pleasure suppress, accelerate, or retard; that is manifestly by the help of the Intercostal Muscles, there being no other instruments of Motion voluntary, but the Muscles; and no other Muscles immediately con-

10.
Yet as well the *Intercostall*, as *Pectoral* Muscles are allowed to conspire with the Diaphragme, in Respiration *violent* and *Arbitrary*.

ducing to the contraction and dilatation of the breast, *ex arbitrio nostro*, but the Intercostal.

Concerning the *Third*, *viz.*

The *Final Cause*, or *Use of Respiration.*

11. The *Final* Cause of Respiration, n ot the *Refrigeration* of the Heart, or Vital Flame: but the *subtiliation of the blood*, which by the admistion of Aer, is made the more convenient Fewell for the Lamp of life, and matter of the Vital Spirits.

The most General opinion (to omit all others, as less considerable) is, that the principal use of Respiration, is for the *Refrigeration of the Heart*. Which though very ancient and plausible, is rather meerly Conjectural, than Areopagitical or demonstrative. For (1) As aer over-hot is injurious to the heart, so is aer over-cold: and as aer moderately cold is beneficial to the heart, when it is excessively heated; so is aer moderately hot, beneficial, when the heart is too much cooled. But, while the heart is in good temper, then the aer most agreeable to it, is neither hot, nor cold, but temperate. (2) It is inconsistent with the prudence of Nature, to make the natural heat of the heart so intense and excessive, as to require perpetual ventilation with cold aer: when it had been much easier for Her, to have kindled a more gentle fire therein at first, than to bring cold aer to the hearth with so much adoe, to keep it in moderation ever after. And, in case that-Fire should chance, at any time, to grow less, or languish (as it often doth, in extreme cold aer, many men being frozen to death in *Green-land*, *Russia*, and other Northern Countries) what provision hath Nature made

for

for the reaccension or instauration of it? (3) If it be only the Cold of the aer, that is beneficial to the heart; then, certainly, the Water, (which is much colder than the aer) would more conveniently satisfie that necessity in Fishes, which yet cannot live without aer. (4) In persons of cold and Leuco-phlegmatique constitutions, there would be no need at all of Respiration; especially in frosty weather, when the heart hath as much want of warmth, as of cold, and more too. We confess, indeed, that at such times, our Respiration is more slow and rare, and in the heat of Summer, more quick and frequent; as it is also in Fevers: but the reason hereof is, that in Summer, the blood being made hotter, is sooner subtiliated into spirits, and those spirits faster consumed and dissipated; and so requires more aer to promote the subtiliation and inflammability of its spiritual parts. So that it should seem, the Aer is required rather as an Excitement, than as an hindrance to the vital Flame. We say, for the Excitation, or Accension of the Flame of life, by subtiliating the blood, and making the inflammable parts thereof more convenient Fewell for the same vitall Flame, and for the matter of the spirits, which being diffused through the whole body, serve to conserve and vivifie all the parts; no otherwise than Bellowes conduce to the accension of flame in wood.

12. The same exemplified by

For, as the Aer blown out of a Bellowes, doth promote the accension of fire, in wood,

the accension of flame in wood, by aer blown out of Bellowes.

or other combustible matter; not by reason of any Cold (for Contraries never generate each other) but by the subtility of its particles, and the vehemence of its motion, in respect whereof it both dissipates the ashes, that hinder the ingress of the fire, and impells the particles of the fire into the pores of the wood; so as that they penetrating more deeply into the substance thereof, invade and kindle all the inflammable particles therein contained: so doth the Aer brought into the Lungs, and commixing it self with the blood circulating through them, insinuate it self, by the Arteria Venosa, into the left ventricle of the heart; and there partly by its subtility, partly by its expansive motion, so conspire with the pulse of the heart, as to conduce to the rarefaction and subtiliation of the more thin and inflammable parts of the blood, that so they may be made both commodious fewell for the Fire burning in the heart, and also fit matter of the vital spirits. All the difference is, there are no Ashes made in the heart, the Flame thereof being more pure, than focal-fire, and subsisting in a matter as fine and subtile, as spirits of wine. Nor are there any soory exhalations; such as arise from oyle burned in a Lamp: but such a Flame is perpetually revived out of the blood in the heart, as is made by the purest spirits of wine set on fire.

13. And inferred from the structure of the Lungs.

This Use of the Aer inspired, may be in some sort inferred from the very structure of the Lungs. For, to what purpose doth both the

Vena

Vena arterioſa, and *Arteria Venoſa* divide and diſperſe into ſo many branches and ſurcles, throughout the lobes of the Lungs; unleſs it be to convey the aer brought into them (out of the *Bronchia*, or pipes derived from the Aſpera arteria) together with the blood, into the left ventricle of the heart, there to excite the vital flame? For, certain it is, from the ſtructure of theſe veſſells, that the Aer doth not arrive at and enter the heart, pure and ſincere (as it ought to do, in caſe it were to refrigerate the heart) but mixed with the blood returning out of the Lungs: which is the reaſon, why in the diſſections of living creatures, no aer is to be found in the Arteria venoſa, being, before it comes thither, throughly commixed or confuſed with the blood. Nor can we force aer into the heart, through the Lungs of a dead body; becauſe the motion of the blood is then ceaſed. And this we conceive to be the Principal End, or Uſe of Inſpiration.

14. The Uſe of Exſpiration.

As for that of *Exſpiration*, it ſeems to be no other but the exploſion of the ſame aer formerly received; together with the *Halitus*, or vapours of the blood, that ſteam from it, while it is circulating through the Lungs. For, as to that Antique opinion, of the diſcharging of *Faliginous Exhalations* iſſuing from the heart; to the reaſons by us formerly alleaged to diſcredit the Generation of them, we ſhall ſubjoyn two or three convincing ones, to diſprove their Excluſion through the Lungs. (1) The motion of the blood out of the Lungs, by the

Arteria

Arteria Venosa, into the left ventricle of the Heart, being continual and strong; doth manifestly forbid any thing to come from the Heart, into the Lungs that way: and (2) the situation of the Valves in the same Arteria Venosa, doth as much. (3) That the Aer passing to the Heart, and the (supposed) Fuliginous exhalations issuing from the Heart, should be carried through one and the same vessel, by contrary motions; is insolent to Nature, and incompetent to the oeconomy of the body.

15. A *Probleme*, of the Respiration of the *Fœtus*, in the Mother's womb.

And here we aske leave to propose a *Problem*. Certain it is, that the *Foetus*, while in the Mother's womb, doth receive nourishment (not by the Umbilical Vessels, for in them nothing is contained, but Blood, which is not the Aliment of the parts; and the Umbilical Vein serveth onely to the Circulation of the blood, by bringing back to the heart, what the two Umbilical Arteries carried from it into the *Placenta Uterina*: but) by the *Mouth*, sucking in that milky liquor, wherein he swimmes: which *Hippocrates* long since, and *Dr. Harvey* of late, have undeniably proved. Now, this being so, doth it not seem necessary, that the *Fœtus should also have the use of Respiration*? For, since all *Suction* is by *Impulsion* (as we have elsewhere at large demonstrated) being caused only by the presſure of the thing sucked, by the Aer impelled in round (as we lately expressed, in the cause of the influx of the aer into the Lungs, in Inspiration) certainly,

ly, without the help of aer, the *Fœtus* cannot possibly suck in his nourishment. To this Reason (and we think it a weighty one) may be added, (1) the Authority of the *Divine old Man*, who in most expresse termes saith, καὶ τοῖσιν [viz. *Fœtibus*] ἄνω τὴν πνοὴν ποιέεται, τῷτε στόματι, καὶ ῥισί, *Puer ab alto respirat, & ore & naribus.* (2) that Chickens breathe in their shells (through which the aer hath a more difficult passage, than through the secundines) and Fishes in the water. And as the Chicken pipes within the shell not yet broken; so hath it been observed and recorded by sundry learned and authentical Writers, that Infants have been heard to cry in their Mothers wombs: which were impossible, unlesse they enjoyed the benefit of Respiration. lib *de Natur. pueri.*

(3) The posture of the Child in the womb seems to assert the same. For, as there is an ample space betwixt the coats of the Secundines, and the Child, to the end that a sufficient magazine of milk for his sustenance, might be stored up, and conserved therein; so is not that whole space filled up with that Liquor, but in the upper part there remains so much space unpossessed by any thing but Aer, as is sufficient for so gentle a Respiration, as the Infant hath need of: just as in the blunter end of an Egge, we perceive a certain empty space after the Hen hath sate upon it. And lest the *Chorion* should at any time be corrugated or shrieveled up together, and so streighten or compresse either the Liquor, or the Infant;

Nature

Nature hath affixed the same to the *Placenta Uterina*, to the end, that adhering to the bottome or upper part of the womb, it might hang fast, as an Apple hangs by its stem, or as our Globes of Glass are hung up by strings to the Seeling of a room. So that the *Chorion* thus adhæring to the *Placenta Uterina*, which is fastned to the bottome of the womb, and the *Amnios* in like manner adhering to the *Chorion*, in the same upper part; and the lower part of each membrane being depressed by the weight of the Infant, and of the Humors contained in them: it thence comes to pass, that this Natural Machine both of the Child, and Membranes (though at first it were perfectly round, as the yolk of an Egge) is afterward made of an oval figure. For, though the *Fœtus*, sitting incurved or bowed forward, as much as possible doth keep himself in a round figure, because of taking up the lesse room (for he sits with his leggs crossed, his heels drawn up to his buttocks, his elbowes resting on his knees, one hand held up close to his ear, the other to his cheek, for the more firme and easie sustentation of his head) yet, in that situation he hath need of a Mansion of an *Oval Figure*, that swimming in liquor, he might keep his head above water, and at his pleasure take in his nourishment by his mouth, and also inspire the temperate aer surrounding his head, in the void space of the Secundines; according to the opinion of *Hippocrates* newly recited. (4) Nor is the ingress of Aer into the womb impossible

ble. For, albeit the mouth of the womb, in pregnant women, be ſhut up, ſo as to exclude ones finger, or (as others will have it) a ſmall probe: yet is it not ſo ſealed or luted up, as to exclude the Aer; as may be inferred from hence, that many Femals have *ſuperfœtations*, and more women (eſpecially in this our moiſt Iland) are troubled with the *Fluor albus*, all the time of their Gravidation; neither of which could be, unleſs the *Cervix Uteri* were pervious: For, if there may be an ingreſs for the ſeed of the male after a former Conception; and as free an egreſs for the matter of the *Fluor albus*, all the time of the geſtation of the Foetus: then, doubtleſs, *Hâc etiam penetret per cuncta meabilis Aer.* Theſe Reaſons duely perpended, though it ſeems a Paradox, yet is it no light and vain Conjecture, that the Foetus doth reſpire in the womb, at leaſt gently and placidly, and in proportion to the pulſation of his heart; which being calmly and ſoftly moved (as are the hearts of Dormice and other Animals, that ſleep all the winter) hath but a ſmall neceſſity of Aer. However, reflecting upon the ſingular fabrique of the veſſels in the heart of an Infant unborn, which all Anatomiſts conceive made by the providence of Nature, only in defect of Reſpiration; as we propoſed it a *Problem*, ſo we leave it to the conſideration of wiſer heads.

16. The Motion of the *Brain* dependent, not upon Reſpiration but upon the *Pulſation of the Arteries.*

Here alſo we may opportunely touch upon the *Motion of the Brain*, which conſiſting (as that of the Lungs) of a Diaſtole and Syſtole, many

many have referred to the Inspiration and Exspiration of Aer; as if the Brain were dilated for the admission of Aer, and contracted again for the exclusion of it. Whereas, indeed, this Motion doth not belong (1) to the *substance of the Brain*; for, that being very soft, tender, and delicate, seems uncapable of any such dilatation and compression. Nor (2) to the *Membranes* investing the braine; because, as *Riolan* observed in the head of a Sheep, the diastole and systole of the brain hath been continued long, after part of the skull and Membrans also were cut off. But only to the *Arteries*, (1) because the Motion of the brain is exactly coincident and concordant with that of the Arteries, as may be discerned by the touch, in the heads of Infants new born, and in large wounds of the skull. (2) Because the chief Pulsation is in the upper part of the *Dura Mater*, which is conspersed with store of Arteries ascending from the *Plexus Arteriosus Mirabilis*, and disseminating themselves upon it. (3) Because *Walæus* observed, that in some persons, who fell into extrem agonies, and swooning fits, upon great fractures of the skull, the motion of the brain ceased, and was begun again, as their Pulses recovered. (4) Of what *use* should the inspired Aer be to the Brain? For *Refrigeration*, it cannot be; the temper of the brain being such, as seems to require rather Calefaction. And, as for the *Generation of Animal spirits*; *Dr. Harvey* hath upon good reasons made it doubtfull, whether there be any such or not: and

and if there be, certainly they consist only of the purest and most subtile parts of the blood, and not of Aer, by the admission of which they must needs become more crass and unfit for those noble uses, to which they are consigned. And, therefore, *Riolan* said well; *Nec spiritibus permiscetur Aer in Cerebro, quia debent esse subtilissimi; alioquin permixtione aeris crassiores evaderent, nec tam celeriter in universum corpus excurrerent per nervos.* *Encheirid. Anatom.* lib. 4. c. 2.

17. The *Secondary* Uses of Respiration.

Nor must we here omit to touch upon the *Secundary* Uses of Respiration, which are Manifold. For, it serveth (1) to the *creation of the Voice* (whether Articulate, as in Man; or Inarticulate, as in Bruits) the Lungs exploding the inspired aer, through the Aspera Arteria, with such impetuosity and swiftness, as that its frequent and strong Elisions in the head of the Larynx, the throat and other parts of the mouth, cause it to yeeld a sound. (2) to the *Distribution of the Chyle* both out of the stomach and guts, through the venæ Lacteæ, into the grand Receptacle, and out of that Receptacle into the ductus Chyliferi: the middle part of the Diaphragme, in Inspiration, depressing the stomach and guts; and its two long carneous productions lying so immediately under the Receptacle, as that they cannot be distended, but they must at the same time also distend it, and so express the Chyle out of it. (3) to *the Exclusion of the Excrements* both of the Guts and Bladder; the depression of the Diaphragme together with the compression of the Abdomen,

ſtreightning and urging thoſe parts. (4) to *Smelling*; the odours being brought into the Noſtrills together with the inſpired Aer. (5) to *Coughing*, *Sternutation*, *Exſcreation*, and *Emunction* of the Noſe; while the breath is driven forth with violence and ſuddainly. And (6) to *aſſiſt the whole body in any ſtrong and vehement motion*; while, either the Inſpiration being made gentle and ſmall, and the breath kept in, the Muſcles of the Abdomen and other parts are conſequently ſtretched; and ſo we are the better enabled to lift up things of great weight, or to repell things making reſiſtence by force of impulſion or otherwiſe: or, after a great inſpiration, a vehement and ſuddain exſpiration ſucceeds, and then the Muſcles are extended together with the like force, ſo as the Armes and Legs are ſtrengthned either in giving a blow, or leaping, or other the like efforts, to which main force is required. And thus much of *Reſpiration*.

OF

OF THE LYMPHEDUCTS.

Exercitation the Ninth.

Of the Lymphedufts.

Article 1. The Lymphe-ducts, a new and excellent Invention.

AMong the new Diſcoveries made in the Microcoſme, by the Anatomiſts of this our age (wherein Nature ſeems to have rewarded the ſweat and induſtry of her ingenious Votaries, with the knowledge of ſundry Secrets, which ſhe wholly concealed from our Predeceſſors) *Theſe veſſels* are not the leaſt: nor can you have a compleat Hiſtory of the Oeconomy of Nature in an Animal, without aſſuming both them, and the Liquor they contain, into particular conſideration.

2. To whom the honour of their Diſcovery is to be aſcribed.

To whom the Honour of their *Invention* doth belong, is yet in diſpute. For, though that moſt diligent and perſpicacious Anatomiſt, *Thom: Bartholinus*, be the man, who firſt wrote of them; and He challengeth the glory of their diſcovery wholly to Himſelf: yet is it well known, that our Country man, *Dr. Jolive* (a perſon of ſingular dexterity, and admirable felicity, in diſſection of all ſorts of Animals, as well living, as dead) had diſcovered and

and mentioned them to many Physicians of best note, and among the rest particularly to that eminent Master in Anatomy, *Dr. Glisson* (who makes gratefull acknowledgment thereof, in his most elaborate and judicious Book, *de Anatom. Hepatis*) more than a whole year, before *Bartholine* wrote his Treatise particularly concerning them. So that it being improbable *Dr. Jolive* should borrow the notice of these Water-vessels from *Bartholine*; and as improbable, on the otherside, that *Bartholine* should receive the first Hint of them from *Dr. Jolive*: it seems equitable the Honour of this invention should be divided betwixt Them, as Men, whom good Fortune, conspiring with their industry, might haply bring to the investigation of the same thing, neer about the same time; notwithstanding they were divided by so large a distance, as is betwixt England and Denmark, and held no commerce each vvith other by Letters, or othervvise. But vvhoever vvas the Inventor, certain it is the Invention it self is of admirable advantage to the Republique of Physick: and therefore, vve shall briefly recite the summe of vvhat hath been vvritten concerning their *Description*, their *Origination*, their *Insertion*, and their *Uses*.

3. Their Description,

The *Lympheducts* are certain Whitish Vessels, in many places of the body running along close upon the veins, and sometimes embracing them in various circles, as the surcles of the Vine tvvine about the branches of an Elm, consisting

consisting of a very thin and transparent *membranous substance*, not much unlike a spiders vveb; in *Figure* for the most part roundish; in *magnitude* seldome exceeding a Ravens quill; furnished vvith sundry tender valves; and containing a *Liquor* thin, insipid, and for the most part vvhitish, but sometimes tinged either vvith blood, or vvith a yellovvish colour.

Of these are *two sorts*; some accompanying the larger veins in the Limbs, or exterior parts; and others associating themselves vvith the veins in the Abdomen, especially vvith the *Vena Portæ*, the *Iliacal* veins, those disseminated upon the *Testicles* in both sexes, and upon the bottome of the *womb* in Females. 4. Differences.

Accordingly, their *Origine* is tvvofold; for those in the Abdomen arise either from the Liver, or from the Bladder of the Gall, or *Capsula communis*: and those in the Limbs, have their original from those parts; but, vvhether from the capillary veins, or from the capillary Arteries, or from the extremities of the Nerves, is not yet determined. Onely vve have the late observations of *Olaus Radbeck* (Physician to Queen *Christina* of *Sueden*) to attest, that they arise almost from all parts; he having found them also in the Lungs, Mediastinum, Heart, suspensory ligament of the Liver, stomach, spleen, loyns and sundry other parts. 5. Origination.

Their *Insertion* likevvise is tvvofold. For, those in the Abdomen are all terminated in 6. Insertion.

the

the grand Receptacle of the Chyle, into which as into a ciſtern, they infuſe that thin liquor, which they carry in their pipes; that ſo the ſame being there commixed with the Chyle, may be conveyed along with it, through the *Lacteæ Thoracicæ*, into the *ſubclavian vein*. And thoſe above the *Diaphragme*, or ſuch as ariſe from the Limbs, are inſerted into the *External jugular* Veins, into which they diſembogue their ſeveral rivulets. Wherefore they have no common Trunck, but (like ſeveral Springs of water) riſing up here and there from divers parts, they all tend into two large channels, *viz.* the Receptacle of the Chyle, and the *Vena Axillaris*, that their ſtreams may all meet in the common Ocean of the Heart.

7. Situation and Progreſs.

As for their *Situation* and *Progreſs*, it is thus. In the Armes, they creep up by the ſide of the *Vena Brachialis*, to which they are firmely connected, and ſo aſcend together with it to the *Vena Axillaris*, into which they open themſelves with a ſmall inlet, or Orifice, that is guarded with a valve, ſet there by Nature, to prevent the reflux of the liquor out of the Axillary vein. And, from the *Thighs*, many in like manner climb up in the company of the Crural and Iliacal veins, which they encircle in ſome places more cloſely, in others more laxely; and in this manner they mount up to the Meſentery, where together with the ſmall branches of the *Vena Portæ*, they are terminated. Again, thoſe iſſuing from the *Liver*, or *Bladder of the Gall*, do alſo deſcend in com-

pany

pany of the *Vena Portæ*, to the middle Glandule of the Meſentery, and are therein terminated. But, if with a more curious eye you trace theſe proceeding from the Liver, up to their very original; you may perceive them to enter the *Capſula Communis*, of the *Vena Portæ*; and therein ſo to loſe themſelves, as that you cannot diſcern their progreſs from thence: yet it is probable, that being included in the ſame *Capſula Communis*, they follow the diſtribution of the ſame, and never ſtray from it into the *Parenchyma* of the Liver; becauſe, if they did, how comes it, that they are no where to be found in the parenchyma, no not in that part of it, where the *Capſula Communis* is?

Concerning the *Liquor* they contain, there are two Difficulties, *viz.* (1) *Whence they receive it?* (2) *Why they return it into the Receptacle of the Chyle, and into the Heart?*

The *Former* is ſolved, by ſaying, that the *liquor is derived partly from the Arteries, partly from the Nerves.* That the *Arteries* have ſome ſhare in bringing that mild and thin Liquor into the Lympheducts, may be argued thus. The blood, being by the Vital Heat and Motion, agitated in the Arteries, doth neceſſarily diffuſe abundance of Vapours into thoſe parts, into which it is immitted; and this ſo much the more, becauſe thoſe vapours are repreſſed and kept in, by the thickneſſe of the coats of the greater Arteries, untill they are driven into the ſmaller arteries, through whoſe thinner coats they more eaſily transſpire.

8. Liquor deduced partly from the Arteries, and

pire. And theſe vapours thus diſperſed, are for the moſt part retained and re-collected by the Fibrous and Membranous parts, and by that means condenſed into a Liquor, which makes one part of that Humor which the Lympheducts carry away. For, we are not to conceive, that that Liquor was preexiſtent in the Arteries, under the ſame form it afterward obtains in the Lympheducts; and that being protruded together with the blood out of the Arteries into the ſubſtance of the parts, it is in thoſe parts ſeparated from the blood, by any kind of Percolation, as the Urine is in the Kidneys: becauſe there are in all parts Veins anſwering to the Arteries, and thoſe ample enough to export whatever liquor is by them imported: nor can any reaſon be given, why that watery humor ſhould be at all ſeparated from the blood; ſeeing it is no Excrement of the blood, though it may be accounted an Excrement of the parts, from which immediately it is immitted into the Lympheducts. No Excrement of the blood, becauſe it is again brought into the blood; and Nature uſeth not to loſe her labour, or to ſeparate things each from other, on purpoſe to mixe them again afterward.

9. Partly from the Nerves.

Secondly, that the *Nerves* alſo contribute ſome part of this Liquor to the Lympheducts, may be inferred from hence; (1) that whatſoever Liquor ariſeth from vapours condenſed, is perfectly pure, thin, and tranſparent: but this liquor is not ſo, and therefore it is neceſ-

ſary

sary some other Humor should be admixt to it, which gives it a greater thickness, than a simple distilled water usually hath. For, this whole liquor is more dense, and less diaphanous, and sometimes white like milk, sometimes tincted with yellow, and sometimes with blood, like water wherein raw Flesh hath been washed. (2) It is an opinion highly agreeable with Reason, that the thicker part of the Liquor found in these Water-conduits, is the Vehicle of the *Succus Nutritius*, which being dispensed from the brain and spinal Marrow, to all parts for their nourishment, by the Nerves, is assimilated into their substance, leaving its thinner part (which before served to promote and facilitate its distribution through the slender passages of the Nerves) to be infused into the Lymphe-ducts, which return it into the blood, for a *double use*, viz.

First, to prevent the *Coagulation* of the blood, to which otherwise it would be strongly inclined. Secondly, to promote the *Mication* of the blood; for this thin liquor, being formerly advanced to the state of Volatility, or exhalation: it is easily united to the Vital blood, and doth as easily advance the mication of it. 10. Uses of that Liquor.

But, what we here say, of the derivation of one part of this Liquor from the Nerves, will be more illustrated by what follows, concerning the dispensation of the nourishment by the Nerves.

OF THE DISTRIBUTION OF THE NOURISHMENT THROUGH THE NERVES.

Exercitation the Tenth.

Of the Diſtribution of the Nouriſhment through the Nerus.

Article 1. That the Nervs are the veſſells carrying the Nutritive juyce to the parts; argued

IN one of our precedent Diſcourſes (as you may pleaſe to remember) we denied the Blood to be the Adequate Aliment of the Nervous, Fibrous, and Membranous parts of the body; and transferred that noble office upon a certain milder and ſweeter juice, congenerous to that ſpermatical Matter, of which thoſe parts are firſt made up: Leſt therefore, we ſhould defraud your curioſity of ſuch further ſatisfaction, as this new and paradoxicall (yet moſt reaſonable) opinion requires; we muſt no longer omit to explain (at leaſt according to what light the excellent *Dr. Gliſſon* hath given, in ſo obſcure an Argument) *From whence, and by what veſſells, the Nutritive juice is diſtributed to all parts of the body.*

The *Theſis* is, that the proper and adequate Nutriment of the Parts, is derived to them from the Brain and Spinal Marrow, by the Nervs.: and the *Reaſons* aſſerting it, are theſe.

(1) In

(1) In the *Palsy*, it is observed, that the parts resolved do at first appear somewhat tumid or swolne, by reason of the laxity of their Fibres, and the easie afflux of blood unto them. And yet it is manifest, that swelling doth not arise from the true and genuine Nourishment of those parts; because afterward they by little and little pine away, to extream leanness, notwithstanding the blood floweth as freely and plentifully to them then, as before. A pregnant argument, that the vessells, by which they ought to be supplied with nourishment, are obstructed; which vessels, certainly, can be no other but the Nervs, because both Arteries and veins are wholly exempt from any impeachment, in this Disease; and the Nervs alone fail of performing their office, as they ought.

2. from the Atrophy, or decay of nutrition in parts affected with the Palsy, and whose Nervs have been wounded.

This may be confirmed by an observation of our owne. A certain woman having a Nerv pricked by an unskilfull Chirurgeon, as he was letting her blood in the right arme, was at first surprised with Convulsions of that Arme; and those ceasing, there ensued so great an Atrophy of that member, as nothing now (for the woman is yet living) remains of it but skin and bones: which extream extenuation, doubtless, is to be referred to the want of passage for the Succus Nutritius, through the principal Nerv in the Arme; no such accident (but an Aneurisme) usually following upon the incision of an Artery.

3. from the beneficial use of *Cephalique* Emplastres in Consumptions from ulcerated Lungs.

(2) In a *Phthisis*, or Consumption from ulcerated Lungs, *Cephalique Emplastres* (though

composed

composed of heating and drying ingredients, and in that respect seeming very incompetent for such a Disease) are found by experience to be very beneficial to the sick; and that, not only because they stop the defluxion of humors from the head upon the Lungs: but also (and chiefly) because they warme and corroborate the Brain and Nervs, and so promote the Nutrition of the Parts. Which effect cannot be expected from their Heat and Drineſs, but from some comfortable influence transmitted to the Nervs, by which they are strengthned and made fit for the performance of their office, *viz.* the conveying the nourishment from the brain to the parts.

4. From the *Fatness* of men endowed with large, open, spongy and moist nerves

(3) As those persons are inclined to Leanness, who abound with blood; so are those inclined to grow *Fat*, who *have large, moist, open, and spongy Nervs*; for, such Nervs afford much Aliment, and distribute it easily.

5. From the *rosacid humor* exstilling from wounds of the joynts and sinewes.

(4) It is commonly observed, that from wounds of the joynts and Nervs, there distills a certain rosacid Humor, not much unlike the white of an Egg; which being not likely to come from either the Arteries or veins, in respect they carry nothing but blood; why may we not believe it to drop out of the Nervs? Also in such wounds, in issues, in hollow Teeth, &c. there grow up frequently certain fleshy Excrescences, or Proud Flesh; which being exceeding sensible, and subject to acute pain upon the least touch, cannot but have a very neer relation to the Nervs: and blood certainly

certainly is very unapt to produce ſuch Excreſcences, to the Generation of which ſome matter analogous to the ſperme is neceſſarily required.

6. From the *Material Principle of Wens* and *Scrophulous Tumors.*

(5) The ſame may be ſaid alſo of Wens and Scrophulous Tumors, which ſeem to derive their Seminal Matter from the dew or Gleet of the Nerves, and not from any humor effuſed out of the Arteries or veins; blood being a liquor partaking of too much Aſperity and Acrimony, to be the material Principle of ſuch Tumors: beſides, we have the teſtimony of our ſenſe, that the rudiments of ſuch Tumors, are like Eggs included in a membranous filme, which contains a humor reſembling the white of an Egg, but nothing like blood. Moreover, theſe Tumors frequently tend to ſome kind of Formation, though but an imperfect one; producing ſometimes a maſs or lump of Fleſh, ſometimes a Worme, or other ſuch Monſter; which is a ſtrong Argument, that their primitive Matter is not blood, but a certain juyce much milder and ſweeter, and brought to the parts in which they are generated, by the Nervs.

7. From the *Matter* of the ſeed, and the *Manner of its preparation* in the Teſticles.

(6) This Opinion is further confirmed by the Matter of the Seed, and the Manner of its preparation in the Teſticles. For, the Seed ſeems to be generated, not of the blood (as hath been vulgarly believed) but of a matter much ſweeter and more generous, brought into the Seminary veſſells, from the brain, by the Nervs: foraſmuch as the Nervs are both more

more copiously and more deeply disseminated into the parenchyma of the Testicles, than either the Arteries, or the veins; which is the reason, why their inward substance is white, not red. Again, their proper Coat appears to be nothing else, but a certain expansion of the Nervs inserted into them; from which Coat many small Nervs are on all parts derived to the middle of the Testicles, where meeting together, they make the long Nervous vessell, that manifestly exonerateth it self into the Chanel of the Epididymis, as may be plainly seen in the stones of a Horse, Bull, Boar, or other large Animal. As for the veins of the Testicles, they serve only to export the blood imported by the Arteries: and the Arteries themselves, though they variously diffuse themselves round about the Testicles; and accompanying the Nervs, tend in divers places from the inward coat, to the *Ductus Seminalis* (situate in the very middle of the Testicle) and are connected thereunto; yet they rarely disperse any branches, untill, reflecting from that chanel, they have begun their progresse back again toward the Circumference of the Testicle. But, there they send out some surcles to the outside of the Testicle; to the end that, those capillary veins, opening themselves into the substance of the Testicle, may the more easily receive the blood effused out of the Arteries, and so carry it off again. Because, that blood, if left there, would soon obstruct the parenchyma of the Testicles, and

disturb

diſturb the præparation of the ſeed. Yet theſe Arteries no where inſinuate themſelves into the Nervous, or Seminal Chanel, or infuſe the leaſt drop of blood into them: So that it is more then probable, they ſerve rather for the vivification of the Teſticles, by bringing the vital blood and ſpirits into them, than for the importation of the Seminal Matter. Now, the Nervs implanted in the Teſticles, cannot be in order to their Motion, becauſe they have none that is voluntary; nor is there any need of them, as to ſenſation: and therefore it is more credible, that their Uſe is only to bring in ſome certain Liquor, for the making of ſeed. Furthermore, the Teſticles are furniſhed with many Lympheducts, which could be of little Uſe unto them, unleſs there were ſome other veſſells preſent alſo, by which that generous Liquor is brought in, whoſe thinner and ſuperfluous part thoſe Lympheducts are framed to export. Add to this, that the ſeed is a liquor much more noble and Ambroſiack, than the blood; as is evident even from hence, that a ſmall expence of ſeed doth more exhauſt the ſpirits, than the loſſe of twenty times ſo much blood. Which doubtleſs, is the reaſon, why Heavineſs and dejection of ſpirit, do alwayes enſue after the delights of Venus; and it hath been obſerved, that in men exceſſively addicted to women, the Brain it ſelf is not only much debilitated, but made alſo lax, thin, and watery. The Gout likewiſe is generally an Attendant of immoderate venery; becauſe the joynts

and nervous parts being much debilitated, and the roscid and Unctuous Liquor of the Nervs, deprived of its milder and sweeter part, the Succus Nutritius becomes too thin and sharp, and so is more expeditely discharged upon the joynts.

8. from the *Glutinous matter* issuing from the ends of *broken bones*, and cementing them together again.

(7) From the Extremities of broken Bones, there sweats forth a certain Glutinous substance, very beneficial toward the uniting and cementing them together again: which liquor cannot proceed from the Arteries, whose office is only to convey the blood (a liquor vastly different from this Glew): and since besides them, and the Nervs, there is no vessell yet found out, that carries any humor from the Center to the circumference of the body; it is very reasonable to conceive, that this Glew is derived from the Nervs.

(8) The *white* of Eggs is brought into the womb of the Hen, by the Nervs. For, it hath no resemblance at all to blood; nor can it be generated of blood, unless by way of separation, but there can be no separation made in that part, in respect it is wholly destitute of any *Parenchyma*, which is absolutely necessary to the separation of any two Humors one from the other. Whereas the secretion of the *Succus Nutritius* brought by the Nervs, seems to want no *parenchyma*, and may be effected in parts the most bloodless. And that such a Secretion of the *Succus Nutritius* is made in the womb, is manifest from the great number of *Lymphedutts* returning from thence, which Nature had ne-

ver

ner ordained in that place, unleſs it were to export the thinner and ſuperfluous part of the *Succus Nutritius* brought to the womb by the Nerves. So that the very Lympheducts ſeem to teach us, that the *Succus Nutritius* is derived into the womb by the Nerves; and that the watery part thereof being protruded into the Lympheducts, the more unctuous and profitable is tranſmitted into the cavity of the womb, there to make the *white* of the Egg.

9. From the *Unequal* nouriſhment of ſome part, in that *Rickets*.

(1) In the *Rickets* there is generally obſerved an *Inequality of Nutrition*, which (according to the moſt of probability) proceeds from the leſs aptitude of ſome Nerves, to carry the nouriſhment, than of others. For, that Diſeaſe ſeems to be ſeated originally and principally in the Spinal Marrow without the skull, and in the Nerves thence propagated: and therefore thoſe Nerves muſt be more weak, languid, and unfit to tranſmit the Succus Nutritius, than ſuch as ariſe from the Brain, or Marrow within the skull. And hence is it, doubtleſs, that the Head, Face, and *Viſcera* of the *Abdomen* (all which derive their Nerves from the Marrow within the skull) grow exceſſively great: while the Armes and Leggs become lean, flaccid, and enervate, as being ſupplyed with nouriſhment by Nerves, iſſuing from the Spinal Marrow without the skull. Moreover, becauſe it ſometimes happens, that ſome one particular branch of this or that Nerve, is more debilitated, than the reſt;

thence it comes, that one part of a Limb is better supplyed with nourishment, than the other; and so, by that unequal Nutrition of its parts, the whole member growes crooked. And these are (among many others) the chief Arguments, that have perswaded us, that the *Nourishment of the parts is brought to them by the Nerves.*

10. *Three* grand *Difficulties*, troubling this opinion.

Among the *Difficulties* encumbering this opinion, there are 3 that especially deserve consideration, *viz.*

(1) *That in the Nerves no passages or cavities can be discerned, through which the Succus Nutritius may be convey'd.*

(2) *That in the dissection of Animals alive, and the application of a ligature to any Nerve, no swelling can be observed to arise on either side the Ligature: and upon cutting off a Nerve, very little or none at all of this supposed Liquor can be discerned to distill from either end; contrary to what happeneth in the binding and cutting off any other vessell.*

(3) *No such Liquor hath yet been found in the Nerves of bodies dissected.*

And yet these Difficulties are not weighty enough to counterbalance the Reasons formerly alleadged; forasmuch as they may be easily solved, by *Answering* to the

11. *Solution* of the First, asserting the possibility of the flux of the Nutritive

First; that though no manifest hollowness be discernable in the Nerves (such as is in Arteries and Veins) yet is it not impossible, but the supposed Succus Nutritius may distill gently through them. For, it is well known by

by the experiment of laying the Spinal Marrow, or any Nerve in water, that the Nerves are made up of many ſmall Fibrous Filaments, or threads cohæring together, with a ſoft medullary ſubſtance betwixt them: much like the Indian Canes, which, though in the cortex ſo hard and compact, as to yield fire upon percuſſion with a Tobacco-pipe, and as ſolid within as many ſorts of wood; being yet compoſed of many ſmall and long Filaments, with ſmall perforations betwixt them, are pervious from one end to the other, ſo as a man may without much difficulty blow his ſpittle quite through them. Likewiſe, in the leaves of plants, there ſhoots up a certain ſmall Nervous rib, ariſing from the Foot-ſtalke, by which they are faſtned to the branch; and without which nothing of nouriſhment can be brought to them. This little rib running up in the middle, ſends forth various leſſer ſurcles or threads equally to all parts of the leaf, ſo as the whole is thereby equally nouriſhed. And yet, if you cut off this rib, or any one branch of it, you ſhall diſcover none the ſmalleſt cavity or hollowneſs therein, nor any drop of juice iſſuing out of it, unleſs in the Sowthiſtle, Eſula, Celendine, and ſome few other plants, which emit either a milky, or a yellowiſh juice, which certainly is their nouriſhment. And though other plants yield not, upon cutting of their leaves, the like juice; yet moſt certain it is, they are nouriſhed with ſome kind of juice or other, derived to them by their Foot-ſtalks: So that

juice, through the Nervs, notwithſtanding no maniſeſt *Hollowneſs* can be diſcerned in them.

that we can perceive no such absolute necessity of any manifest cavity in their small ribbs, for the dispensation of their nourishing juice, as this Objection seems to import ; especially when we consider, that the Motion of the Succus Nutritius in those slender Filaments or threads, is very gentle, slow, and insensible; not rapid, or Violent, as the motion of the blood in the Arteries and Veins of Animals. Now, since our sense is witnesse, that liquor may be transmitted through a Fire-cane though sufficiently solid and compact ; and our Reason assureth, that the Nutritive juice of Plants is distributed to all parts of the leaves, through the Foot-stalk, and little Rib running up in the middle of each leafe, though we can discern no manifest passages, or channels, through which it flowes : Why may not the nourishment of Animals be, in like manner, dispensed to the parts, through the Nerves, notwithstanding they appear destitute of any conspicuous hollowness ? But yet some Nerves there are not so impervious, but they admit a small style or probe into them; in which number are the Optique and Odoratory Nerves : and though the rest have not the like visible hollowness, yet reflecting upon this, that all the Nerves are framed for the performance of some one Common Office, it is not unreasonable to conceive, that all of them are perforated more or less, so as to be capable of conveying the *Succus Nutritius.* This may be in good part inferred even from hence, that the

Apoplexy

Apoplexy often ends in a Palſy; in which caſe all Phyſicians grant, that the Humor oppreſſing and obſtructing the Brain, is diſcharged thence upon the Spinal Marrow, and Nerves affected; which could not be, unleſs the Nerves were capable of being obſtructed by the Humor protruded or impelled into them.

You will reply, perhaps; *that they are capable, indeed, of the influx of Animal Spirits, unleſs their originals chance to be obſtructed, as in the caſe of the Palſey: but, as for any Liquor, or Humor (of far leſſe ſubtility, than thoſe Spirits) it is impoſſible they ſhould admit it into them.* And we may return, that the ſuppoſed Animal Spirits (nor, in truth, the Vital ones) are any where to be found in the whole body, pure or ſincere, and without mixture; and therefore, if the Nerves were framed for the reception of any matter pure and diſtinct from all others, certainly that matter muſt be of a groſſer ſubſtance, than ſimple and abſtracted Spirits.

Furthermore, that there are ſmall Channels in the Nerves, may be perceived by their Compreſſion in our limbs, as when we have long ſate upon a hard ſeat, or otherwiſe ſtreightned our ſinews; for, in that caſe, we feel a certain *Stupor*, or *Numbneſs* (the vulgar ſay, their limbs are *aſleep*) in that part, to which the compreſſed Nerves are prolonged: a certain document, that the free paſſage of ſome matter through them, is at that time intercepted; and the compreſſion being removed, there inſtantly

instantly ensues a kind of troublesome Tingling or Pricking, as if the part were pierced with needls; and this only because what was arrested and intercepted there, begins again its former liberty of motion. These things duely weighed, we may lawfully conclude; that it is not sufficiently evinced, that the Nerves are impenetrable by the *Succus Nutritius*, only because they have no manifest cavity.

12. *Solution* of the *Second*, yeelding the reason, why no *swelling* ariseth in a Nerv, when bound with a Ligature, in a living Animal.

Second; that in the dissection of an Animal alive, it generally happens that by reason of the extream striving and agony of the poor tortured Creature, before the dissector can come, either to apply a ligature unto, or to cut a Nerve; all the Liquor contained therein is squeezed forth into the part, wherein the Nerve is terminated; so that no wonder, if there appears neither swelling on either side of the ligature, nor any exstillation of liquor from the ends of the Nerve cut off. And this Violent streyning of the Nerves in dying-Animals, and the squeezing of the Liquor contained in them, into the parts to which they are inserted; seems to be the Cause, why that *Lympheduct*, which corresponds to the Nerve bound or cut, is found more full and distended, than ordinary, as hath been of late frequently observed. And yet we have been assured by judicious and credible persons, that they have seen no small quantity of the Nutritive juice exstilling out of the *Nervous Chord of the Thigh* in a man; and pressed some of it

out

out of the *Axillary Chord*, in Dogs.

Third, as to the *Second*; adding withall, that (beſides what hath been ſaid, of the cutting of the Nervous Fibres in divers plants, without effuſion of the leaſt drop of their Alimentary juice) the Motion of the Succus Nutritius through the Nervs, is neither Continual, nor impetuous, but by intervalls, and gentle, ſo as not to be perceived: and that all of it being forced into the parts, by reaſon of the ſtrong Contention or ſtreyning of the Nervs, in the very agony of death; and all impulſion of humors in the body, ceaſing after death; it cannot ſeem ſtrange, that none of the Succus Nutritius can be found in the Nervs of bodies diſſected after death.

13. *Solution* of the *Third*, ſhewing the reaſon, why the *Succus Nutritius* is not found in the nerves of *dead* bodies diſſected.

Theſe Grand Objections thus ſolved, it remains that we enquire; (1) *What is the Principium Elaborationis of the Succus Nutritius, or where it is præpared*: (2) *What is the Principium Diſpenſationis of it, or whence it is immediately infuſed into the Nervs, which convey it to the parts*: (3) *By what veſſells it is imported into that principium Diſpenſationis*: (4) *What kind of Motion it hath in the diſtributing Nervs*: and (5) *What is the Cauſe of that Motion.*

14. What is the *Principium Elaborationis* of the Nutritive juice; *viz.* the *Glandules* of the *Meſentery*, of the *Loins*, and the *Thymus*.

Concerning the *Firſt*, *viz.* the Parts wherein the *Succus Nutritius* is prepared, immediately before it is imbibed by the Nervs; there is good reaſon for us to believe, that this work is effected in the *Glandules of the Meſentery*, in the *Three Glandules of the Loins*, and in the *Thymus*, or Glandule in the Thorax. Which opinion

that we may the better explain, it is requisite we make a short Digression concerning the *Differences* and *Uses* of the *Glandules*, according to the observations, and consequent Conjectures of *Dr. Glisson*, and *Dr. Wharton*.

Of the *Glandules* in the body, there seem to be 3 sorts (respectively to the Nervs) whereof some are inservient to *Excretion*, some to *Reduction*, and some to *Nutrition*. For, though it be most true, that the Common office of all the Glandules, is *Secernere*, to make some separation; yet is it no less true, that that separation is various, as tending to Excretion in some, in others to Reduction, and in others to Nutrition; and the *Matter* it self, which is separated by those divers wayes of Secretion, being likewise various, the first sort being a meer Excrement; the Second, an Excrement only in relation to some parts, but profitable in relation to others, and therefore not to be excluded, but retained; and the last, the true *Succus Nutritius*.

Under the *First* Classis of those Glandules, are comprehended the *Testicles*, the *Prostates*, the *Vesiculæ Seminales*, the *Paps* in women, and the *Glandulæ Maxillares*, or spitting Glandules under the Tongue: all which are furnished with a peculiar *Excretory* vessell, by which they discharge and avoid some superfluous matter brought into them by the Nervs.

To the *Second* (inservient to the secretion of a humor, and the reduction of it into the veins afterward) belong the *Glandulæ Renales*, or Deputy

putyKidneys,the Glandules *neer the Fundament*, thoſe adjacent to the *Oeſophagus*, the *Parotides*, *Axillary*, *Inguinal*, &c. Glandules. All which receive from the Nervs, a certain humor more rough and acrimonious (and approaching to the nature of the blood) than is agreeable with the Succus Nutritius; and therefore the Nervs, by the help of theſe Glandules diſcharge themſelves of it, and retain only the more ſweet, mild and profitable juice. But, becauſe the Humor, thus rejected by the Nervs, hath ſome affinity to the blood, and in reſpect of its thinneſs is commodious for the more eaſie tranſportation of the blood, through the narrow meanders of the veins: therefore is it not excluded out of the body, as an abſolute Excrement, but imbibed by the Glandules adjacent to the veins, and by them imported into the veins. Which ſeems to be the moſt ſatisfactory reaſon, that hath hitherto been given, why ſuch Glandules are placed, for the moſt part, neer to the greater Diviſions of the Nervs and veins; *viz.* that they may the more conveniently receive the humor effuſed out of the Nervs, and deliver it again into the veins.

And to the *Laſt* (inſervient to the Præparation of the true Succus Nutritius) belong the Glandules of the *Meſentery*, the 3 Glandules of the *Loins*, and the *Thymus*, or ſingle Glandule in the Cheſt, neer the Ductus Lacteus Thoracicus, and in Brutes called the Sweet-bread. For, (1) as to the *Glandules of the Meſentery*; Anatome aſſureth us, that a great multitude

of the *Venæ Lacteæ* tend unto them, and are in them distributed into surcles extreamly small; and that other small branches (or rather roots of milky veins take their beginning in the same Glandules, and progressing from thence, make a second sort or race of *venæ lacteæ*, as we have more particularly declared before, *in the 2d Art. of the 3d Exercit.* Now, to what end hath Nature made these two kinds of Venæ Lacteæ, one sort to import the Chyle into these Glands, and the other to export it? unless it be, that the Chyle should either suffer some Alteration, or be separated from some Humor, in these Glandules? Alteration it suffers none; because it is carried off again in the same forme, as it was brought in. And, therefore, it remains probable, that it is brought into the Glandules, only that it might be separated from some parts less agreeable with the nature of pure nourishment. Now, what should the Humor be, that is thus to be separated? An absolute Excrement it cannot be, because these Glandules have no peculiar Excretory vessells, as all parts infervient to any Excretion have. Nor is it like that matter, which is reduced into the veins, by the Reductory Glandules: for, if it were such, it would need no such separation at all, the rest of the Chyle soon after flowing into the subclavian vein, and it being easie for Nature to have contrived, that the chyle brought into these Glandules, might have accompanied the rest in that journey, without any intermediate Secretion. This

considered,

conſidered, it is reaſonable to conceive, that the Liquor ſeparated from the Chyle, in theſe Glandules, doth not belong either to the Firſt, or Second ſort of Matter (*viz.* the abſolute Excrement, and the Excrement Relative) formerly mentioned; but is the true *Succus Nutritius*. Which being granted, it is not difficult to explore, by what veſſells this *Succus Nutritius* is from thence carried away. For, ſince it cannot be thence exported by any peculiar veſſells, nor by veins; it muſt be by the Nervs. (2) As for the Three *Glandulæ Lumbares*; it is probable, They alſo are official to the Nervs, in the ſame way; and that for two important Reaſons. *Firſt*, becauſe they are furniſhed with Venæ Lacteæ of both ſorts, ſome tending to them, and others propagated from them, and exonerating themſelves into the Common Receptacle: in all points like the Glandules of the Meſentery. *Secondly*, becauſe in ſuch Animals, as have the Glandules of the Meſentery very large, theſe *Glandulæ Lumbares* are either very ſmall, or wholly deficient; and in men, in whom the Glandules of the Meſentery are but ſmall, the Lumbares are great: an undeniable argument, that the ſame office is common to both ſorts, and that the exility of thoſe is ſupplied by the amplitude of theſe. And (3) the *Thymus* alſo ſeems to be a *Nutritious* Glandule. For, in Infants, and other Animals new born (at which time, they grow much, and ſo require the more abundant nouriſhment) the magnitude of this Glandule doth

doth exceed that of any other in the whole body: but, in old men (who daily go down the hill of life, and so have less need of nourishment in such abundance) it dwindle's away to a smallness many times scarce discernable. Again, this Glandule hath no Excretory vessell, nor (like other greater Reducing Glandules) any hollowness within; and therefore, we may well list it in the number of Nutritious Glandules. Add also, that it is white, soft, and very sweet, and in substance resembling the Glandules of the Paps: so that in probability, as the paps serve to prepare nourishment for the infant, *ab extra*; the Thymus supplieth him with nourishment, *ab intra*; receiving the same, perhaps out of the *Ductus Lacteus* in the Thorax, which in its approach to the Thymus, is usually divided into two streams or rivulets. And these are the reasons, upon which we conclude, that the Nerves take in some of the *Succus Nutritius*, out of each of these Glandules mentioned, whose use seems to be, to separate the same from the less Alimentary parts of the Chyle.

15. What is the *Principium Dispensationis* of the same; *viz.* the *Brain* and *Spinal Marrow*.

Concerning the *Second* thing enquired, *viz.* what is *the Principium Dispensationis*, whence the Succus Nutritius is immediately immitted into the Nervs, which convey it to the parts requiring nourishment? We say, that the *Brain* and *Spinal Marrow* seem to have the best title to that office, of all other parts, in respect that all the Nervs desuming their original from, and having their extremities or roots

immediately

immediately faſtned unto either the Brain, or Spinal Marrow, the Nutritive juice may commodiouſly and eaſily from thence diſtill down upon all parts of the body; according to their particular conditions and neceſſities.

16. What are the *Veſſells importing* the Nutritive juice into the Brain and Spinal Marrow; *viz.* the *Nerves*, and particularly thoſe of the *ſixth Conjugation* of the brain.

Concerning the *Third*; viz. *By what veſſels the ſame Nutritive Liquor is brought into the brain and Spinal Marrow* ? We ſay, By the *Nerves*, and particularly thoſe of the *ſixth Conjugation* : For, this pair of Nerves, though they appear leſs than all others, at their firſt riſing from the Brain ; do yet hold a commerce with all other nerves of the whole body, and are immediately derived to more parts, than any other pair or Conjugation, which is the reaſon why Anatomiſts called them, the *Wandring* or *Diſperſed* pair. And the Commerce they maintain with ſo vaſt a multitude of other nerves, is founded on a threefold relation or intercourſe, *viz.* *Complication*, *Conſociation*, and *Inoculation* : all which are largely deſcribed by *Fallopius*, and after him by our excellent *Dr. Gliſſon*. Now, if we ſeriouſly conſider the ſcope or deſign of Nature, in all thoſe laborious and curious Connexions of Nerves, we ſhall find none, wherein our reaſon may with ſo much ſatisfaction acquieſce as in this, that they conduce to the commodious reception of the Nutritive juice and tranſportation of it to the principle of its Diſpenſation. For it ſeems, the Nutritive juice is firſt imbibed by the ſmall branches of the Nerves of the ſixth Conjugation ; and thoſe, though very many, being

in obſervat. Anatomic. de Anatom. Hepatis. P. 436.

being yet too few for the transportation of so large a quantity of that rich Nectar, as is required to the nourishment of the whole body, Nature hath conjoyned with them a vast number of other Nerves, as Auxiliaries in that great work. So that it is not dissentaneous to reason, to conceive, that by these Nerves and their Coadjutors, the *Succus Nutritius* is carried to the brain and Spinal Marrow, thence to be afterward derived to all parts for their sustenance.

17. What is the *Motion* of the same in the Nervs; *viz.* not continual, nor vehement: but *by intervalls*, and *slow* and *gentle*; to the brain, in sleep, and from it to the members, after sleep.

Concerning the *Fourth*, viz. *the Motion of the Succus Nutritius in the Nerves*; though it be a problem of great obscurity, yet doth the light, let in at the postern gate of Conjecture discover thus much, that it is not continual (as that of the blood in the Arteries and veins) but *by intervals*; nor violent, but *slow* and *gentle*; as the defect of any swelling on either side of a Nerve bound about, in a living creature, doth sufficiently manifest. Nor is it unreasonable to conceive, that in a short time after each meal, immediately upon the distribution of the Chyle through the *Venæ Lacteæ*, the Succus Nutritius is imbibed by the Nerves of the sixth Conjugation, and by them carried to the brain and Spinal Marrow. Which perhaps, is the reason, why alwayes, within an hour or two after meat, we perceive a certain dulness in our heads, together with an indisposition to motion, and a propensity to sleep, according to that proverb, When the belly is full, the bones would be at rest: and soon after,

ter, all thoſe vaniſh again, and we perceive our ſelves more light, ſtrong, and active than before our refection; becauſe then the nouriſhment begins to be diffuſed from the principle of Diſpenſation, outwards into the limbs and other parts of the body. And with this opinion agrees that obſervation of *Bartholinus* that the Lympheducts are more plainly diſcernable about five or ſix hours after meat, than at other times;as being at that time more filled with the ſuperfluities of the *Succus Nutritius*. Nor is it improbable, that the Brain and Spinal Marrow are chiefly nouriſhed in ſleep, and that then the Nutritive Liquor is uſually carried to them, relaxing them with its ſweet and mild vapours, and ſo both inducing and prolonging ſleep. From whence perhaps it comes, that after long ſleeps, we perceive our brains to be oppreſſed and beclouded with vapours,our ſenſes dull, and the motive-faculty enervated. Beſides, in ſleep all motions of humors flowing to the parts by the Nerves, ſeem to be ſuſpended; and yet the Circulation of the blood is certainly at that time more free and quick, than while we wake: So that It cannot be thought the cauſe of that ceſſation,but the Nerves onely, which intermit their office of diſtributing the Succus Nutritius, during ſleep. And all this will appear more reaſonable, if we reflect upon the flux of humors in the Nerves immediately after ſleep. For, then the Brain and Spinal Marrow re-contract themſelves, and become

more tense; so that the *Nutritive* liquor is from thence transmitted, partly to the members to be nourished, and partly to the Glandules; as well such as serve for the excretion of its absolute Excrement, as those that serve for the reduction of its relative, *viz.* its acrimonious parts, that are returned into the blood, for the reason formerly mentioned.

18. And what the *Causes* of that Motion, *viz.* the motions of the *Diaphragme*, of the *Brain*, and of the *Nerves* themselves.

And concerning the *Last*, viz. the *Causes* of this Motion of the *Succus Nutritius*; we may be allowed to conceive (at least, untill Time shall have dispelled that Obscurity, which yet surrounds this abstruse Theoreme, and the industry of some more dextrous Anatomist pierced deeper into the mystery of the Nerves; a subject not much lesse inscrutable, than the Nature of the Soul it self, which useth them as her principal instruments: we hope, we may have the liberty to conceive) that the *Succus Nutritius* is not imported to the brain and Spinal Marrow, nor exported from thence to the members, by any Attraction similary or Elective, against which we have formerly alleadged convincing arguments, unnecessary to be here repeated: but, as the blood, and indeed all other humors of the body are moved, by meer *Impulsion*, or *Protrusion*, the immediate Cause of all motions in Nature. And the Agents, in this case impelling, we conceive to be the motions of the *Diaphragme*, of the *Brain*, and of the *Nerves* themselves.

For since the *Depression of the Diaphragme*, is generally admitted to conduce to the distribution

bution of the Chyle out of the ſtomach, guts, *Venæ Lacteæ*, common Receptacle, and *Ductus Chyliferi*, ſucceſſively into the ſubclavian Vein: by alternately compreſſing all thoſe parts, and ſo compelling the Liquor contained in them, to flow upward; and indeed to all other Natural motions: why may not the ſame be thought ſufficient alſo to the Expulſion of the Nutritive juice, both out of the Præparing Glandules, into the Nerves of the Sixth conjugation and their Auxiliaries, and out of them into the brain and Spinal Marrow; their poſition being ſuch, as renders them no leſſe ſubject to compreſſion, by the deſcending *Diaphragme*, than the Venæ Lacteæ, common Receptacle, and other *Chyliferous* parts are?

If this ſeem difficult, we may have recourſe to the reaſon of the aſcention of a liquor from the bottome through all parts of a ſponge, cloath, or other filamentous ſubſtance (as is experimented in the percolation of *Aqua Calcis*, made by a long piece of woollen cloath, whoſe one end is dipt in the water, and the other hung over the brim of the veſſel containing it) which we have profeſſedly explained in the 356 *page of our Phyſiology*: and ſeems to be the ſame with the reaſon of the aſcention of the nutritive juice of all plants from the roots to the top of the branches.

And as for the *Motion of the Brain*; though it may ſeem to be no other, but what is impreſſed upon the brain, by the Pulſation of the Arteries (aſcending from the *Plexus Arte-*

rioſus mirabilis chiefly to the *Dura Mater*, and copiouſly diſſeminating themſelves upon it); yet, ſince it is credible, that the Pulſation of the arteries doth promote the flux of the liquor in the Nerves, in other parts, eſpecially ſuch, where Nerves are either contiguous, or neer enough to *Arteries*, to participate of their impulſe: why may not the motion of the Brain alſo, to which the Nerves are continued, ſerve to ex-preſs the liquor out of them, toward the parts wherein they are terminated? Beſides, it is moſt certain that immediately after ſleep, the whole Brain, together with the conjoyned net-work of its Nerves, becomes more tenſe and firme, than in ſleep, which ſeems to render it moiſt and lax: and ſince that Tenſion cannot but in a manner ex-preſs, or ſqueez forth, the liquor contained in the original of the Nerves, it is reaſonable to conceive, that the motion of the *Succus Nutritius* from the brain to the parts, is to be imputed thereunto; eſpecially it being by us obſerved, that the diffuſion of the nouriſhment is chiefly ſoon after we awake and riſe from ſleep.

And laſtly, as for the *Motion of the Nerves* themſelves; nothing is more manifeſt, than that, while the Nerves and Muſcles are diſtended in Voluntary motion, the juice contained in the Nerves muſt be impelled or ex-preſſed to the parts, into which they are inſerted; the extenſion of any nervous body, neceſſitating the flux of any liquor contained betwixt its filaments, from one extream to the other.

But,

But, this we deliver, not as doctrine, but meer *Conjecture*. Nor ſhould we have adventur'd to deliver it, but that we hope, that as the ſingular obſcurity of the Argument may incite ſome other more able brain to labour in the ſame ſcrutiny; ſo it may excuſe us, if we have not been ſo happy, as to light upon the knowledge of the true Cauſes, we ſought after; there being among Candid Spirits, not only pardon, but even commendation, due to ingenious Errors; eſpecially in things of Difficulty, and where the diſcovery of Truth is to be hoped rather from Time and multiplied Obſervations, than from the ſingle felicity of Witt.

OF

OF VOLUNTARY MOTION,

Exercitation the Eleventh.

Of Voluntary Motion, or the Use of the Muscles.

Article 1. The Inference, and Method of this discourse.

FRom *one* Use of the *Nerves*, viz. the conveying of the nourishment to all parts requiring it; we now transfer our contemplation to the *other*, viz. the *transmission of the Animal Spirits from the Brain* (the principal throne of the Soul, where she judgeth of the good or evill of objects; and from whence she dispenseth her commands) *to the Muscles*, the immediate and proper instruments of Motion Voluntary: and here, for the more perspicuity, we shall take the liberty of permitting our Curiosity to exspatiate it self a while in that delightfull and ample field, the admirable Art of Nature shewn in the *Structure* of those organs, in their *Variety*, and in the *Reason* of their Motions.

2. Requisites to Voluntary motion.

The things required to Voluntary Motion, are (1) the *object* communicated by the sense

to

to the judicatory Faculty, or Soul; (2) the *Soul* perceiving that object, judging it to be good or evill, and accordingly pursuing, or avoiding it; (3) the *Instrumentum Mediatum*, by which the Soul impresseth a motive-Faculty upon the Muscles, and immediately acteth, toward the attainment of her end; and (4) the *Instrumentum Immediatum*, by which immediately the motion intended is executed or effected.

3. That the *Animal Spirits* are the *Mediate* Instruments, by which the Soul moves the Muscles; argued from

Concerning the Exciting Cause, or object; and the primary Agent; there is, nor can be no dispute: it being most evident, that the Soul is the principle of Motion, and that it is excited thereunto by the good or evill appearing in the object. But, concerning the *Instrumentum Mediatum*, or that by which the Soul doth cause the Muscles to move either the whole body, or some member of it, in order to her embracing, or avoiding the object; many, especially of late yeers, have seemed very much to doubt. To satisfie them, therefore, in this particular; we (with all the Ancients) conceive, that the *Animal Spirits* sent from the brain, by the Nerves, into the Muscles, are the Immediate instrument of the Soul, whereby she doth impress an actuall motion upon the Muscles: and to evince the probability of this opinion, we offer these few, yet (in our judgment) weighty *Reasons*.

4. the *Mutation of Figure* both in the Muscle and Member moved:

(1) Voluntary Motion being nothing, but the willing translation of the body of an Animal, or some part of it, out of one place, into another;

nother ; it is neceſſary, the member moved ſhould meaſure the determinate ſpace betwixt the *Terminus à quo*, and the *terminus ad quem* ; and conſequently, that the proportion of the member moved, be anſwerable to the proportion of that intermediate ſpace: now from that neceſſary proportion, there ariſeth a *change* of *Figure*, as well in the member moved, as in the Muſcle moving (as we ſhall ere long demonſtrate by *Principles Mathematical*, in explanation and confirmation of the doctrine of our Maſter *Galen*, *in* 1. *de motu Muſculor. cap.* 8.) but that Mutation of Figure in the external inſtrument, cannot ariſe immediately from the Soul it ſelf: which being Immaterial, can of her ſelf produce no ſuch effect: and therefore it muſt ariſe from ſomething more proportionate to the immediate energy of the Soul, than either the groſsneſs of the member, or muſcles ordained to move it, will admit them to be ; which Something can be no other, than the Animal Spirits, whoſe ſubtility makes them to approach neerer to the nature of the Soul, and whoſe ſudden influx through the Nerves, into the body of the Muſcle, cauſeth a ſwelling or diſtention, and ſo a contraction thereof, and conſequently a change of Figure in the member.

5. the *Quickneſs* of voluntary motion.

(2) Since every Inſtrument ought to be accommodate, as well to the nature of the Agent which is to uſe it, as to the effect to be produced by the uſe of it ; and that Voluntary Motion is performed as it were in an inſtant and by

by a most swift and speedy Impulse from the soul: it followeth, that betwixt the incorporeal Agent, the soul, and those corporeal instruments, the Muscles, there must be some Intermediate instrument, such as is capable of being so transmitted from the Brain, into the Muscles, with the greatest velocity imaginable, and of setting them instantly a-work, according to the determination and direction of the soul. Now, no part of an Animal can be thought capable of such easie and expedite *Mobility*, but the *spirits*, which flow through the body in less than the twinckling of an eye: and therefore, we conclude, that They are the Immediate instrument of the soul, in voluntary motion; according to the assertion of *Galen* (*in* 4. *de locis affect cap.* 6.) in these words; *Est in cerebri ventriculis Spiritus, Animæ primum instrumentum, quo & sensum & motum per universas corporis partes Anima transmittit, &c.*

6. the conquest of the acting Muscle, over its Antagonist.

(3) As the Power or Faculty of Seeing doth not reside in the Eye, nor that of Hearing, in the Eare, &c; but is imparted to the organs of sight, and hearing, from the soul, by the mediation of Nervs and Spirits: so likewise is not the Virtue Motive inhærent in the Muscles, but communicated to them upon occasion, from the same soul, and seems to consist wholly in the quick afflux of spirits, as that by which alone they are moved. Which *Galen* also doth not obscurely intimate (*in* 1. *de mot. Muscul. cap.* 8.) where he saith, *Æquipollens musculorum motus fit, quando neuter tonum Animalem habet auxiliarem;*

auxiliarem; non-æquipollens verò, cum alter solus dominatur: quare necessum est, ut vincat contractio illius musculi, qui ab Animali Facultate adjuvatur. For, what can be understood by this *Tonus Animalis*, or *Facultas Animalis*, unless it be the distension of the conquering muscle by Animal spirits, sent from the brain, at the pleasure of the Soul?

7. the *swelling* of each Muscle, when it moveth.

(4) What's the reason, that a muscle is never moved, but it becomes more hard and swelling in the middle, than before (as is most evident in both the Masseter and Temporal Muscles, when we chew our meat) unless because it is then filled and distended with a greater gale of spirits, issued out of the store-house of the Brain? For, it seems more reasonable, that this swelling in the body of the Muscle is the Cause of its Contraction; than, on the contrary, that the Contraction should be the cause of the Swelling, as those contend who would have the motion to be performed without the afflux of spirits.

8. the privation of motion in a Muscle, whose *Nerve* is cut off.

(5) If a Nerve be cut asunder, the Muscle into which it was inserted, doth for ever become uncapable of motion; and this, certainly, for no other reason, but because the intercourse of the spirits betwixt the brain and that particular Muscle is wholly destroyed. So that we may well conclude, that the Soul cannot cause voluntary motion, but by the distribution of Animal spirits, through the Nervs, into the Muscles.

The necessity of Animal spirits, as the Immedia

mediate Instrument of the soul, thus appearing; we are next to speculate the Conditions requisite in the Immediate Instrument of the Motion it self: that so we may come to a clear understanding both of the structure and diversity of the Muscles, and at length of the reason of their moving the members, the thing at which our Scrutiny is chiefly levelled.

As for the requisite *Conditions*, therefore, of this last Instrument, we observe,

9. why a Muscle is composed for the most part of *Flesh*.

(1) That in an organ of voluntary Motion is required such a Constitution, as may render it fit to receive the Animal spirits, at the pleasure and command of the soul. Which makes it manifest, that a hard, inflexible, and bony substance is most incompetent to an instrument of motion; for which reason, perhaps, *Galen* adventured to affirme, that any part made hard and stiffe by a thick Cicatrice, becomes unfit for motion: and that it must be such a part, as being soft, rare, spongy, and flexible, and distinguished with multitudes of Fibers, may most easily and readily admit the Gale of spirits flowing into its substance, and be by them filled or distended. Which is the reason, why the substance of the Muscles is for the most part *Fleshy*; than which no part, is more soft, rare, flexible, and distendible: as *Galen* hath observed (*in* 1. *de usu part. cap.* 13.)

10. of a *Nerve*.

(2) Lest the spirits might flow into this flesh, indeterminately or at randome and scatteringly; there ought to be such peculiar vessells or Conduits, which being continued from

the brain or ſpinal marrow, quite home to the Fleſh, into which they are inſerted, may both carry the ſpirits thither, and preſerve them from ſtraying or diſperſing by the way; and by which the Soul, or Regulating Faculty, principally reſiding in the brain, the original of the Nervs, may rule the members, as a Coachman rules his horſes by the veins of his bridles; that we may uſe the ſame compariſon with *Galen*, (1. *de mot. muſculor. cap.* 1.). Now, the *Nervs* being the only parts of the whole body thus qualified, Nature moſt wiſely inſerted one, or more of them, into each Muſcle. So that from this conſtitution of the Nervs, it appears, that they make the ſecond Eſſential part of a Muſcle. Nay, according to ſtrict truth, we may adventure to ſay, that the Fleſh and Nerve are the principal ingredients required to compleat the eſſence of a Muſcle: becauſe there are ſome Muſcles (*viz.* thoſe of the Temples, of the Forehead, of the Eyes, of the Bladder, of the Fundament, &c.) in whoſe bodies are neither Tendons, nor Ligaments to be found, but only Nervs, and Fleſh diſtinguiſhed with various Fibres.

11. Of a *Ligament.* (3) Becauſe in ſome Members, by reaſon of their Gravity, there is a greater reſiſtence to motion, than the Muſculous Fleſh (in reſpect of its ſoftneſs and tenderneſs) is able to overcome; therefore ought there to be an addition of ſome ſtronger and tougher ſubſtance, which being connected or united to the Fleſh of the Muſcle, may both corroborate the ſame, and firmly

firmly conjoyn it to the bones, so as to enable it to move the ponderous member, to whose bones it is fastned. Now, this Nature foresaw, when she furnished some Muscles with *Ligaments*, especially such as were ordained to bear great stress, in moving the greater and more weighty members. Which *Galen* most elegantly expresseth thus; *Ut enim ossa, quæ dearticulantur, exactè simul ligarentur ac continerentur, ne facilè in motibus vehementioribus à sese abrumperentur; Ligamentum, quoad maximè potuit, durum, atque ab injuriis remotissimum efficere oportuit: ut autem ossibus à Musculis tractis promptè obsequeretur, molle rursus esse oportuit, atque ob id ipsum imbecillum. Atqui, forte quidem imbecillo, ac durum molli est contrarium. Quænam igitur fuerit in his Naturæ solertia, quæ corpus invenit, quod commoditatem utramque haberet, idemque ab injuriis tutum esset; ex ipsa Anatome discas, licet,* &c. 12. *de usu part. cap.* 2.

12. Of a *Tendon*:

(4) Besides the connexion of the Musculous Flesh to the bone, by the mediation of a Ligament, there must be also something to render it prompt, easy and agile in its motion, so as to answer the celerity of the influx of the Spirits, and to fulfill the command of the Soul, as it were in an instant. Which Nature reflecting upon, superadded also a *Tendon*, or Chord, which in respect both of its subtility, and of its tough and strong Contexture, or substance, and also of its connexion to the joynt, doth make the motion more facile and quick, than otherwise it could possibly be;

as

as appears in the Muscles of the Hands and Feet, &c.

13. of a *Membrane* investing it:

(5) That these parts named, *viz.* the Flesh, Nerve, Ligament and Tendon, might not be endangered by lying uncovered or confused; therefore hath Nature cloathed the whole Muscle with a proper *Membrane* or *Coat*: which hath these two further **Uses**, that it causeth the Muscles that are contiguous, to slip up and down easily and without interfearing each other, and preserves the spirits immitted into the body of the muscle moved, from passing quite through, or dispersing themselves, which they are apt to do, both in respect of their subtility, and of the force of their impulse.

14. and of *Arteries* and *veines*.

(6) And lastly, since this organ of voluntary Motion is to be continually supplied with life, as being *pars corporis vivens*; therefore is it provided of Arteries and veins: those to bring in the vital blood, by whose irradiation all parts of the muscle are made participant of life; and these, to return the blood to the Heart, therein to receive a new impression of life.

15. That a Muscle is the *Immediate Organ* of Motion Voluntary.

Now, seeing that in the whole body of an Animal, there is no other part that hath any the least title to this Description; it is undeniable, that a Muscle is the adæquate or proper and immediate instrument of Motion voluntary: and may conveniently be defined to be, *A part of an Animal, endowed with life, composed of a Nerve and Flesh, and frequently also of a Ligament and Tendon covered with a membrane,*

and

and so framed to be the proxime organ of voluntary Motion. And thus much of the *Structure* of the Muscles.

As for the next Considerable, the *Differences* of the Muscles; they are many, as being desumed from their substance, quantity, figure, situation, original, insertion, Fibres, parts, Use and Action.

16. *Differences* of Muscles, in respect of their substance.

In respect of their *Substance*, some Muscles are mostly composed of *Flesh*, as the *Sphincters*, and the Muscles of the *Tongue*: others are mostly *Nervous* and *Membranous*, as the *Fascia lata* abducing the leg, &c.

Quantity;

In respect of *Quantity*, which comprehends the 3 dimensions of Longitude, Latitude, and Profundity. Some are *Long*, as the *Musculus rectus* of the Abdomen, the *Thylers* Muscle in the thigh: and others *short*, as the *Musculi Pyramidales* in the bottom of the Abdomen. Some are *Broad*, as the *Oblique* and *Transverse* Muscles of the Abdomen, the *Latissimus dorsi*, *brachium deprimens*, &c: others *Narrow*, as the Muscles of the *Fingers* and *Toes*, &c. Some *Thick*, as the two *Vasti*, or Huge Muscles in the thigh: others *Thin* and slender, as the *Musculus Gracilis* bending the leg, &c.

Figure;

In respect of *Figure*, some are *Triangular*, some *Square*, some *Pentagonal*, some *Pyramidal*, some *Round*, some *Oblong*, and others of other shapes; as the Muscles *Deltoides*, *Rhomboides*, *Scalenus*, *Trapezius*, &c.

Situation;

In relation to their *Situation*, some are *Right*, some *Oblique*, some *Transverse* (understand it in respect,

respect of their Fibres) some *Above*, some *Below*, some on the *right* side, some on the *left*, some *before*, and some *behind*. Where we may note in the general, that oblique muscles serve to oblique motions, Right to exact Flexion, or Extension; and such as are seated within, conduce to Flexion; and such as are posited without, to Extension.

Origination; In respect of their *Original*; some arise from *Bones*, and that either from the *Heads* of them; as most of the greater Muscles; or a little below, or from the *Glene*, some *sinus* or small hollowness in the bone: some only from *one* single bone, some from *two* or *three*: some from *Cartilages* or Gristles, as the Muscles proper to the *Larynx*: some from the *Membrane* enshrouding the Tendons, as the *Musculi vermiculares*: and others from other parts, as the *Sphincters* of the Bladder, and Fundament.

Insertion; Their *Insertion* considered; some are inserted into *Bones*, some into *Cartilages*, as the Muscles of the *Eye-lids*, and of the *Larynx*; others into a *Membrane*, as the Muscles moving the *Eyes*; others into the *skin*, as those of the *Lips*: some arising from divers parts, are inserted only into one; and on the contrary, some arising only from one part, are terminated in many.

Parts; In respect of their *Parts* (by which we must now understand not only such, whereunto as chief ones every Muscle is divided, but those also upon which it is seated); there are various differences. The parts into which each Muscle

is

is commonly divided, are the *Head*, or Beginning; the *Belly*, or Middle; and the *Tail*, or Tendon. Most Muscles have but one Head; yet some have two, others three: whence they are called *Bicipites*, and *Tricipites*. Most have but one Belly, yet some are double-bellied, as the Muscle shutting the *lower jaw*, of the Bone *Hyoïs*, whence they are named *Digastrici*. The Tendons of some are broad and membranous; of others, round; of others, short; of others, long; of some, perforated; of others, intire; of some, single; of others, multiplied. Sometimes you shall find many Muscles ending in one and the same Tendon; as, in the Leg, the *Gemelli* or Twin-Muscles, and the *Solaris*, are united into one Chord. Lastly, from the parts upon which they are seated, they sometimes borrow their names; as the *Crotaphitæ*, or Temple-Muscles; the *Rachitæ*, or *Spinati* of the back; the *Iliaci*, &c.

According to the variety of their particular *Actions*, the Muscles admit of a triple Difference. Whereof the *First* is, that some are *Congeneres*, or *Confederates*, which both conspire to one and the same motion; as when two are Flexors, two Extensors; one possessing the right, the other the left side of the member: and others *Antagonists*, which have motions contrary to those of others; there being scarce any one Muscle, which hath not its Contrary, or Opponent; as to every Flexor is opposed a Tensor; to every Elevator, a Depressor; to every Adductor, an Abductor; excepting only and Actions.

the two Sphincters, and the Cremasters. The *Confederates* are generally equal in magnitude, number, and strength: the *Antagonists not*, but different, according to the weight of the part to be moved, and the vehemence of the motion. Thus, the Muscles bowing the Head, are only Two; while there are Twelve to lift it up; and those that shut the lower jaw-bone with the upper, are many, but those that open it, are only two; for the weight of heavy bodies doth facilitate their falling downe. The *Second* is, that some Muscles move only Themselves, as the two Sphincters: others somewhat else besides themselves. And the *Last* respecteth the peculiar motions of particular Muscles; whence some are called *Benders*, some *Extensors*; some *Elevators*, others *Depressors*; some *Adductors*, others *Abductors*; some *Rotators*, some *Circumactors*, some *Masseters* or Eaters, some *Cremasters* or Hangers, some *Sphincters* or Constrictors, &c. And thus much concerning the several *Differences* of the Muscles.

17. That the *Reason* of the motion of the Muscles, cannot be explained, without having recourse to *Mathematical* principles.

As to the *Reason* and *Manner* of their Motion (an Argument, as singularly delightfull, so singularly difficult) forasmuch as the Locomotion of the whole body, or any one member of it, being considered *per se*, meerly as Motion, without reflecting upon the end of it, seems to be an effect purely *Mathematicall*, as well because it is a Commensuration of the length of the space betwixt the *Terminus à quo*, & *ad quem*, as becaufe it is a resistence and overpowering of *Gravity*: therefore shall we lay down

down some few *Mathematical principles*, of plain concernment in the explication of it, such as without which our disquisition into the nature of Voluntary Motion would be obscure and unsatisfactory.

Fundamenta Geometrical.

18. Principles *Geometrical*, of necessary importance toward the understanding thereof.

Proposition, 1.

What are equal to the same, are equal also among themselves: *& è contra.*

Proposition, 2.

All right lines drawn from the Center to the Circumference, are equal.

Proposition, 3.

Two right lines whatsoever, mutually cutting each other, make, at the *vertex*, Angles equal among themselves.

Proposition, 4.

The squares of equal lines, are equal.

Proposition. 5.

A right line, falling upon two right lines æquidistant, or parallels, makes equal Angles.

Proposition, 6.

In Triangles, where the Angles are equal, the sides also are equal and proportional.

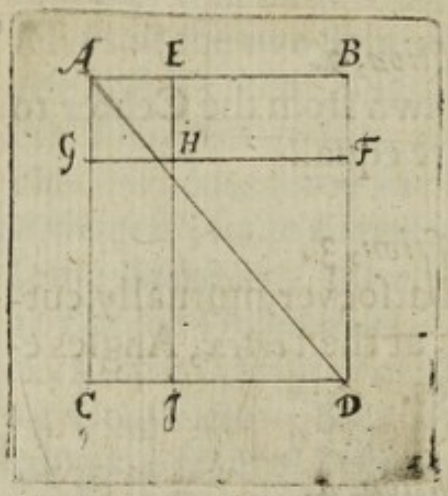
propoſition, 7.

In a Triangle, where any one Angle is greater; there the ſide ſubtending that Angle, is alſo greater.

propoſition, 8.

In every Parallelogram, the Complements of thoſe Parallelograms, that are about the Diameter, are equal among themſelves.

Demonſtration.



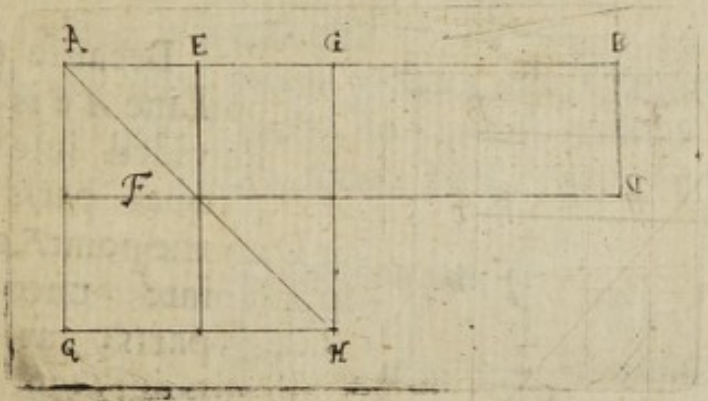
Suppoſe *A B C D* the Parallelogram; *A D*, the Diameter or Dimetient; and the ſupplements *H B*, and *H C*. We ſay, the ſupplement *H B*. is equal to the Supplement *H C*. becauſe the Parallelogram hath for its Diameter *A D* : and therefore the Triangle *A B D*. is equal to the Triangle *A. C D*. Again, becauſe *A E G H*. hath its diameter *A H*. therefore the Triangle *A G H*. is equal to the Triangle *A E H*. By the ſame it is demonſtrated, that the Triangle *H F D*. is equal to the Triangle *H I D*. Now, ſince the Triangle *A G H*. is equal to *I D*; and *E H G*. equal to *F D I*: it followes, that the ſupplement *H B*. is equal to *H C*. Which was to be demonſtrated.

Pro-

proposition, 9.

If a streight Line be divided into parts equal and unequal; the Parallelogram, that is contained in the unequal segments of the whole Line given, together with the square of that which is between the segments, will be equal to the square described by the half Line.

Demonstration.



Let the right line be *A B*, divided into equal parts, at the point *C*; and into unequal, at the point *E*. Let from the point *A*, to the proportion of the equal segment, be made a square *A C G H*; and from the point *E*, on the unequal segment, be drawn a parallel line *E F*; and from the point *A*, the Diameter or Dimetient *A H*; and a parallelogram *E F B D*. We say, the Parallelogram *E D*. with the square *F H*. is equal to the square *A H*: which is proved from the Antecedents.

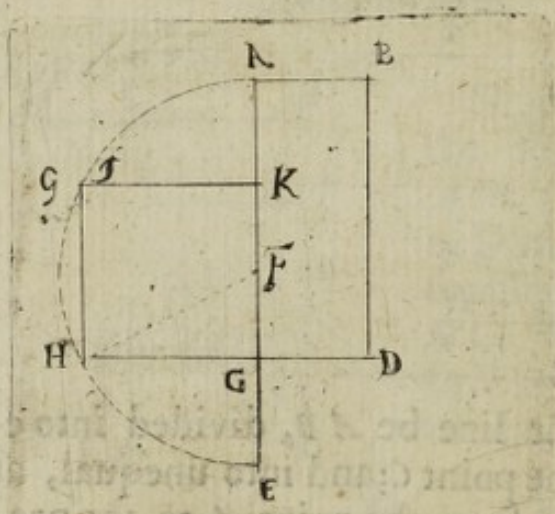
proposition, 10.

To make a Square equal to a Parallelogram given.

Let

Let the Parallelogram be *A B C D*. To which to find a ſquare equal, draw a line from *C* to *E*, to the proportion of *G D*; and divide *A E* into equal parts into the point *F*. from whence make a circle *A G E*; and continue the line *C D* to the point *H*. We ſay, the Line *C H*. is the roote of the ſquare *I K C H*. which is in equal proportion to the Parallelogram *A B C D*.

Demonſtration.



Becauſe the Line *A E* is divided into equal parts at the point *F*. and into unequal parts, at the point *C*; and the Parallelogram contained in the unequal ſegments, together with the ſquare *F C*, is equal to the ſquare *F H*. or *F E*. the equal ſegment, according to the ninth propoſition precedent: it followes, that the Parallelogram *A B C D*. is equal to the ſquare *I K H C*. according to the 47. *propoſition*. 1. *lib. of Euclid*. Which was intended.

Funda-

Fundaments *Architectonical*, out of *Vitruvius*, lib. 10. cap. 8.

19. Principles *Architectonical*, of the same Concernment.

Proposition.

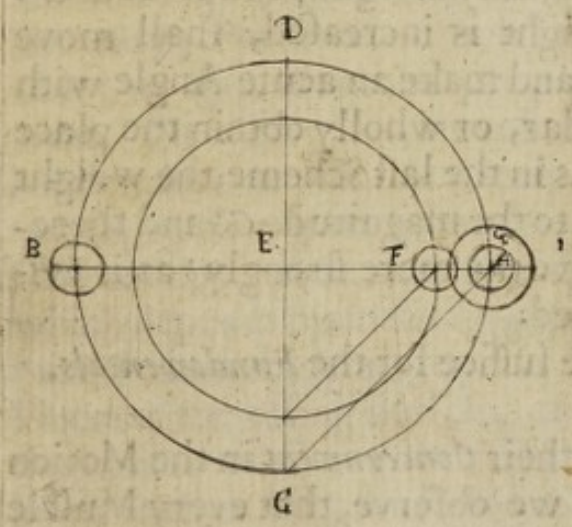
1. In the Center all Gravity ceaseth; so that therein nothing is either Heavy or Light.

2. The power of all Motion is varied, according to the ration of the Center to the Circumference.

3. By how much the more remote or elonged from the Center, any thing is; by so much the swifter is it moved.

4. By how much greater the Circumference of the Circle, so much greater the Diameter, and so much swifter the Motion.

Demonstration.



Let the Center be *E*. from which under the Diameter *E F*. let the weight be placed at *F*. We say, this weight at *F*. doth not rest there, but moveth to its Center, towards *C*. Again, if the same weight be elonged, or removed to *A*; then by reason of its greater

greater distance from *E*, and of the greater Circle; it will be moved towards its Centre *C*, with the greater velocity accordingly.

5. Bodies equal, and under the same Diameter; equally distant from the Center ; do cutt a perpendicular Line at right Angles.

Demonstration.

In the former Scheme, let one body be at *B*, and another at *A*. upon the Diameter of the Circle, whose Center is *E*. and neither of them shall move, because their Gravity is equall, in that proportion of the Diameter, and so hasten to the Center *C*. with equal swiftness ; but, because they make equal Angles with the perpendicular *D E*.

6. If to one of two equal bodies, placed under the same Diameter, and equally distant from the Center, any weight be superadded ; that, whose weight is increased, shall move more strongly, and make an acute Angle with the perpendicular, or wholly obtain the place of the Center: as in the last Scheme, the weight *A* is encreased to the magnitude *G*; and therefore it must move the more strongly ; as is evidently concluded.

And let these suffice for the *Fundamentals*.

To come to their *Concernment* in the Motion of the Muscles, we observe, that every Muscle hath a twofold Motion, *viz.* one *Natural*, wherein the Fibers of the muscle spontaneously recontract themselves, after they have been exten-

extended, or restore themselves to their native tenour; by Philosopher named, the motion of *Restitution*, common to all *Tensile* bodies: and this is alwayes from the end, towards the beginning of the Muscle, according to the position of its Fibers: another, *Animal*; wherein the same Fibers are further Contracted, by the forcible and copious influx of Animal spirits, at the command of the soul, in order to the performance of some action intended.

20. That every Muscle hath a Twofold Contraction, viz. *Natural* and *Animal*.

That the Natural Contraction of a Muscle, is not sufficient to voluntary Motion, though we allow every muscle to be made upon the stretch, *i.e.* in an extended position; is manifest from hence, that betwixt each Muscle and its Antagonist, there is an equal power of naturally-moving themselves toward their originals; so that betwixt two Contrary forces, the one drawing one way, the other the clean contrary, the member must be held immoveable; as appears in the 5th. *propositi. Architectonical.* Necessary it is, therefore, to voluntary Motion, that one Muscle over-power the other, not by reason of its spontaneous or Natural Contraction, but of its impressed or Animal; which depends upon the supply of spirits transmitted from the brain, by the Nerves into the Fibers of the acting muscle, and so-distending them, as to cause the whole Muscle to shorten or contract it self. And, that the power of Antagonists is, as we affirme, naturally equal; may be concluded from hence, that if one Muscle be cut off, its Antagonist instantly

21. That the Natural Contraction is not the cause of Voluntary Motion; but only the *Animal*.

drawes the member to its side, which before was held in the middle, and as it were æquilibrated betwixt them.

22. That in Motion, are Two Terms, one *Fixt*, the other *Moveable*; the last of which is sometimes more, sometimes less remote from the former, according to greater or less resistence of Gravity in the member to be moved, and vehemence of the Motion.

Secondly, we observe; that in all Motion there are *two Terms* to be acknowledged, the *one* is the *point of Rest*, or the Fundament, in which the muscle is firmed or fastned, because all motion is *super aliquo Quiescente*: the *other* is in *parte Mobili*, or insertion of the muscle, from whence the Muscle, by contraction, drawes the member toward it self; and this is sometimes less, sometimes more remote from the Center, or point of rest, according to the less or greater resistence of Gravity in the member to be moved, and according to the less or greater vehemence required to the motion. Which Nature (whose Art is not more admirable in any thing, than in her proportioning the length of the insertion of each muscle, from the Hypomochlion or point of Rest, to the Gravity of the member to be moved) respecting; most ingeniously contrived a way to compensate the slender strength of divers muscles, by inserting them at great distance from the Center of their motion, or that point, about which the member is to be moved. For, since (according to the 1. *propositi. Architectonical*) *there is no motion in the Center*; we may easily understand, why in many muscles, ordained for strong motions, the *Terminus stabilis*, or original, is more remote from the *Terminus Mobilis*, or insertion, than in others framed for motions less strong; *viz.* that by even a small force

force, the muscle (which, considered in its proper bulk, or in any other position, would be insufficient to the effect designed) might elevate a great weight, as we see in the muscles of the Hand, Arme, Thighs, and other parts. For this reason also is it, that in some bones we have certain *prominences*, or Buttings forth in the end, called *Epiphyses*, and *Apophyses*, to which the muscles are fastned. The truth of all which is evinced by the 2d *and* 3d *propos. Architectonical.*

These things being thus firmly established, it appears an undeniable truth, that no motion can be made, without changing the Figure of the muscle. For, since equal Angles subtend equal sides, by the 6th *Geometrical Proposition*: it followes necessarily, that in all motion, the Figure of the member moved, is changed.

23. No Motion without change of Figure.

And, because the change of Figure doth depend on the change of Angles; therefore must we admit a threefold Figure, as there are three sorts of Angles, *viz.* (1) a right, in which neither of the two opposite muscles acteth; (2) an obtuse, which being greater than a right, is consequently subtended by a greater side; and (3) an acute, which being less, requires a less subtending line.

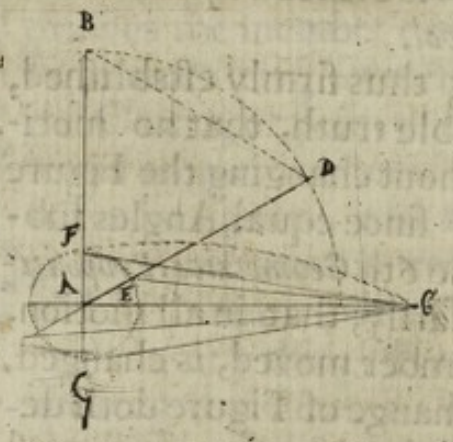
24. Which is Threefold, respective to the difference of Angles.

Now, forasmuch as in the *Middle* Figure, no motion can be made, because then both the opposing Muscles are equally extended: we are to demonstrate, how it is effected in both the *Extreams*. And this, certainly, is done when one of the acting Muscles is filled or distended

25. All motion is made in one of the Two *Extream* Figures; and how, demonstrated.

ſtended by the Animal influx, more than its Antagoniſt, whereupon the Figure of the Conquering muſcle is changed; and the Angle of Articulation is made more Acute, or leſs, by that Contraction; and that ſegment, detracted from the line, is in proportion to the ſpace comprehended. For Example.

Demonſtration.



Imagine the Brachium, or upper halfe of the Arme, from the ſhoulder to the elbow, to be *C A*; and the Cubit, or lower half from the elbow to the hand, to be A B: the Muſcle bending the Arme, to be *C F*: and its Antagoniſt extending it, to be *C G*: and the object to be apprehended by the hand, *D*. Now, we ſay, while thoſe two oppoſite Muſcles *G F.* and *C G.* are equally contracted, the Appetite muſt fail of being ſatisfied, *i. e.* the hand cannot be brought to lay hold on the object deſired; becauſe the Figure or Angle of Articulation remains invariable. But, that the hand may be raiſed to the object, it is neceſſary, that Angle ſhould be made more Acute, by contraction of the Muſcle *C F.* in proportion to the motion of the line *B D*: and

becauſe

because that Angle is less, therefore is the line subtending it also less, or shorter; according to the 5th and 6th propositt. Geometrical. And, since the Line *E F.* is in proportion to the Line *D B:* it followes that so much is to be detracted from the length of the Muscle: yet, we are not to suppose, that this detracted portion of the Muscle is to be wholly cast away; in regard, then it would be uncapable of the like or any other motion ever after: but, that being plumpt up or filled with a gust of spirits, it is incurvated, or made Convex by that distension; and that line, which before was streight, is now changed into an Arch, and consequently made shorter.

Moreover, since there are 3 Dimensions, Longitude, Latitude, and Profundity; and that it is not any one, but all of these, that determine the Figure of a Muscle: it followes, that all Muscles, while they are contracted, are as much encreased in Thickness and Latitude, as they are diminished in Longitude. Which may be naturally inferred from the importance of the 5. 7. 8. 9. and 10. propositious Geometrical; where a square is found equalto a Parallelogram.

25. That a Muscle, in contraction, is encreased in *Latitude* and *Profundity*, proportionately to its diminution in *Longitude*; demonstrated.

Demon-

Demonstration.

Let the Parallelogram be *A B C D.* representing the Muſcle Biceps, of the Arme, as it is extended; and a Square equall thereunto, *B E G F*, repreſenting the ſame Muſcle, as it is contracted. We ſay, that the Muſcle, in its ſecond Figure, or Contraction, hath loſt nothing of its bulk, that it had in the firſt Figure, or Extenſion: but, becauſe the Square of the muſcle, *B E G F.* is equal to the Parallelogramme, *A B C D*; therefore it followes, that the ſuperfice of the muſcle is the ſame, and that the part *G D.* changed in its Latitude, is in proportion to the Line *A D.* which determin's the Local motion.

26. **The Neceſſity of Antagoniſt-Muſcles.**

Reflecting upon what hath been ſaid, we ſoon diſcover, *why each Muſcle generally hath its Antagoniſt*; there being contrary motions to be performed ſucceſſively by every member, and

it

it being impoſſible, one and the ſame Inſtrument ſhould ſuffice to both. Now of theſe Antagoniſts one doth bend the member, by Contracting it ſelf; and the other by its contraction doth extend it: and both extend each other ſucceſſively: that which is contracted, doth alwayes act, and that which is extended, doth not act, but ſuffer, and is transferred with the part moved.

27. How Circular Muſcles are Contracted.

But here we are to except ſome Muſcles, which ſeem ſo ſufficient to the motion of the part into which they are inſerted, as to have no need of Antagoniſts; as all *Circular* muſcles, whoſe motion is eaſily underſtood from the mathematical principles premiſed. For, ſince a Circular muſcle hath circular Fibres, and that all contraction is made *ſecundum continuitatem lineæ*; it followes, that ſuch muſcles ſhut the part to which they are affixed, by contracting themſelves toward their Center; as may be obſerved in the Sphincters of the Bladder and Fundament, and in the Round muſcle of the Eye-lids.

28. Why the Sphincters have no Antagoniſts.

Onely it may be enquired, Why thoſe *Sphincters* have no Antagoniſts, as the *Clauſor Palpebrarum* ſeems to have, the *Elevator* opening the eye-lids, as the *Clauſor* ſhuts them? Whereof the Reaſon certainly is this, that both the Bladder and Fundament are not opened by muſcles, but by the quantity of Excrements contained in them, which being preſſed or detruded downward by the Diaphragme and muſcles of the Abdomen, force open the Sphincters,

Sphincters, by extending their Fibers from the Centre to the Circumference; so that to speak strictly, the excretion of the Urine, and of the Excrements of the belly, are not actions *immediately* voluntary, as the opening of the Eyelids is.

29. Conclusion. And this is all we thought necessary to be said, concerning the Use of the muscles, in *general*, and concerning the admirable Geometry observed by Nature in the Fabrique of them.

Should we extend our discourse, to the accommodation of the Figure and motion of each particular muscle in the whole body, to the Geometrical, and Architectonical principles premised: as we should abuse your Patience, so should we disparage your Capacity of making use of the same Clue for your guidance through the whole Labyrinth of Voluntary Motion, that we have put into your hands for your more easily entering into it. We shall conclude, therefore, with this due acknowledgment; that the *Omniscient Creator hath made all things, as in the Greater World, so also in the Lesser, Man*, in Number, Weight, and Measure.

THE

Galen. in 2. de Motu Muſculor. cap. 5.

QUi evidentibus fidem abrogat, ſenſûs eſt expers ; qui verò de dubiis promptè pronunciat, temerarius eſt ; qui autem, propter obſcuritatem, quæ in his ineſt, quæ etiam clara ſunt & manifeſta, habet ſuſpecta ; de numero eorum eſt, qui dubitationibus oblectantur. Porrò, qui non modò quæ ſuſpecta habet ; verùm etiam quæ clara ſunt, propter obſcuritatem dubiorum, ſtudet evertere ; extremè fatuus eſt. Ne igitur ſponte ſenſum nobis ipſi adimamus, neque dubitationis æmuli, aut fatui, aut aliud ejuſmodi quidvis ſimus ; ſed quod tum rectum eſt, tum modeſtis Hominibus convenit ; quod quidem evidens eſt, promptè accipiamus ; quod autem dubium eſt, per ocium quæramus. ¶.

Errors of the Presse, Correct thus.

PAge.1.line.20. read *Plastique.*
page.5.line.1,read Aristoteleans.
page.8.line 2.read *Void*, and line 20. read δεσικὴ.
Page.10. line. 7. read *Homœmerian.*
p. 13. l. 10. read ructus acidus,and l.25. one and the same,&c.
page.15.line 9.read difficultly.
page. 17.line.13 read *Pecquet.*
page.26.line.29.read *Pecquet.*
page.31.line. ult. read,other branches
page 40.line.4. read, its own nature,&c.
page.61.line.13.read,apposition.
page.64.linc.4.read,*Venom.*
p. 72. l. 1. r.*Slegelius*,and the same,line.12.
page.77.line.penult.read,only thus much.
pag.83.line.18.read,draw themselves,&c.
page.86.line.22.read *Fracastorius.*
page.89.line.29.read lax.
page.95.line.17.read voided.
page. 114. line.7.read *Capsula.*
page. 116. line. 10. read Nerve.
page.157.line.19.read Nerve.
page.190.line.8.read,veins.
page.192.line.ult. read,covered.
page.193.linc. 17.read *Taylors* Muscle.

THE CONTENTS.

Exercitation the Second.

Of Chylification.

Exercitation the Third.

Of the journey of the Chyle.

Exercitation the Fourth.

Of Sanguification.

Exercitation the Fifth.

Of the Uses of the Blood.

12. *The*

Exercitation the Sixth.

Of the Motion of the Blood, its Conditions and Causes.

Exer-

The Table.

Exercitation the Seventh.

Of the Depuration of the Blood.

Exercitation the Eighth.

Of Respiration.

4. *The*

Exercitation the Ninth.

Of the Lympheducts.

Exercitation the Tenth.

Of the Distribution of the Nourishment through the Nerves.

Exer-

The Table.

Exercitation the Eleventh.

Of Voluntary Motion.

19. *Prin-*

FINIS.