

The anatomical exercises / of Dr. William Harvey ... concerning the motion of the heart and blood. With the preface of Zachariah Wood ... To which is added Dr. James de Back his Discourse of the heart.

Contributors

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ANATOMICAL
EXERCISES
—
HARVEY



1673

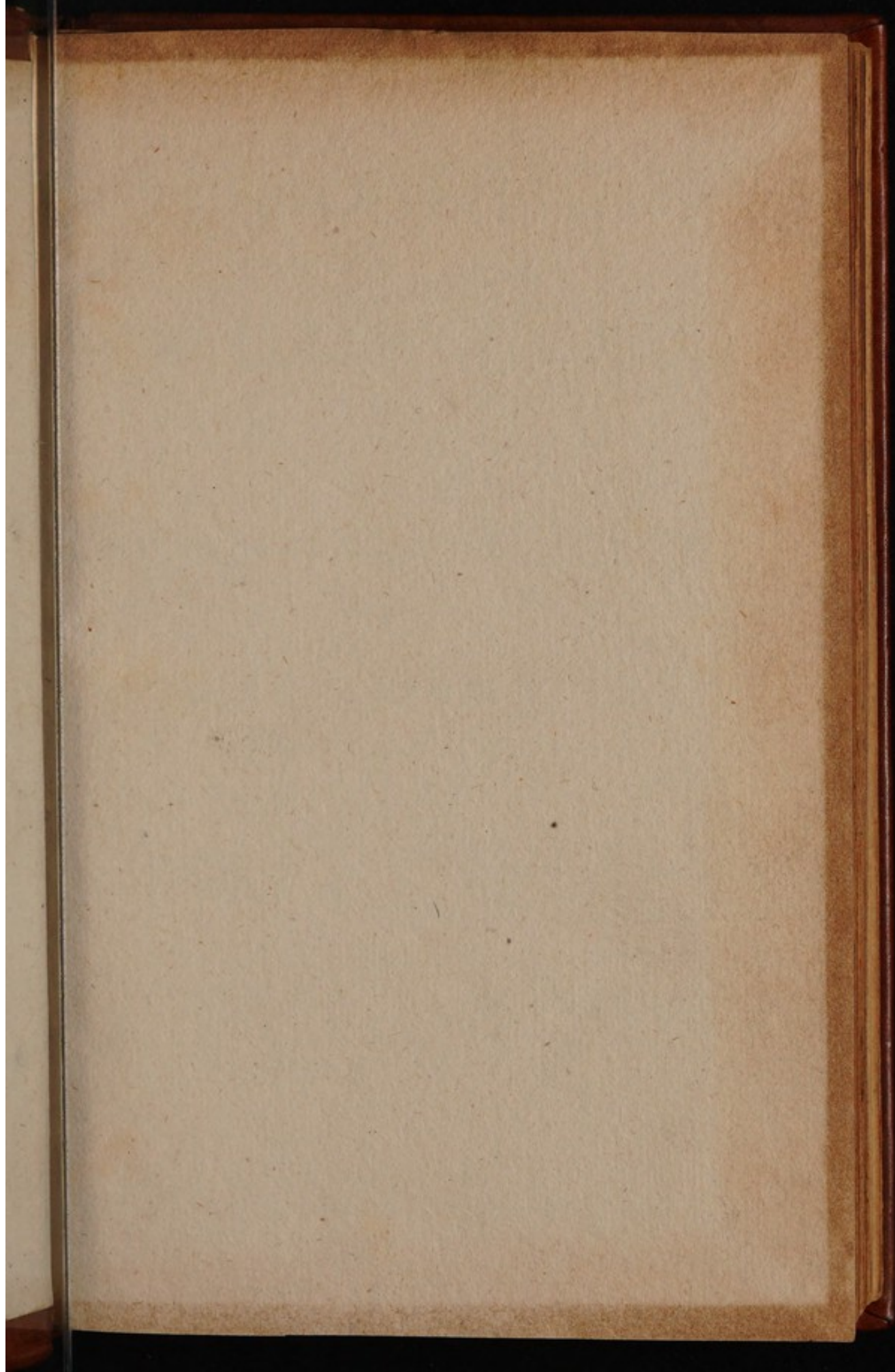


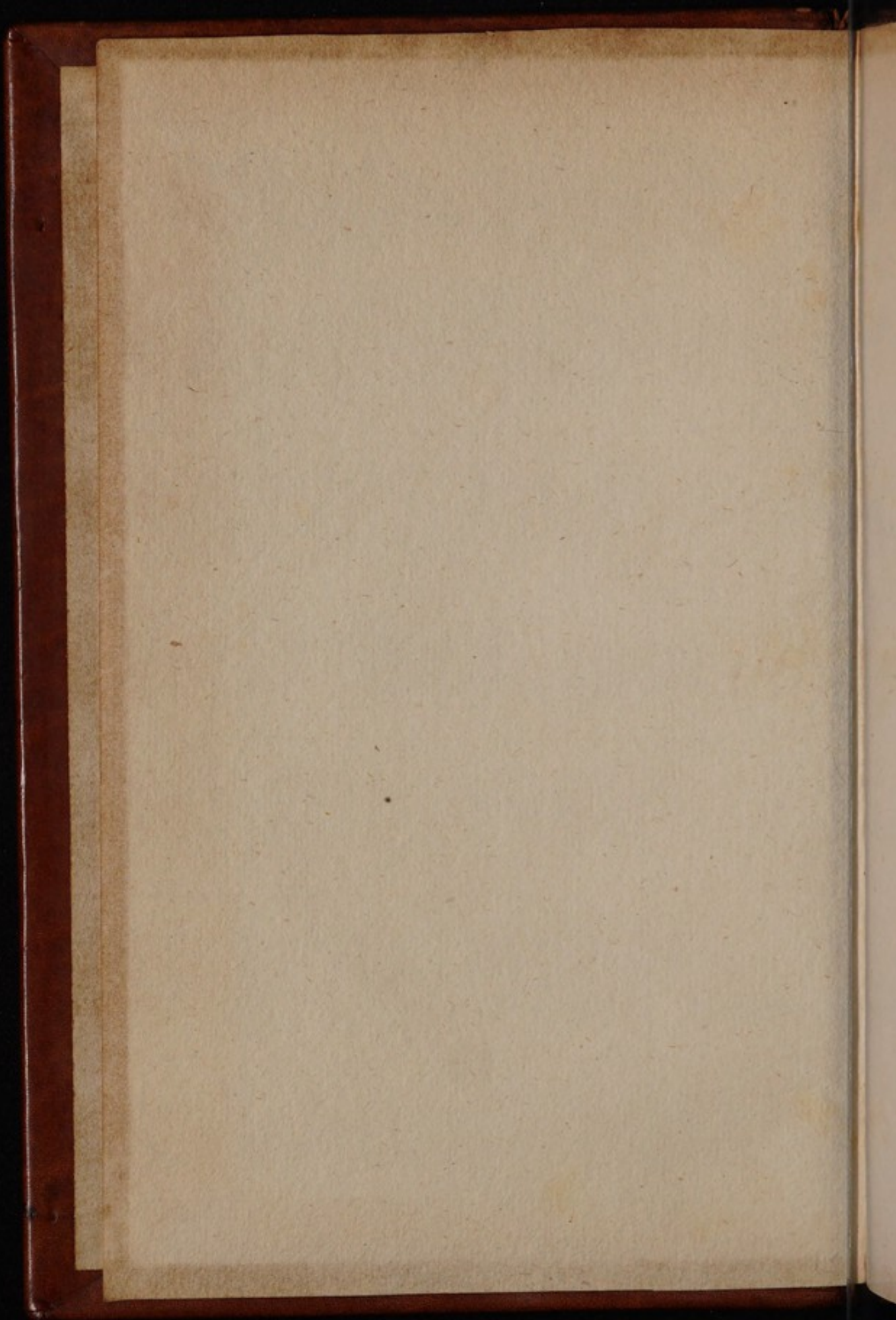


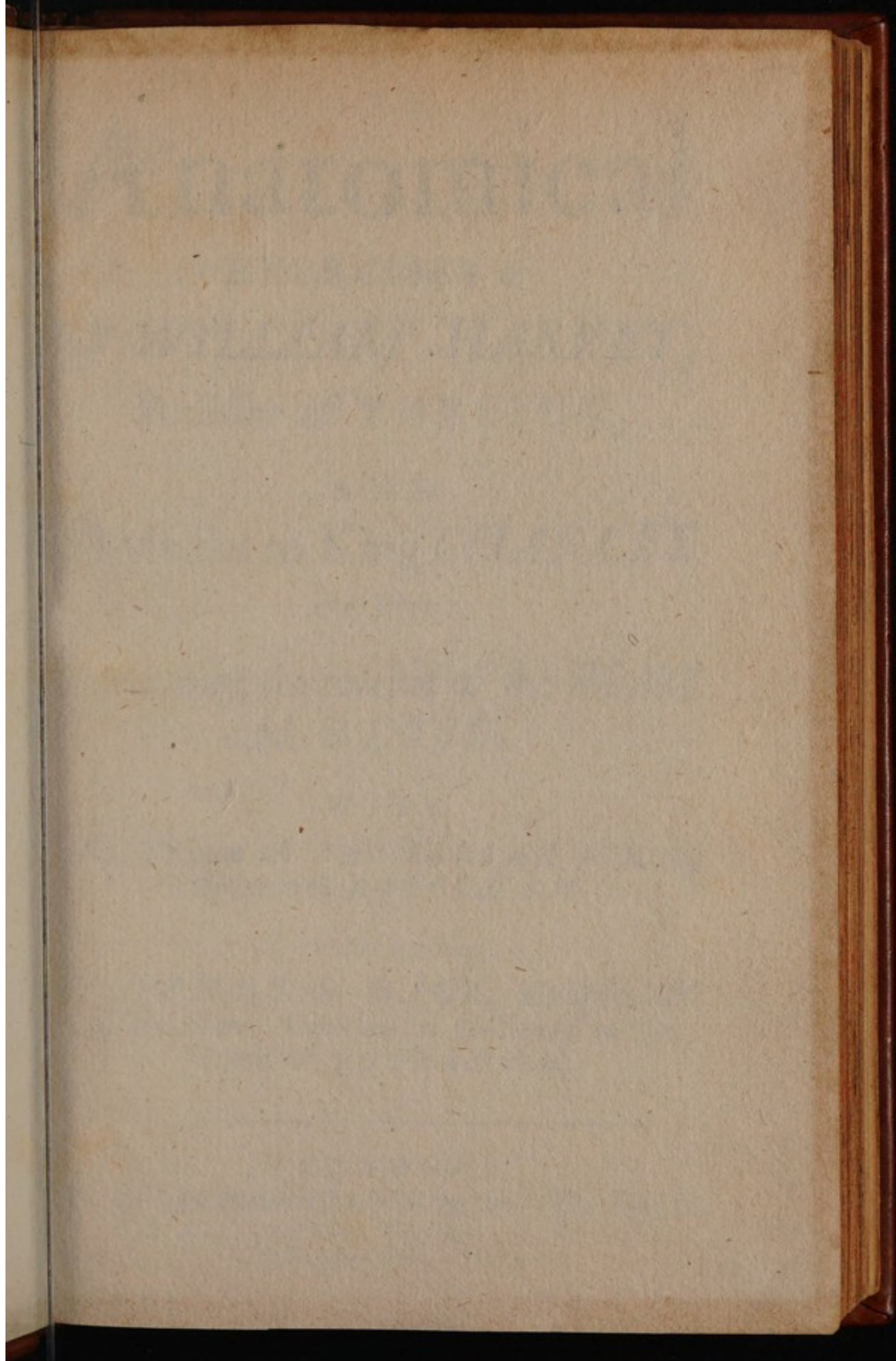


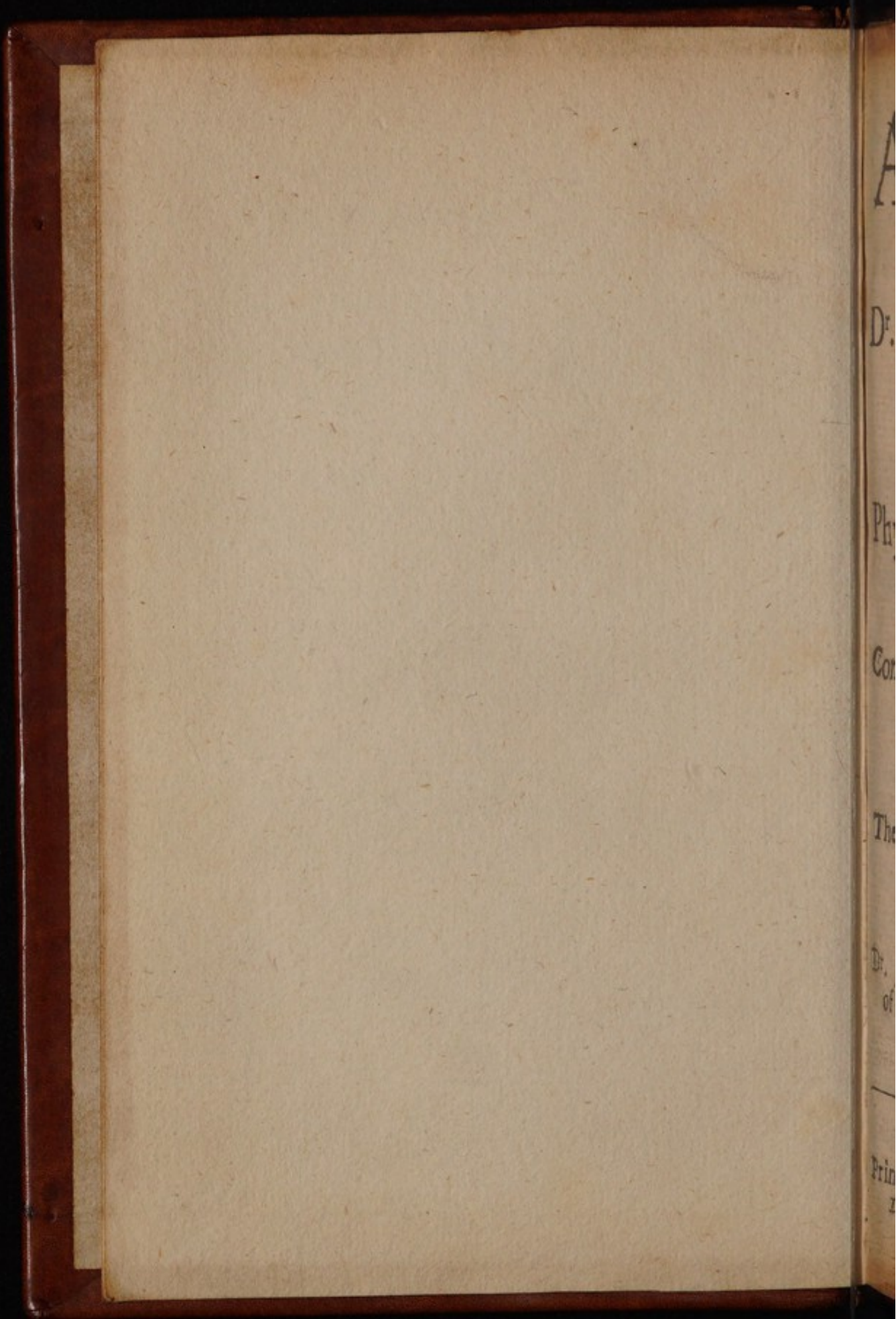
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THE

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Anatomical

EXERCISES of

Dr. *WILLIAM HARVEY*,

Professsor of *PHYSICK*,

AND

Physician to King *CHARLES*

the First;

Concerning the motion of the *HEART*
and *BLOOD*.

WITH

The Preface of *ZACHARIAH WOOD*,
Physician of *ROTTERDAM*.

To which is added,

Dr. *JAMES de BACK*, his Discourse
of the *Heart*, Physician in Ordinary to the
Town of *ROTTERDAM*.

L O N D O N,

Printed for *Richard Lowndes* at the *White Lion* in
Duck Lane, and *Math. Gilliflower*, at the *Sun* in
Westminster-Hall, 1673.

THE
ANATOMICAL

EXERCISES OF
D. WILLIAM HARNET,
Professor of PHYSICS,

A. N. D.
Physician to King CHARLES
the First;

Concerning the motion of
and B. L.



WITH
The Preface of ZACHARIAH WOOD,
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of the Heart, Physician in Ordinary to the
Town of ROTTERDAM.

LONDON
Printed for Richard Linsell at the White Lion in
St. Pauls Church-yard, 1717.

To the most Illustrious and In-
vincible Monarch **CHARLS** King of
Great Britain, France, and Ireland,
Defender of the Faith.

Most Gracious King,

He Heart of creatures is the
foundation of life, the Prince of
all, the Sun of their Micro-
cosm, on which all vegetation
does depend, from whence all vigor and
Strength does flow. Likewise the King is the
foundation of his Kingdoms, and the Sun of
his Microcosm, the Heart of his Common-
wealth, from whence all power and mercy pro-
ceeds. I was so bold to offer to your Majesty
those things which are written concerning the
Heart, so much the rather, because (according
to the custom of this age) all things humane
are according to the pattern of man, and

most things in a King according to that of
the Heart; Therefore the knowledge of his own
Heart cannot be unprofitable to a King, as
being a divine resemblance of his actions (so
us'd they small things with great to com-
pare,) You may at least, best of Kings, being
plac'd in the top of humane things, at the
same time contemplate the Principle of Mans
Body, and the Image of your Kingly Power.
I therefore most humbly entreat, most gracious
King, accept, according to your accustom'd
bounty and clemency, these new things con-
cerning the Heart, who are the new light of
this age, and indeed the whole Heart of it, a
Prince abounding in vertue and grace, to
whom we acknowledge our thanks to be due,
for any good that England receives, or any
pleasure that our life enjoys :

Your Sacred Majesties most
devoted Servant,

WILLIAM HARVEY.



To the most Excellent and
most Ornate man *D. Ar-*
gent, President of the College
of Physicians in *London*, his
singular Friend, and the rest
of the Doctors and Physi-
cians his most loving Collegs.

S. P. D.



Did open many times before, worthy
Mr. Doctor, my opinion concerning the
motion and use of the heart, and Circu-
lation of the blood new in my lectures;
but being confirm'd by ocular demonstra-
tion for nine years and more in your sight, evidenced by
reasons, and arguments, freed from the objections of
the most learned and skilfull Anatomists, desired by
some, and most earnestly required by others, we
have at last set it out to open view in this little
Book; which, unless it were pass'd through your
hands,

Dedicatory.

hands, I could hardly hope that it would come abroad entire and safe, since I can call most of you, being worthy of credit, as witnesses of those observations from which I gather truth, or confute error, who saw many of my Dissections, and in the ocular demonstrations of these things which I here assert to the senses, were us'd to stand by and assist me. And since this only Book does affirm the blood to pass forth and return through unwonted tracts, contrary to the received way, through so many ages of years insisted upon, and evidenced by innumerable, and those most famous and learned men, I was greatly afraid to suffer this little Book, otherwayes perfect some years ago, either to come abroad, or go beyond Sea, lest it might seem an action too full of arrogancy, if I had not first propounded it to you, confirm'd it by ocular testimony, answer'd your doubts and objections, and gotten the Presidents verdict in my favour; yet I was perswaded if I could maintain what I proposed in the presence of you and our College, having been famous by so many, and so great men, I needed so much the less to be afraid of others, and that only comfort, which for the love of the truth you did grant me, might likewise be hoped for from all who were Philosophers of the same nature. For true Philosophers, who are perfectly in love with truth and wisdom, never find themselves so wise, or full of wisdom, or so abundantly satisfied in their own knowledge, but that they give place to truth whensoever, or from whosoever it comes. Nor are they so narrow spirited to believe that ever any art or science was so absolutely and perfectly taught in all points, that there is nothing remaining to the industry and diligence of others, since very many profess

The Epistle

feſs that the greateſt part of thoſe things which we do know, is the leaſt of the things which we know not. Neither do Philoſophers ſuffer themſelves to be addiſted to the ſlavery of any mans precepts, but that they give credit to their own eyes; nor do they ſo ſwear Allegiance to Miſtris Antiquity, as openly to leave, or in the ſight of all to deſert their friend Truth. For as they think them credulous and idle people, who at firſt ſight do receive and believe all things, ſo do they take them for ſtupid and ſenſeleſs, that will not ſee things manifeſt to the ſenſe, nor acknowledge the light at mid-day; and do teach as well to decline the records of the Scepticks, as the follies of the rabble, or the fables of Poets. Likewise, all ſtudious, good and honeſt men, do never ſuffer their mind ſo to be overwhelm'd with the paſſions of indignation and envy, but that they will patiently hear what ſhall be ſpoken in behalf of the truth, or underſtand any thing which is truly demonſtrated to them; nor do they think it baſe to change their opinion, if truth and open demonſtration ſo perſwade them, and not think it ſhamefull to deſert their errors, though they be never ſo ancient, ſeeing they very well know that all men may erre, and many things are found out by chance, which any one may learn of another, an old man of a child, or an underſtanding man of a fool.

But my loving Collegs, I had no deſire in this Treatiſe to make a great volume, and to oſtentate my memory, and labours, and my readings, in rehearſing, teſſing the works, names, and opinions of the Authors and writers of Anatomy, both becauſe I do not profeſs to learn and teach Anatomy from the axioms of Philoſophers, but from Diſſections, and from

Dedatory.

from the fabrick of Nature. As likewise that I do not endeavour, nor think it fit, to defraud any of the ancients of the honour due to them, nor provoke any of the moderns; nor do I think it seemly to contest and strive with those that have been excellent in Anatomy, and were my teachers. Moreover I would not willingly lay an aspersion of falshood upon any that is desirous of the truth, nor blemish any man by accusing him of an error; but I follow the truth only, and have bestowed both my pains and charges to that purpose, that I might bring forth something which might be both acceptable to good men, agreeable to learned men, and profitable to literature. Farewell most excellent Doctors, and favour your Anatomist,

WILLIAM HARVEY.

THE



The Preface of *Zachary Wood*,
Physician at *Roterdam*, upon the
Anatomical Exercise of Doctor
William Harvey.

Tis a memorable Story which is related by one *Aventine* a *Boian* Writer, That *Bonifatius* a certain Bishop of *Ments*, hearing *Virgilius* a Bishop of *Salesburg* in a Sermon which he made before the people of those times, make mention of those men whose footsteps tread opposite to ours, was so much incensed, that he did not stick to accuse *Virgil* of Blasphemy, as that having spoke of the Antipodes, he did seem plainly to aim at another Christ; and having related the business to *Utilio* King of the *Boii*, he procured the Letters of Pope *Zachary* to *Utilio*, and so *Virgil* was both condemned by the Kings and the Popes Verdict. There is such another Story related of *Democritus*, This *Democritus* being a diligent searcher of the works of Nature, whilst he was continually busied in cutting up of creatures, he was thought mad by the *Abderitans*, who pitying the Mans condition, called *Hippocrates* that he

A

might

The Preface.

might give him Physick, and restore him to his lost wits; being desired, he came in all hast, and there he found *Democritus* cutting up of creatures, with which sight being marvellously taken, he avouch'd, That all the *Abderitans* were mad, and not a wise man but only *Democritus* amongst them. Now many men are like the *Abderitans*, there are now many *Bonifaces* and *Utilios* who do traduce the new inventions of those, who, as it were by the great inspiration of God, have bestowed all their studies upon the search and knowledge of things, as unprofitable, and the force of a custom once settled is able to effect so much, that no man in any barbarous place did ever seem to usurp more unlicensed power. Doctor *William Harvey*, Kings Physician, and professor of Anatomy in the Colleged of Physicians in *London*, has set out a new and unheard-of opinion concerning the motion of the heart, and circulation of the blood, which is briefly thus, First the ear of the heart contracts it self, in that contraction it thrusts out the blood contain'd in it into the ventricle of the heart, which being fill'd, the heart is dilated, and straight-ways it contracts the ventricles and makes a pulsation, by which pulsation it thrusts forth the blood thrown into it into the arteries out of the left ventricle, and out of the right into the lungs through the *vena arteriosa*, from whence immediately it is snatched into the left ventricle through the *arteria venosa*, and by it driven out into the *Aorta*, and so afterwards into the whole body through the arteries; the blood so driven out into the habit of the body, passes from the arteries again into the veins, and returns into the *vena cava*, and from

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from it into the right ear of the heart, and then into the right ventricle, and so afterwards it passes through the same circle as before, and so continually, from whence he calls that motion of the blood Circulation. Truly a bold man indeed,

O disturber of the quiet of Physicians!

O seditious Citizen of the Physical Commonwealth!

Who first of all durst oppose an opinion confirm'd for so many ages by the consent of all, and delivered up in the monuments of so many Physicians, and as it were given from hand to hand to posterity, as if no man had been wise in all ages past. Indeed they do very decently who worship antiquity as becomes them; but it is a thing unworthy in wise men who do ascribe wisdom to antiquity, with no little wrong to posterity, as if it were not common to all times, and to all men; for as *Lactantius* in the 2 Book of his Divine Constitutions, 8 Chap. Because they had the precedency before us in time, they had not the precedency before us in wisdom, which, if it be given to all alike, it cannot be forestall'd by those that go before, but is untouchable as the light and clearness of the Sun; for as the Sun is the light of the eyes, so wisdom is the light of mans heart. And truly, if those by whose benefit and study we have the invention and constitution of Physick, had been of the same mind with these reprovers, & had thought nothing worthy publishing but what had been approved in the account and judgement of their Ancestors, such refin'd and elaborate arts had never come to light; but the ancients knowing certainly that they had found out many things, some things like-

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likewise they had not perfectly enquir'd into, and that some were to them perfectly unknown, and believing that the way of searching out the truth was not stopp'd, but guarded for them by the example and diligence of antiquity, they did with ready minds endeavour that they might either go on in the same path with them, or pass beyond them in a further search. They did as it were advance the banner towards the search of hidden causes, and went before us in example, that we might follow them; for this is the liberty of wisdom, that being oblig'd to none, it's under its own command and jurisdiction; in her Common-wealth it's permitted to abrogate, derogate, and search without prejudice to any, which liberty if we take away we shall alwayes continue in the cradle of arts, nor will there be any thing from whence we hope for their increase, or for any thing better than has been published; for which cause we do require, that justice and courtesie in judgement may be given of us which we afford to others; if the same thing be alwayes to be thought and spoken, it will not be lawfull to find out any new thing, nor must we take hold of what the very thing and reason it self dictates to us; 'tis ridiculous therefore to tread in the steps of the Ancients, and alwayes to follow them. Nor does *Galen* approve of any Anatomical Comment, unless it contain some new thing. It is a dull wit which is satisfied with that which others have invented, seeing all humane things are subjected to the sharpness of the mind. The treasures of Nature are immense, and her wisdom inexplicable, so that those things which daily come abroad do prepare
a way

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a way to search out those things which follow ;
for truth is drown'd in a deeper well than that
it should be drawn out from thence in a few ages.
It is true that *Aratus* said , That we were not
taught all things at one time by *Jupiter* , but that
a great many things do remain hid, of which some
he will grant to us afterwards. *Galen* says, that
the cunning of Nature in the fabrick of mans
body is so great, that though great men have dili-
gently and constantly searched after it, yet have
they not found it all out.

*Long age, and divers travels in times change
Have better'd it, nor all those whom we range
Amongst the Antients know what we do know,
Young men some things to observation owe.*

Therefore since to be wise, that is to say, to search
after the truth , is born with all men, they take a-
way all wisdom from themselves who without any
judgement approve of their forefathers inventi-
ons, and are by them lead like Cattel, and do brag
rashly, that they see those things in them which
they do not see. The Comedy which uses to be
acted by the Players looks much like this. By a
certain cheating Taylor, there was a piece of ex-
cellent cloath describ'd to an idle and simple
Braggadochio, but of such a colour, that it could
not be seen by base begotten people or bastards ;
therefore this Braggadochio desirous to buy, re-
quires a sight of the cloath ; the Cheat present-
ly as a huge piece having many els in it , brings it
out in both his hands, as the Merchants use to do
here, turns down the folds, wonders at the fair-

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ness of it, praises it, and commends it to his buyer; this vain Braggadochio was presently touched with a suspicion that his Mother had played the Whore, yet shame hinder'd him to confess, therefore he says that he sees, and wonders at the cloath which he did not see, and indeed was not at all, and buyes it, and commands him to make him a Suit of it; then the Taylor began to be very merry, and jovial, divides the cloath, imitates wonderfully the noyse of cutting it, and makes him up a garment of this fine unseen and invisible cloath, receives his money, and gives it him. Believe me this fable in incredulous men without judgement is a true history, and no fable; they believe, and why should not they give credit to Physicians approv'd by the judgements of so many ages? yet they do not see, nor can they see, that which is not; yet lest they should seem blockheads, they praise, admire, and buy; not only with expence of money, whose damage is tolerable, but even with the loss of time and life, the damage of which can be redeem'd by no money. Truly, that I may speak the truth, we must give less credit to authority, and we must restrain our assent, and besides authority look after reason too by the example and authority even of ancient Philosophers and Physicians; and first of all by the example of that divine *Plato*, whom *Cicero* so much esteems, that he does not stick sometimes to call him the *Homer* of Philosophers, sometimes a God; in whose Book, O fortunate Sir (says *Socrates* to *Polus* a young man who in his discourse concerning a blessed life produc'd testimony) you endeavour to convince me as Orators do,

The Preface.

do, and as they do in tryals where they think that they foil one another when they bring many and famous Witnesses for their Cause, and the Defendant brings none, or some one, since this proof is of no consequence towards the truth; for many times a man is unjustly oppress'd, because of the multitude of witnesses, and of those too who seem to be of some worth and account: and so likewise in his *Charmides*. Nor is it to be considered who speaks, but whether truth be spoken or no; these and the like are every where in *Plato*. But let us hearken to *Aristotle* in this point, treading directly in his Masters footsteps, who, as he did not spare any of the antient Philosophers no more did he *Socrates* and his Master *Plato*; for being to dispute against the Ideas, he says, Though it be a hard question, because that those who brought in the Ideas are our friends, yet it is necessary for the retaining of the truth to take off their opinions, especially they being Philosophers; for albeit they be both gallant men, yet it is a gallanter thing to honour the truth beyond them. Shall not we say that it is here clearly set down in what esteem the authority of the most grave Philosophers is to be had? when *Socrates* cries out, That *Hippocrates* and others witnesses evidences; and *Aristotle* cries out, That *Socrates* and *Plato*s evidences, are not so much to be weighed and esteemed as those of truth and reason; especially since *Cicero*, a man of divine quickness of wit, and singular judgement, who for the many praises both of *Plato* and *Aristotle* may seem to have sworn allegiance to them both, did not unwillingly turn to the haven of the Stoicks, leaving the Acade-

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my of *Plato*, and the Lyceum of *Aristotle*. I do likewise believe that he would have passed over to the Cynosarges of the *Cireneans*, or the Gardens of the *Epicureans*, and the Schools of other Philosophers, with the same freedom, if he had found or judged any thing in them worthy of his knowledge; as likewise calling back all learners from their credulous superstitions, by name he admonishes them that the evidences of Authority are not to be so much to be sought for as the evidences of reason; because the authority of those who teach is many times prejudicial to those who learn, for they leave off to try any thing by their own judgment, they account that firm which they see to be so judged by him whom they approve of. For which cause let us compare true principles of Physick, though new, with the opinions of the Antients, for here we shall find many things disagreeing; let us try the Anatomical exercise of *Harvey*, let us see what that will help us: nor let us longer imitate the *Sepias*; for as those who when they find that the Fishermen are in pursute of them throwing out ink, which they have instead of blood, darkning the water, hide themselves, and do as it were stop and block up the Fishermens way; nor let us need to be so press'd and constrain'd by truth, light, firm and constant reason, for that troubled water will settle at some time, time will blot out the inventions of opinion, and confirm the judgments of truth. We have a very remarkable tryal of this in a very famous man, *Vopiscus Fortunatus Plempius*, Doctor of Physick and Arts in the Univerlity of *Lovain*, and prime practitioner there, whose opinion of *Harvey* we thought fit

The Preface.

fit here to set down, which he gave in his 2 *Book* concerning the foundation of Physick, *Chap. 7.* these are his words, *England* of late hath brought forth a new opinion concerning the motion of the heart, which *William Harvey* hath published in a little *Book* purposely set out by him; he builds his opinion upon very plausible reasons, insomuch that it is allowed by many learned men at this day, and he is call'd as by a title of honour by one of his own Countreymen, the surrounder of the little World, to distinguish him from another Englishman who first went about the greater World. This invention did not please me at first, which I did testifie both by speech and writing against it, but afterwards when I did most earnestly endeavour to refute and explode it, I was refuted and exploded my self, so much are his reasons not only perswading but forcing; but diligently did I examine it all, and in some dogs, dissected by me for that end, found it to be very true, being likewise advis'd to do this by a most famous man, *Waleus*, Professor of *Leyden*, whose candid and settled judgement I do much esteem, and in this business am much engaged to him. Here's a great change in his judgement. Hence I begin to hope for equity in others, that laying aside all hatred, and acknowledging their error, they will at last with *Plempius* begin to think well of *Harvey*. It is a sign of a malicious and wicked mind to be delighted with error, to hate light, to follow darkness, to calumniate the industry of good men, which fault belongs only to
very

The Preface.

very filthy and vile persons; vile we may say, not a good nature, nay, no tollerable or high disposition was ever tainted with this blemish. Search antient times, search ours, you shall not read, hear, nor see, any other than melancholly and malignant natures, which *Saturn* has blasted with his constellation, envious to others, and distrustful of themselves, prone and made apt to this vice. Do not you see that those little dogs which bark at guests, do not touch wild beasts? such men as those are worse, being only born to wound and vex people; born I say, for really they do so lean and encline to that vice, that they are never at rest but when they disturb others. If his reprovers should say, *William Harvey* has observed, and found fault with the errors of the antients, they should indeed say true but they should say much truer if they should add, *William Harvey* by his long and studious observation, and meditation of things in Anatomy, has propounded the means to take away all Thorns, Flints, and other impediments out of the way of Physick, that the journey of it might be plain, easie, quick, and streight, that not only the attainment to the truth and understanding of Physick, but also to the profit and fruit of it might be more easie. The wisdom of *Socrates* is known well enough by the Oracle of *Apollo*, amongst whose praises that was remarkable, and the chief, to refer the ends of liberal arts to the fruit of mans life, that men being instructed by these arts, might more easily and more readily advise concerning the transacting of businaess, and more readily

The Preface.

dily execute and perform them; our *Harvey* had this end before his eyes, he open'd only the truth and fruit of the art of Physick; for he saw that there was a great gleanings left, that many things remain'd in the wild acres of Nature hitherto un-touch'd and unpassageable, into the possession of which, as to an empty place, wise men might come; but *Harvey* did not trust other mens writings, but his own faithful eyes, the truest reporters of Anatomy, because Anatomy is better gain'd by ocular inspection than by long reading, and profound meditation. None is forc'd to swear allegiance to a Master, whom nevertheless we likewise trust after experience. *Empompus* a singular good Limner being asked whom of all those that went before him he chiefly followed, it is reported that he said, showing a multitude of men, Nature herself was to be imitated, not the Artificer. This same *Harvey* perform'd so much, and has arrived so far by searching of Nature, that he, just like *Archimedes*, when he found out that the Coronet of Gold was mixt with Brasse, he cryed aloud, I have found it, I have found it. This is a true and hallowed Law of antient Philosophy, *Plato's* my friend, and *Socrates* too, but Truth is more my friend than they both. Wherefore let *ipse dixit* never be held here, let no excellent mans Authority be brought for an Argument, let no opinion have a prerogative, but let the better bear it away. Lastly, whilst others endeavour to defend Antiquity, let us, together with *Harvey*, plead Truths cause; Let us approve those things which are agreeable to truth, and reject those things which are contrary to it; weighing and esteeming the inventions

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ventions of antiquity not in the scale of Antiquity, but in the scale of Truth. To this purpose we have again set forth *Harveys Anatomical Exercise*, which in the year 1648 was set out at *Francfort*, very faulty by the Fault of the Printer, which the Author oft complain'd of, finding that the calumnies of his reproachers had their beginning from thence, who not understanding what he said, did take them ill, and endeavour'd to traduce him publickly; I say we have set it forth, and have taken a great deal of pains, that so much as was possible all things intricate, confused, or unperfect being taken away, that same exercise might come forth mended and restored, in this business having had the help of most learned *De Back* our intire Colleg, whose judgment we do much esteem. But that we may fold up the sails of this our preface, let us imitate Antiquity in honoring the inventors of things. Truly, in former time the invention of Physick was so admirable, the experience of it so secret, that the Authors of it were either plainly esteem'd Gods, as *Apollo* and his Son *Æsculapius*, or else they were thought worthy of Divine honour, as *Asclepiades* whom the *Illyrians* receiving as a God, did equal in honour to *Hercules*. Truly I do not approve all that Antiquity hath done, yet truly I do praise their affection and judgment, as having rightly thought, and judged, no reward sufficiently worthy to be paid to the inventors of the art of Physick. Therefore let *Harvey* be amongst us in perpetual esteem, by whose learning we have a way open'd to see so great a light of the Art of Physick, to

love

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love and to imitate it. Let us freely attribute the modest commendation of the Son of *Syrach* concerning his own work, to *Harvey*: I watched law of all, as he that gleans ears after the Reapers, I have profited through Gods Grace, I have fill'd the Winefat; Consider that I have not taken pains for my self, but for all those which love learning.

THE

love and to imitate it. For the freely and
the most commendation of the Son of God
concerning his own work. to Father: I was
not in all, as he has given after the
Respect, I have given through God's Grace,
I have given the Witness: Consider that I have
not taken pains for my self, but for all those
which love learning.

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T H E



T H E

PROEME.

By which is Demonstrated, that those things which are already written concerning the motion and use of the Heart and Arteries, are not firm.

IT will be worth our while, seeing we are thinking of the motion, pulse, use, action, and utility of the *heart* and *arteries*, first to unfold such things as have been published by others; to take notice of those things which have been commonly spoken, and taught, that those things which have been rightly spoken may be confirmed, and those which are false both by Anatomical dissection, manifold experience, and diligent and accurate observation, may be mended.

Almost all Anatomists, Physicians, and Philosophers to this day, do affirm with *Galen*, that the use of Pulsation is the same with that of Respiration, and that they differ only in one thing, that one flows from the Animal faculty, and the other from the Vital, being alike in all other things, either as touching their utility, or manner of motion. Whence they affirm, (as *Hieronimus, ab Aq. p.* in his Book of Respiration, which

he has newly set out) Because that the pulse of the *heart* and *arteries* is not sufficient to fan , and refrigerate, that the *lungs* were made about the *heart*. Hence it appears , that whatsoever those in former times did say concerning the *Systole* and the *Diaстole*, concerning the motion of the *heart* and *arteries*, they spoke it in relation to the *lungs*.

But since the motion and constitution of the *heart* is different from that of the *lungs* , and the motion of the *arteries* different from that of the breast, it is probable that divers uses and utilities should follow , and that the pulse of the *heart*, and the use of it, as likewise that of the *arteries* , should differ much from the pulse and use of the breast and *lungs*. For if pulse and respiration do serve for the same use , and that the *arteries* do receive the air into their concavities in the *Diaстole*, as they commonly say , and that in their *Systole* they send out fumes through the pores of the flesh and skin ; as likewise that in the space betwixt the *Systole* and *Diaстole* they do contain air ; and that every time they do either expell Air, or Spirits, or Fumes ; what will they then answer to *Galen* ? who wrote a Book, that blood was naturally contain'd in the *arteries* , and nothing but blood , that there is neither Spirits , nor Air , as from Reasons and Experiments in the same Book we may easily gather. And if in the *Diaстole* the *arteries* are fill'd with Air which they take in , and that in a greater pulse there enters a greater quantity of Air ; it will follow , that whilst there is a great pulse if you dip your whole body into a bath of Water or Oyl, that the pulse shall either be lessen'd , or much slower, since it is a hard thing for the Air to pass through the body of the bath which encompasses them, and get into the *arteries*, if not altogether impossible. Likewise since all the *arteries* , as well those which lye deeper,

as

as those which are next to the skin, are distended with the same swiftness, how can the Air so freely, so swiftly, pass through the skin, flesh, and habit of the whole body, into the depth, as it can through the skin alone? And how shall the *arteries* of *Embryons* draw the Air into their concavities through their mothers belly, and the body of the womb? And how shall Whales, Dolphins, and great Fishes, and all sorts of Fishes in the bottom of the Sea, take in the Air, by the swift pulse in the *Systole* and *Diastole* of their *arteries*, through such a great mass of water? But to say that they suck up the Air implanted in the water, and do return their fumes into it, is not unlike a fiction. And if in the *Systole* the *arteries* do expell their fumes out of their concavities through the pores of the flesh and skin, why not the Spirits likewise, which they say are contain'd there too, since Spirits are much thinner then fumes? And if the *arteries* do receive the Air both in the *Systole* and the *Diastole*, and return it, as the *lungs* do in respiration, why do not they do this in inflicting of a wound when an *arterie* is cut? In the cutting of the wind-pipe by a wound it is clear, that the Air does enter and return by two contrary motions. But it is clear in the section of an *arterie*, that the Air is thrust out with one continual motion, and the Air does not enter and return. If the pulse of the *arteries* do refrigerate the parts of the body, and cool it, as the *lungs* do the *heart* it self, how do they say that the *arteries* do carry the blood very full of vital Spirits into all the parts which do nourish the heat of the parts, wake it when it is asleep, and recruit it being spent? and how comes it to pass, that if you tye the *arteries*, the parts are not only numm'd, cold, and look pale, but at last leave off to be nourished? which happens, according to *Galen*, because they are also depriv'd of

that heat, which did flow from above out of the *heart* : Since it is clear from hence, that the *arteries* do rather carry heat to the parts, then cooling or refrigeration. Besides, how shall the *Diastole*, both draw Spirits from the *heart* to warm the parts, and likewise draw cold from outwards? Further, although some affirm, that the *lungs*, *arteries*, and *heart* do serve for one and the same purpose; Yet they say that the *heart* is the store-house of the Spirits, and likewise that the *arteries* do contain Spirits and send them abroad, but contrary to the opinion of *Columbus*, they do deny that the *lungs* do make any Spirits or retain them. But likewise these men affirm with *Galen* against *Erasistratus* that blood is contain'd in the *arteries*, and not Spirits. These opinions seem to quarrel with one another, and to refute each the other, insomuch that all are not undeservedly suspected. It is manifest that the blood is contain'd in the *arteries*, and that the *arteries* alone do carry out the blood, both by the Experiment of *Galen*, as likewise by the cutting of an *arterie* in wounds, (which *Galen* in his Book, that blood is contain'd in the *arteries* affirms, and in very many places) that by a great and forcible profusion the whole mass of blood will be exhausted in the space of half an hour. The Experiment of *Galen* is thus, Bind the *Arterie* at both ends with a little cord, and cutting it up in length, in the middle you shall find, in that place which is comprehended betwixt the two ligatures, nothing but blood, and so does he prove that it contains only blood. Whence we may argue likewise in the same manner; If you find the same blood in the *arteries* which is in the *veins*, being bound and cut up after the same manner, as I have often tryed in dead men, and in other creatures, by the same reason we may likewise conclude, that the *arteries* do contain the same blood which the *veins*; and nothing but

but the same blood. Some whilst they endeavour to dissolve this difficulty, affirming that it is *Arterial blood* and full of Spirit, they do silently grant that it is the function of the *arteries* to carry the blood from the *heart* into the whole body, and that the *arteries* are full of blood. (For the blood that has Spirit is no less blood.) Likewise no man does deny that the blood, as it is blood, and flowes in the *veins*, is imbued with Spirits. Albeit the blood in the *arteries* do swell with greater store of Spirits, yet those Spirits are to be thought inseparable from the blood, as those which are in the *veins*; and that Blood and Spirit make one body, as whey and butter in milk, or heat and water in warm water, by which the *arteries* are fill'd, and the distribution of which body from the *heart* the *arteries* do perform, and this body is nothing else but blood. But if they say that this blood is attracted out of the *heart* into the *arteries* by the *Diaστοle* of the *arteries*, then they seem to presuppose that the *arteries* by their own distension, are fill'd with that blood, and not with the ambient Air as before; but if in the *Diaστοle*, they shall together receive the blood, the air, the heat, and the cold at one time, that is improbable. Further, when they do affirm that the *Diaστοle* of the *heart* and *arteries* is at one time, and so their *Systole*, one of these two will be inconsistent. For how shall two bodies so nearly joyn'd together, whilst they are distended, one of them draw from the other, or when they are contracted at one time, how shall one receive any thing from the other? Over and above, it may be perchance impossible, that any body should so attract into it self, as that it should be distended, seeing to be distended is to suffer, unless it do as a sponge returning to its own natural constitution after external constriction. It were a hard thing to feign that any such

thing could be in the *arteries*. But I believe I can easily demonstrate, and have heretofore demonstrated that the *arteries* are distended, because they are fill'd like Satchells or baggs, not because they are blown up like bladders. Yet notwithstanding *Galens* Experiment, in his Book, that blood is contain'd in the *arteries*, is otherwise, after this manner. He did cut the *arterie* being laid open in length, and into the wound he thrust a reed or a hollow pipe and stop'd the wound that the blood could not leap out. *So long* (sayes he) *as the arterie is thus, all of it will beat, but so soon as with a thred you have above the arteries and pipe contracted the tunicle of the arterie with a noose, and stop'd it with heed, you shall not see the arterie beat any more above the noose.* I have neither tryed this Experiment of *Galens*, nor do I think it can be tryed and the body kept alive, by reason of the preruption of the blood out of the *arterie*, nor can the pipe close the wound without a *ligature*; nor do I doubt but that the blood will stream further through the concavity of the pipe. Nevertheless *Gal*en by this Experiment seems to prove, that the pulsifick faculty flows through the *tunicles* of the *arteries* from the *heart*, and that the *arteries* whilst they are distended by the pulsifick faculty are fill'd, because they are distended as bellows, not distended because they are fill'd like baggs. But the contrary is manifest, both in cutting of an *arterie*, and in wounds: For the blood is poured out of the *arteries* with a forcible leaping, sometimes farther, sometimes nigher, leaping by fits, but the leaping of it is alwayes in the *Diastrale* of the *arterie*, not in the *Systole*. By which it appears clearly, that the *arterie* is distended by the impulsion of blood. For of it self it cannot by its distention throw the blood out so far, it should rather attract Air into it through the wound, according to those things

things which are commonly spoken. Nor let the thickness of the *arterial tunicles* cosen us in that, that the pulsfick faculty flows from the *heart* by the *tunicles* themselves; for in some creatures *arteries* do differ nothing from *veins*, and in the most remote parts of a man, and the disseminations of the *arteries*, as in the brain, hand, &c. no body can distinguish an *arterie* from a *vein*, for they have both the same *tunicles*. Besides in an *Aneurism*, which is begot by the arrosion or incision of an *arterie* it has the same pulsation with an *arterie*, and yet it has not the *tunicle* of an *arterie*. Most learned *Riolan* doth witness this with me in his seventh Book. Nor let any man believe, that the use of pulse and respiration is one and the same, because that the pulses are greater, more frequent, and swifter, for the same causes as respiration is, to wit with running, anger, bathing, or any other thing which heats. For not only that Experiment is false (which *Galen* endeavours to convince) that by immoderate repletion the pulses are greater, and breathing lesser; but likewise in boys, pulses are frequent, and respiration the while very seldome. Likewise in fear, care, and anxiety of the mind, as also too in some feavers the pulses are swift and frequent, and respirations more seldome. These and the like inconveniences do follow upon the opinions which are set down concerning the pulse and use of the *arteries*. Likewise those things which are affirmed concerning the pulse and use of the *heart* are no less entangled with very many and inextricable difficulties. They do commonly affirm that the *heart* is the store-house and fountain of vital Spirit, by which it gives life to all the parts, and yet they deny that the *right ventricle* makes Spirits, but only gives nourishment to the *lungs*; from whence say they fishes have no *right ventricle* of the *heart*, and indeed in

those which have no *lungs* it is wanting, and that the *right ventricle* of the *heart* was meerly made for the *lungs* sake.

1. Why I beseech you? since the constitution of both the *ventricles* is alike, their *fibers* fram'd alike, and so of their *tendons*, *Portals*, *vessels*, *ears*, and both of them are found full of blood in dissection, alike blackish, alike knotty: why I say should we think that they were appointed to such diverse different uses, seeing action, motion, pulse, is the same in both? If the three three pointed *portals* in the entry of the *right ventricle*, be a hinderance of the return of the blood into the *vena cava*, and if those three semilunary *portals* in the *orifice* of the *arteriosa vena* were made to hinder the regrefs of the blood; since they are so likewise in the *left ventricle*, shall we deny that they were likewise made to hinder the egress and regrefs of the blood there?

2. And since they are almost altogether after the same manner, both in their form and position in the *left* as in the *right*, why do they say that here they hinder the egress and regrefs of the *Spirits*, and in the *right* hinder the egress and regrefs of the blood? this same *organ* does not seem to be fit to hinder the motion of the blood and *Spirits* alike.

3. And how is it probable, as *Realdus Columbus* does observe, that there needs so much blood to the nutrition of the *lungs*, since this vessel, (that is to say) the *vena arteriosa*, is bigger then both the branches of the distributives descending into the *crural vein*?

4. And I beseech you since the *lungs* are so near, and the vessel is so great, and they in continual motion, what needs the motion of the *right ventricle*, and what is the matter that nature for the nourishing of the *lungs* was forc'd to joyn another *ventricle* to the *heart*?

When

When they say that the *left ventricle* draws matter out of the *lungs*, and the right bosome of the *heart*, to make Spirits, that is to say air and blood, and does likewise distribute the spirituous blood into the *aorta*, and that fumes are sent back by the *Venal arterie* into the *lungs*, and the Spirits into the *aorta*, what is it that makes the separation, or how comes it to pass, that spirits and fumes pass sometimes hither sometimes thither without permission and confusion? if the three-pointed mitre-fashioned *portals* hinder not the return of fumes into the *lungs*, how shall they hinder the return of air? And how shall the half-moon *portals* hinder the regrefs of the spirits from the *aorta*, the *Diastole* of the *heart* pursuing? and by what manner of way do they say that the spirituous blood is distributed through the *Venal arterie* into the *lungs* out of the *left ventricle*, and that the three-pointed doors do not hinder? seeing they affirm that the air does enter through the same vessel out of the *lungs* into the *left ventricle*, to the regrefs of which they would have these three-pointed doors to be a hinderance. Good God how shall the three-pointed doors hinder the regrefs of air and not of blood? Further they having destined the *vena arteriosa* being a large vessel, made with the *tunicle* of an *arterie*, for one only and a private use, that is to say to nourish the *lungs*, Why do they affirm that the *Venal arterie* being scarce so big, having the *tunicle* of a *vein* soft and loose, to be made for more uses, to wit three or four? For they will have the air pass through it, out of the *lungs* into the *left ventricle*, and they will have the fumes likewise to return through it out of the *heart* into the *lungs*, they will have a part of the spirituous blood to be distributed by it, for the refreshing of them: They will have these to send fumes from the *heart*, and the other to send air to the *heart* by the
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the same pipe, when notwithstanding nature did not use to frame one vessel, and one way, for such contrary motions and uses, nor is it ever seen to be so.

If they do affirm that fumes and air do go and return by this way, as through the transpirations or *Bronchia* of the *liver*, why cutting up the *arteria venosa* can we find neither air nor fumes? And whence is it that we see that *arteria venosa* alwayes full of thick blood, and never full of air, since we see air remaining in the *lungs*?

If any would try the Experiment of *Galen*, and cut the windpipe of a dog being yet alive, and forcibly fill the *lungs* with air, and being filled bind them streight, afterwards cutting up his breast he shall find great store of air in the *lungs*, even to their utmost *tunicle*, but nothing in the *arteria venosa*, nor in the *left ventricle* of the *heart*. But if in a living dog either the *heart* did attract it, or the *lungs* did pulse it through, they should do it much more in this Experiment. Yea in the administration of Anatomy blowing up the *lungs* of a dead body, who doubts but the air would enter this way, if there were any passage? But they do so much esteem the use of this *arteria venosa* for the conveying of air from the *lungs* to the *heart*, That *Hier. Fabr. ab aq. pend.* does assert, that the *lungs* were made for this vessels sake, and that it is the chiefeft part of the *lungs*.

But I beseech you, if the *arteria venosa* had been made for the conveying of air, why has it the constitution of a *vein*?

Nature would stand more in need of pipes, and of annular ones, indeed such as the *Bronchia* are, that should be alwayes open, and never lye flat, that they might be altogether void of blood, lest the wetness should hinder the passage of the air, as it is manifest,

(when

(when the *lungs* are diseas'd by the stuffing or least entry of flegm into the *Bronchia*) when we make a whistling or a noise in our breathing.

That opinion is less tolerable, which (supposing that an airy and bloody matter is necessary for the making of vital Spirits) does assert, that the blood is drawn through the hidden pores of the *mediastin* of the heart, out of the *right ventricle* into the *left*, and that the air is drawn through a great vessel, the *arteria venosa*, out of the *lungs*; and for that cause, that there are more pores in the *septum* of the heart, fitter for the production of the blood. But by my troth there are no such pores, nor can they be demonstrated.

For the substance of the *septum* of the heart is thicker, and more compact then any part of the body, except the *bones* and *nerves*. But if there were holes, how were it possible, (since both the *ventricles* are distended at one time) that the one can draw any thing from the other, or that the *left* can draw blood from the *right*? And why should not I rather believe that the *right* draws Spirits from the *left*, then that the *left* through the same holes should draw blood from the *right*? But it is truly wonderfull and incoherent, that at the same instant the blood should be most conveniently drawn through hidden and obscure passages, and air through very open ones. And why, I beseech you, have they their refuge to hidden, invisible, incertain, and obscure pores for the passage of the blood into the *left ventricle*, when there is such an open way through the *arteria venosa*? Truly it is a wonder to me, that they would rather invent or make a way through the *septum* of the heart, which is gross, thick, hard, and most compact, then through the patent *Vas Venosum*, or else through the substance of the *lungs*, thin, loose, most soft and spongiuous. Besides, if the blood could pass

pass through the substance of the *septum*, or be imbib'd by the *ventricles*, what need were there of the branches of the *Coronal arterie* divided for that purpose? Which is very worthy to be observ'd, if in a Birth (when all things are thinner and softer) Nature was forced to bring the blood through an oval hole, out of the *Vena Cava* through the *Arteria Venosa*, how can it be possible that she should pass it so conveniently, and with no trouble, through the *septum* of the *heart*, being now made thicker after growth?

Andreas Laurentius in his *Lib. 9. Chap. 11. Quæst. 12.* being back'd with the authority of *Galen*, and the experience of *Hollerius*, affirms, that whey, and the attar, out of the cavity of the brest, being supp'd up by the *Arteria Venosa*, can be expelled through the *left ventricle* of the *heart* and the *arteries*, together with the *Urine* and the *Excrements*; As likewise for the confirmation of it he relates the Case of a certain Melancholy man, who was freed from a Paroxysm by the emission of troubled, stinking, tart *urine*, by which kind of disease at last dying, and dissecting the body, no such substance as he piss'd, did either appear in the *bladder* or in the *reins*, any where, but a great deal in the *left ventricle* of the *heart*, and concavity of the breast, whence he vaunts that he foretold the cause of such diseases. But I cannot chuse but wonder, since he had guess'd and foretold that Heterogeneous matter could be evacuated by the same passage, that he either could not or would not see or affirm, that through the same wayes the blood could be conveniently, according to Nature, brought out of the *lungs* into the *left ventricle*.

Therefore from these, and many such things as these, it is clear, that those things which are before spoken by former Authors, concerning the motion and
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use of the *heart* and the *arteries*, do either seem inconvenient or obscure, or admit of no possibility, if one do diligently consider them; therefore it will be profitable to search more deeply into the business, and to contemplate the motions of the *arteries* and *heart*, not only in man, but also in all other creatures that have a *heart*; as likewise by the frequent dissection of living things, and by much ocular testimony to discern and search the truth.

use of the heart and the senses, do either learn in
convenient or obscure, or admit of no comparison
ing, if one do diligently consider them; there-
fore it will be profitable to teach more deeply
into the elements, and to contemplate the motions
of the stars and bees, not only in man, but
also in all other creatures that have a heart; as
likewise by the frequent reflection of living things,
and by much observation to discern and teach
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ANATOMICAL EXERCISES, CONCERNING

The motion of the *Heart*, and
Blood, in Living Creatures.

CHAP. I.

The Causes which mov'd the Author to write.



When first I applyed my mind, to observation, from the many dissections of Living Creatures as they came to hand, that by that means I might find out the use of the motion of the *Heart* and things conducive in Creatures; I straight-ways found it a thing hard to be attained, and full of difficulty, so with *Fracastorius* I did almost believe, that the motion of the *Heart* was known to God alone: For neither could I rightly distinguish, which way the
Diastole

Diastole and *Systole* came to be, nor when nor where the dilatation and constriction had its existence. And that by reason of the quickness of the motion, which in some creatures appeared in the twinkling of an eye,

like the passing of Lightning; so that sometimes the *Systole* did present it self to me from this place, and the *Diastole* from that place, sometimes just contra-

ry, sometimes the motion was various, sometimes confus'd: whence I was much troubled in mind, nor did I know what to resolve upon my self, or what belief to give to others; nor wonder'd I at that which *Andreas Laurentius* writes, That the motion of the heart, was as the ebbing and flowing of *Euripus* to *Aristotle*. At last using daily more search and diligence, by often looking into many and several sorts of creatures, I did believe I had hit the nail on the head, unwinded and freed my self from this Labyrinth, and thought I had gain'd both the motion and use of the heart, together with that of the arteries, which I did so much desire: Since which time I have not been afraid, both privately to my friends, and publickly in my Anatomy Lectures to deliver my opinion.

Which, as it commonly falls out, pleased some, and displeased others; Some there were that did check me, spoke harshly, and found fault that I had departed from the precepts and belief of all *Anatomists*; Others avouching that it was a thing new, worthy of their knowledge, and exceeding profitable, requir'd it to be more plainly delivered to them. At last, mov'd partly by the requests of my friends, that all men might be partakers of my endeavours, and partly by the malice of some, who being displeas'd with what I said, and not understanding it aright, endeavour'd to traduce me publickly, I was forced to recommend these

these things to the Press, that every man might of me, and of the thing it self, deliver his judgement freely. But so much the more willing I was to it, because *Hieronym. ab Aq. P.* having learnedly and accurately set down in a particular Treatise, almost all the parts of living creatures, left the *heart* only untouched. Lastly, if any profit or advantage might by my indutry in this accrew to the republick of Literature, it might perchance be granted that I had done well, and others might believe that I had not spent my time altogether to no purpose, and as the old man says in the *Comedy*,

*No man so well ere laid his count to live,
But that things, age, and use, some new thing give,
That what you thought you knew, you shall not know,
And what you once thought best, you shall forgo.*

This may perchance fall out now in the motion of the *heart*, that from hence the way being thus pervious, others trusting to more pregnant wits, may take occasion to do better, and search further.

CHAP. II.

What manner of motion the Heart has in the dissection of living Creatures.

FIRST then in the *hearts* of all creatures, being dissected whilst they are yet alive, opening the *breast*, and cutting up the *capsule*, which immediately environeth the *heart*, you may observe that the *heart* moves sometimes, sometimes rests: and that there is a time when it moves, and when it moves not.

This is more evident in the *hearts* of colder creatures, as the *Toads*, *Serpents*, *Frogs*, *House-Snails*, *Shrimps*, *Crevises*, and all manner of little *Fishes*. For it shews it self more manifestly in the hearts of hotter bodies, as of *Dogs*, *Swine*, if you observe attentively till the *heart* begin to die, and move faintly, and life is as it were departing from it. Then you may clearly and plainly see that the motions of it are more slow, and seldom, and the restings of it of a longer continuance: and you may observe and distinguish more easily, what manner of motion it is, and which wayes it is made, in the resting of it, as likewise in death, the *heart* is yielding, flagging weak, and lyes as it were drooping.

At the motion, and whilst it is moving, three things are chiefly to be observed.

1. That the *heart* is erected, and that it raises it self upwards into a point, insomuch that it beats the breast at that time, so as the pulsation is felt outwardly.

2. That there is a *contraction* of it every way, especially of the *sides* of it, so that it appears lesser, longer, and contracted. The *heart* of an *Eel*, taken out, and laid upon a trencher, or upon ones hand, doth evidence this: It appears likewise in the *hearts* of little *Fishes*, and of those colder *Animals* whose hearts are *sharp at top, and long*.

3. That the *heart* being grasp'd in ones hand whilst it is in motion, feels harder. This hardness arises from *tention*, like as if one take hold of the *tendons* of ones arm by the *Elbow* whilst they are moving the fingers, shall feel them bent and more resisting.

4. 'Tis moreover to be observed in *Fish*, and colder *Animals* which have blood, as *Serpents*, *Frogs*,
at

at that time when the heart moves it becomes whitish, when it leaveth motion it appears full of sanguine colour. From hence it seemed to me, that the motion of the *heart* was a kind of *tention* in every part of it, according to the *drawing* and *constriction* of the *fibers* every way; because it appear'd that in all its motions, it was erected, received vigour, grew lesser, and harder, and that the motion of it was like that of the *muscles*; where the *contraction* is made according to the drawing of the *nervous parts*, and *fibers*, for the *muscles* whilst they are in motion, and in action, are invigorated, and stretched, of soft become hard, they are uplifted, and thickned, so likewise the *heart*.

From which observations with good reason we may gather that the *heart* at that time whilst it is in motion, suffers constriction, and is thickned in its outside, and so streightned in its *ventricles*, thrusting forth the blood contained within it: which from the fourth observation is evident, because that in the *tention* it becomes white, having thrust out the blood contained within it, and presently after in it *relaxation*, and rest, a purple and crimson colour returns to the *heart*. But of this no man needs to make any further scruple, since upon the inflicting of a wound into the *cavity* of the *ventricle*, upon every motion, and pulsation of the *heart*, in the very *tention*, you shall see the blood within contained to leap out.

So then these things happen at one and the same time, the *tention* of the heart, the *erection* of the *point*, the beating (which is felt outwardly) by reason of its hitting against the *breast*, the incrassation of the sides of it, and the forcible protrusion of the blood by constriction of the *ventricles*.

Hence the contrary of the commonly received opinion appears, which is, that the *heart* at that time when it beats against the *breast*, and the pulsation is outwardly felt, it is believ'd that the *ventricles* of the *heart* are dilated, and replete with blood, though you shall understand that it is otherwise, and that when the *heart* is contracted it is emptied. For that motion which is commonly thought the *Diastole* of the *heart*, is really the *Systole*, and so the proper motion of the *heart* is not a *Diastole* but a *Systole*, for the *heart* receives no vigour in the *Diastole*, but in the *Systole*, for then it is extended, moveth, and receiveth vigour.

Neither is that to be allowed, though it is confirmed by a comparison alleadged by the *Divine Vesalius*, of a wreath of *Oziers*, meaning of many twigs joyn'd together in fashion of a *Pyramide*: that the *heart* doth not only move by the streight *fibers*, and so whilst the top is brought near to the bottom, the sides of it are dilated round about, and do acquire the form of a little *gourd*, and so take in blood, (for according to all the drawing of the *fibers* which it has, the *heart* is stiffned, and gather'd together) But that the outside and substance of it are rather thickned and dilated, and that whilst the *fibers* are stretched from the top of the *corner* to the bottom, the sides of the *heart* do not encline to an *orbicular figure*, but rather contrary, as every *fiber* circular lyes plac'd, does in its contraction encline to streightness, and as all the *fibers* of the *muscles* whilst they are contracted and shortned of their length, so towards the sides they are extended, and are thickned after the same fashion as the bodies of the *muscles*.

To this add, that not only in the motion of the *heart*,

heart, by erection and in-crassation of the sides of it, it so falls out, that the *ventricles* are streightned, but moreover all the sides inwardly are girt together as it were with a *noose*, for expelling the blood with greater force, by reason that those *fibers* or little *tendons*, amongst which there are none but streight ones, (for those in the outside are circular) called by *Aristotle Nerves*, are various in the *ventricles* of the *hearts* of greater creatures, whilst they are contracted together with a most admirable frame.

Neither is it true which is commonly believ'd, that the *heart* by any motion or distention of its own doth draw blood into the *ventricles*, but that whilst it is moved and bended, the blood is thrust forth, and when it is relax'd and falls, the blood is received in manner as follows.

CHAP. III.

What manner of motion the Arteries have in dissection of living creatures.

Here occurs in the motion of the *heart* these things further to be observ'd, which have relation to the moving and pulsation of the *arteries*.

1. That whilst there is a tention, contraction of the *heart*, and a percussio of the *breast*, and an apparent *Systole*, the *arteries* are dilated, do beat, and are in their *Diastole*. In like manner when the right *ventricle* thrusts out the blood contained in it, the *arterious vein* beats and is dilated, together with the rest of the *arteries* of the body.

2. When the left *ventricle* ceaseth to move, beat,

and to be contracted, the beating of the *arteries* ceases: nay when the *tention* is but faint, the pulsation of the *arteries* is hardly to be perceived, and so likewise in the *arterial vein*, when the right ceases.

3. Likewise cutting or piercing any *arterie* in the very *tention* of the left *ventricle* the blood is forcibly thrust out of the wound, so cutting the *arterial vein* at the same time, and in the *tention* and contraction of the *right ventricle*, you shall see the blood to burst out forcibly from thence.

So likewise in *Fishes*, cutting the *conduit pipe*, which leads from the *heart* to the *gills*, at which time you shall see the *heart* stiff, and contracted, from thence you shall see the blood forcibly thrust out.

Lastly, as in the cutting of any *arterie*, the blood leaps out sometimes farther, sometimes nearer, you shall find the out-leaping to be just with the *arterial Diastole*, at which time the *heart* strikes the *breast*, and at that time then when it appears that the *heart* is in its *tention*, and contraction, it is in its *Systole*, and that the blood is thrust out with the same motion.

From hence, this against the Common rule appears to be clear, that the *arterial Diastole* is at the same time with the *Systole* of the *heart*, and that the *arteries* are fill'd and distended, by reason of the immission and intrusion of blood made by the contraction of the *ventricles* of the *heart*; as likewise that the *arteries* are stretched, because they are fill'd like Bags or Satchels, and are not fill'd because they are blown up like Bellows: and for the same cause do all the *arteries* of the body beat, by reason of the *tention* of the left *ventricle* of the *heart*, as the *arterial vein* from the *tention* of the right.

Lastly, That the pulsation of the *arteries* arises from

from the impulsion of blood from the *left ventricle*; just so, as when one blows into a glove, he shall see all the fingers swell up together, and assimilate this pulsation. As also according to the *tention* of the *heart*, the pulsations are greater, more vehement, more frequent, swifter, keeping the number, quantity, and order, of the beating of the *heart*.

Nor is it to be expected, that because of the motion of the blood there should be a certain distance of time betwixt the constriction of the *heart*, and the dilatation of the *arteries*, (especially of those that are furthest distant) that they be not at the same instant, because that in a *Basin* (as likewise in a Drum, and long pieces of Timber) the stroke and the motion are alike soon at both extremes: since the case here is just as in the blowing up of a Glove, or a Bladder. Hence *Arist. 3. Anim. C. 9. de resp. Cap. 15.* The blood (says he) of all living creatures, beats within their veins, (meaning the *arteries*,) and with a continual motion moves every where: so do all the veins beat together, and by turns, because they have their dependance upon the heart. But it does alwayes move, wherefore they likewise move, and in order to its motion when it doth move.

We must observe with *Galen*, that the *arteries* were named *veins* by the ancient Philosophers. I chanced on a time to see and have in hand, an accident which did most plainly confirm this to me to be true: A certain person had a great swelling which did beat on the *right side* of his *throat* near to the descent of the *subclavial arterie*, into the *arm-pits*, call'd *Aneurisma*, begotten by the corrosion of the *arterie* it self, which grew bigger and bigger every day, being filled with the immision of blood

from the *arterie* at every *pulsation* ; which was found upon the cutting up of his body after he was dead. In this man the *pulse* of his *arm* upon that side , was very weak , by reason that the greater portion and influx of blood was turned into the swelling , and so diverted.

Wherefore , whether it be by compression, stuffing, or interception, that the motion of the blood through the *arteries* be hindered, in that case the furthestmost *arteries* do beat less , seeing the pulse of the *arteries* is nothing but the impulsion of the blood into the *arteries*.

CHAP. IV.

What manner of motion the Heart , and the ears of it, have in living Creatures.

BESIDES these , there are to be observed such things as belong to the *ears*, which *Gaspar Bauhinus P. C. Anat.* 22. 21. and *Johan. Riolanus* , men very learned, and skilfull *Anatomists* have observed, and advises us , that if in the live dissection of any *animals* you have good regard to the motion of the *heart* , you shall see four motions , distinct both in time and place : with leave of such eminent men be it spoken , there are four motions distinct in place , but not in time ; for both the *ears* move together, and both the *ventricles* move together, so that there are four motions distinct in place , only at two times, and it is thus,

There are as it were at one time two motions, one of the *ears*, and another of the *ventricles* themselves, for they are not just at one instant , but the motion

motion of the *ears* goes before, and the motion of the *heart* follows; and the motion seems to begin at the *ears*, and to pass forward to the *ventricles*; when all things are already in a languishing condition, (the *heart* dying away, as it is both in *Fishes*, and other *colder animals* which have blood) there intercedes some short resting time betwixt these two motions, and the *heart* being as it were weakened, seems to answer the motion, sometimes swifter, sometimes slower; last of all drawing towards death, it ceases to answer by its motion, and only by nodding its head seems as it were to give consent, and moves so insensibly, that it seems only to give a sign of motion to the *ears*: So the *heart* first leaves beating, before the *ears*, so that the *ears* are said to out-live it: the *left ventricle* leaves beating first of all, then its *ear*, then the *right ventricle*, last of all (which *Galen* observes) all the rest giving off and dying, the *right ear* beats still: so that life seems to remain last of all in the right. And whilst by little and little the *heart* is dying, you may see after two or three beatings of the *ear*, the *heart* will, being as it were rowed, answer, and very slowly and hardly endeavour and frame a motion.

But this is chiefly to be observed, that after the *heart* has left beating, and the *ears* are beating still, putting your finger upon the *ventricle* of the *heart*, every pulsation is perceived in the *ventricles*, just after the same manner as we said the pulsations of the *ventricles* were felt in the *arteries*, a distention being made by impulsion of blood: and at this time, the *ears* only beating, if you cut away the point of the *heart* with a pair of *Scissors*, you shall see the blood flow from thence at every pulsation of the *ear*, so that from thence it appears which way the blood

blood comes into the *ventricles*, not by attraction or distention of the *heart*, but sent in by the impulsion of the *ears*.

It is to be observed, that all those which I call pulsations, both in the *ears*, and in the *heart*, are contractions, and that the *ears* are evidently first contracted, and afterwards the *heart* it self. For the *ears* whilst they move and beat, become whitish, especially when there is little blood in them, for they are fill'd as the *cellars* and *treasuries* of blood, by the compressive motion of the *veins*, and the tending of the blood to its proper *Centre*. Nay further, it is most evident, in the *ends* and *extremities* of them, that the whiteness arises meerly from the contraction of them.

In *Fishes*, and *Frogs*, and the like, having but one *ventricle* of the *heart* (for in lieu of one ear they have a little bladder plac'd at the bottom of their *heart* full of blood) you shall most evidently see the *bladder* first contracted, and the contraction of the *heart* to ensue.

Notwithstanding I thought fit to insert those things which were of a contrary course, the *heart* of an *Eel*, as also of some *Fishes*, and living creatures being tane out beats without *ears*, nay though you cut it in pieces, you shall see the pieces when they are asunder contract and dilate themselves, so that in such, after the motion of the *ears*, the *heart* does leap and beat: But this perchance is only proper to such creatures, which are more tenacious of life, whose *radical moisture* is more glutinous, fatter, tougher, and not so easie to be dissolv'd. This also does appear in the flesh of *Eels*, which after the skinning, exenteration, and cutting in pieces, retains motion.

This

This is certain that upon a time trying an experiment upon a Dove, after that the *heart* had quite left motion, and that the *ears* had a while given over, I wetted my finger with spittle, and being warmed kept it a while upon the *heart*, by this fomentation, as if it had received strength and life afresh, the *heart*, and its ears began to move, to contract, and open, and did seem as it were recall'd back again from death.

But besides all these I have often observ'd that after the *heart* it self, and even its right *ear*, had at the very point of death left off beating, there manifestly remain'd in the very blood which is in the right *ear*, an obscure motion, and a kind of inundation, and beating, that is to say, so long as it seem'd to be possess'd with any blood or spirit.

A thing of the like nature, in the first generation of a living creature most evidently appears in a Hens egg within seven dayes after her sitting, first of all there is in it a drop of blood, which moves, as *Aristotle* likewise observ'd, which receiving encrease, and the *Chicken* being form'd in part, the *ears* of the *heart* are fashioned, which beating there is alwayes life; then afterwards within a few dayes the body beginning to receive its lineaments, then likewise is the body of the *heart* framed, but for some dayes it appears whitish and without blood, nor doth it beat and move as the rest of the body; as also I have seen in a child after three moneths, the *heart* to be also form'd, but whitish, and without blood; in the *ears* of which notwithstanding there was great store of blood, and of a crimson colour: so likewise in the egg when the *Chick* was new form'd, and encreased, the *heart* began likewise to encrease, and to have *ventricles* in which it began

began to receive blood and pass it through.

So that if a man will more narrowly pry into the truth, he will not say, that the *heart* is the first thing that lives, and last that dies, but rather the *ears* (and in Snakes, Fishes, and such like creatures, the part which is instead thereof) and that it both lives before the *heart*, and dies after it.

Nay it's doubtfull too, whether or no before them also the spirit and blood have an obscure beating, which to me it seem'd to retain after death, or whether we may say that with this beating the life begins, seeing the Sperm, and prolific Spirit, of all living creatures, goes from them with a kind of leaping, as if it self were a living creature. So Nature in deathmaking as it were a recapitulation, returns upon her self with a retrograde motion, from the end of her race to the beginning of it, from whence she first issues thither she returns, seeing the generation of living creatures, from not being a living creature, is to be a living creature, as from a non-entity to be an entity, so by the same steps, corruption passes from an entity, to a non-entity; whence it is, that that which in living creatures is last made, fails first, and that which is first made, fails last.

I have likewise observ'd, that there is really a heart in all animals, and not only (as *Aristotle* says) in the greater sort, and such as have blood, but likewise in lesser, and such as have none, as those that are crufted without, or have shels, as house-*Snails*, *Crabfish*, *Crevises*, *Shrimps*, and in many others, nay in *Wasps*, *Hornets*, and in *Gnats*, by an optick glass made for the discovery of the least things, in the upper end of that place which is called their tail, I saw the *heart* beat, and shewed it to others.

But

But in those creatures which have no blood, the heart beats very slowly, and with deliberate strokes, as it does in other creatures which are dying, and is contracted leifurely, as in *Snails* is easie to discern, whose heart you shall find in the right side at the bottom of that *Orifice*, which it seems to open and shut for taking of air, and from whence it casts out foam, dissecting it at the top near the place which is answerable to the *liver*.

But it is to be observed likewise, that in Winter, and colder seasons, some creatures which have no blood, such as is the *Snail*, have nothing which beats, but do rather seem to be like plants; as likewise the rest, which for that cause are called *Plant-animals*. It is likewise to be observed, that in all creatures which have hearts, there are ears likewise, or some thing answerable to them, and wheresoever the heart has two *ventricles*, there are two ears, but not contrarily. But if you observe the fashioning of a Chick in the egg, first of all there is in it as I said only a *bladder* or drop of blood, which beats, and encreasing afterwards the heart is perfected; so in some creatures (as not reaching a further perfection) there is a certain little *bladder* only like a point, red or white, as the beginning of life, as in *Bees*, *Wasps*, *Snails*, *Shrimps*, *Crevises*.

There is found here with us a sort of very little Fish, called in English, a *Shrimp*, and in Low Dutch *Een Garneel*, usually taken in the Sea, and in the River of *Thames*, all the body of which is transparent: This little Fish I have often shewn in water to some of my special friends, so that we could clearly discern the motion of the heart in that creature, the outward parts nothing at all obstruct-

ing our sight, as if it had been through a window. In a Hens egg I shewed the first beginning of the Chick, like a little cloud, by putting an egg of which the shell was taken, into water warm and clear, in the midst of which cloud there was a point of blood which did beat, so little, that when it was contracted it disappeared, and vanish'd out of our sight, and in its dilatation, shew'd it self again, red, and small, as the point of a needle; insomuch as betwixt being seen, and not being seen, as it were betwixt being, and not being, it did represent a beating, and the beginning of life.

CHAP. V.

The action and office of the motion of the Heart.

I Confidently believe then, that out of these and the like observations, it will be found that the motion of the *heart* is after this manner.

First of all the *ear* contracts it self, and in that contraction throws the blood with which it abounds, as the head-spring of the *veins*, and the *cellar* and *cistern* of blood, into the *ventricle* of the *heart*, which being full, straightway the *heart* raises it self, stretches all the *nerves*, contracts the *ventricles*, and makes a pulsation: by which pulsation it continually thrusts that blood, (which by the *ears* is sent in) forth into the *arteries*, the *right ventricle* into the *lungs*, through that vessel which is called the *vena arteriosa*, but is indeed both in its place and function, and every thing else, an *arterie*; the *left ventricle* into the *aorta*, and so by the *arteries* into the whole body.

Those two motions, the one of the *ears*, the other of the *veniricles*, are so done in a continued motion, as it were keeping a certain harmony, and number, that they are both done at the same time, and one only motion appears, especially in hotter creatures, whilst they move with a sudden motion. Nor is this otherwise done, then when in *Engines*, one wheel moving another, they seem all to move together; and in the lock of a piece, by the drawing of the spring, the flint falls, strikes the steel, fires the powder, enters the touch-hole, discharges, the balls fly out, pierces the mark, and all these motions by reason of the swiftness of them, appear in the twinkling of an eye: So likewise in the deglutition, the meat or drink is thrown into the *jaws*, the *larinx* is shut close, by its own *muscles*, and the *Epiglottis*, the top of the *weason*, is lifted up, and opened by its *muscles*, just as a sack is raised to be filled, and opened that it may receive; it thrusts down the meat or drink being receiv'd, by the *thwarting muscles*, and with the *long muscles* sucks it down; yet notwithstanding that all these motions are made by several and contradistinct *organs* whilst they are done in harmony and order, seem but to make one motion and action, which they call swallowing.

So it comes to pass clearly, in the motion and action of the *heart*, which is a kind of swallowing, and transfusion of blood out of the veins into the arteries. And if any man carefully observing this, shall diligently search the motion of the *heart* in the dissection of any living thing, he shall see not only that which I have said, that the *heart* erects it self, and makes one continued motion with the *ears* of it, but likewise a certain motion and inclination sideways,

wayes, and an obscure leaning that way, in order to the draught of the *right ventricle*, so carrying on the work. As we may see when a Horse drinks, and swallows the water, at every gulp the water is sup'd down into the belly, which yields a certain noise and pulse to him that heeds him, and touches him; even so it comes to pass, that whilst some portion of the blood is drawn out of the *veins* into the *arteries*, there is a beating which is heard within the breast.

The motion of the *heart* then is after this manner, and the transfusion and propulsion by mediation of the *arteries* is one of the actions of the *heart*, so that the pulsation which we feel, is nothing else but only the impulsion of the blood by the *heart*.

But whether or no the *heart* contribute any thing else to the blood, besides the *transposition*, *local motion*, and *distribution* of it, we must enquire afterwards, and collect out of other observations. Let this suffice for the present, that it is sufficiently evidenced, that in the beating of the *heart* the blood is transfused and drawn out of the *veins*, into the *arteries*, through the *ventricles* of the *heart*, and so distributed into the whole body.

But this all do in some manner grant and gather from the fabrick of the *heart*, and from the *figure*, *place*, and *use* of the *Portals*, yet stumbling as it were in a dark place, they seem to be dim-lighted, and clamber up divers things, which are contrary and inconsistent, and speak many things at random (as we shewed before.) One thing seems to me to have been the chief cause of doubt and mistake in this business, which is, the contexture in a man of the *heart* and *lungs*; For when they did see the *vena arteriosa*, and the *arteria venosa*, coming like-
wise

wise into the *lungs*, and there to disappear, it could not sink with them either how the *right ventricle* should distribute the blood into the body, or how the *left ventricle* should draw it out of the *vena Cava*. This *Galens* words do testifie in his book *De plac. Hip. & Plat.* 6. Where he inveighs against *Erosistratus*, concerning the beginning and use of the *veins*, and the concoction of the blood. You will answer (sayes he) that it is so ordained, that the blood be prepared in the *Liver*, and so carried to the *Heart*, there to receive its proper form and absolute perfection: which truly seems not without reason; for no perfect and great work is done suddenly, at one attempt, and gains all its refining from one instrument. Which if it be so, shew us another vessel which draws out the blood, being absolutely perfected from the heart, and disposes of it as the arteries do of the spirits through the whole body.

See here an opinion which carries reason with it left and rejected by *Galen*, because (besides not perceiving the passage,) he could not find a vessel which from the heart should distribute the blood into the whole body.

But if at that time in the defence of that opinion (which is now ours, and in all things else agreeable to reason by *Galens* own confession) one should with his finger have pointed out the great arterie dispensing the blood from the heart into the whole body, what would that Divine man, most ingenious, and most learned, have answered? I wonder whether he would have said that the arteries distribute spirits and not blood? certainly he should not by this sufficiently have confuted an *Erosistratus*, who did imagine the spi-

rits to be contained in the *arteries* only, but should in the mean time contradict himself, and basely deny that, which in one of his own Books he stiffly maintains to be true, proves it by many and strong arguments, and by experiments demonstrates it, that blood is naturally contain'd in the *arteries*, and not *spirits*.

But if that Divine man, as he does often in the same place, do grant that all the *arteries* of the body do arise from the great *arterie*, and it from the *heart*, and professing likewise that those *three pointed doors* plac'd in the *Orifice* of the *Aorta* do hinder the return of the blood into the *heart*, and that nature had never ordain'd them for the best of our intralls, unless it had been for some special Office, I say, if the father of the Physicians should grant all these things, and in the same very words as he does in his forementioned book, I do not see how he could deny that the great *arterie* was such a vessel as did carry the blood, after it had received its absolute perfection, out of the *heart* into the whole body: Or perchance he would still continue to be doubtful, (as all the rest since his time to this very day) because not seeing the contexture of the *heart* with the *lungs* he was ignorant of the ways by which the Blood could be carried into the *arteries*, which doubt does not a little perplex the *Anatomists* when always in dissections they find the *arteria venosa* and the *left ventricle* full of thick knotty black blood, so that they are forc'd to affirm that the blood swets through the encloser of the *heart* from the *right ventricle* to the *left*; but this way I have sufficiently refuted already, therefore there must another way be prepared and laid open, which

which being found, there can, I imagine, be no difficulty, which can hinder any body from granting and confessing those things which I propounded before of the pulsation of the *heart*, and dispensation of the blood by the *arteries* into the whole body.

CHAP. VI.

By which ways the blood is carried out of the vena cava, into the arteries, or out of the right ventricle of the heart into the left.

SINCE it is probable, that the connexion of the *Heart* with the *lungs* has given this occasion of mistake, they are to be blamed in this, who whilst they desire to give their verdict, to demonstrate, and understand all parts of living creatures, look but into man only, and into him being dead too, and so do no more to the purpose, than those, who seeing the manner of Government in one Commonwealth, frame Politicks, or they who knowing the nature of one piece of Land, believe that they understand agriculture, or as if from one Particular proposition, they should go about to frame Universal arguments.

Nevertheless were they but as well practis'd in the dissection of creatures, as they are in the Anatomy of mens carcases, this business, which keeps them all in doubt and perplexity, would in my opinion seem clear without all difficulty.

First of all in Fishes having but one *ventricle* of the *heart* (as having no *lungs*) the thing is clear
D 2 enough;

enough. For it is certain, that it may be confirmed before our eyes, that the *bladder* of blood, which they have at the bottom of the *heart*, answerable to the *ear* of the *heart*, sends the blood into the *heart*, and that the *heart* does afterward, through a pipe or *artery*, or something answering to an *artery*, openly transfuse it, both by our own view, and also by cutting the *arterie*, the blood leaping out upon every pulsation of the *heart*.

You may likewise see the same afterward easily in all other creatures, in which there is but one *ventricle* only, or something answerable to it, as in the *Toad*, *Frogg*, *Serpents*, house-*Snails*, which although they are said in some manner to have *lungs*, because they have a voice (of the frame of whose *lungs* I have many observations by me, which are not proper for this place) yet from our own eye-sight it is clear, after the same manner in them that the blood by the pulsation of the *heart* is brought out of the *veins* into the *arteries*, the way of it open, patent, manifest, no occasion or doubt of difficulty at all. For the case is just so with them as it might be with a man, the enclosure of whose *heart* were pierced through, or taken away, and so both the *ventricles* become one, I believe no man then would doubt which way the blood should go out of the *veins*, into the *arteries*.

And seeing there are more creatures which have no *lungs*, than there are which have, and more which have but one *ventricle*, than there are which have two, we may very well averr for the most part, and almost in all, that the blood is transfus'd out of the *veins*, into the *arteries*, through the bottom of the *heart* by an open passage.

But

But I conceiv'd with my self that it is plainly seen too in those *Embryons* which have *hearts*.

In a birth there are four vessels of the heart, the *vena cava*, the *vena arteriosa*, *arteria venalis*, and the *aorta*, or *arteria magna*, and are otherwise united then in one come to age, which all Anatomists know well enough.

The first touch and union of the *vena cava* with the *arteria venosa*, which comes to pass before the *vena cava* opens it self into the *right ventricle* of the heart, or sends out the *Coronal vein*, a little above its out-going from the *liver*, displays unto us its orifice side-ways, that is to say, a hole, wide and large, of an oval figure, made through passageable, from the *vena cava* into that *arterie*: Infomuch as through that hole the blood may freely and abundantly pass out of the *vena cava*, into the *arteria venosa*, and the left ear of the heart, and so to the left *ventricle*. There is moreover against that place which looks towards the *arteria venosa* a *membrane* thin and hard, like a cover, which afterwards in those which grow to riper years, covering this hole, and growing together every way, does quite stop it, and takes away almost all sign of it. This * *Septum*. * *membrane*, I say, is so ordained, that hanging loosely with its own weight, it makes way into the *lungs*, and *heart*, and is turned up, giving passage to the blood which flows from the *vena cava*, but hinders it from flowing back into the *cava* again. So that from hence we may imagine in an *Embryon*, that the blood ought continually to pass through this hole into the *arteria venosa*, out of the *vena cava*, and so into the left ear

of the *heart*, and after it is enter'd, that it can never return.

The other union is that of the *vena arteriosa*, (which comes to pass after that that *vein* coming out of the *right ventricle*, is divided into two branches) and it is as it were a third *trunk*, or *arterial conduit-pipe*, divers from the two former, from hence crookedly drawn, and perforate into the *arteria magna*; so that in the dissection of *Embryons*, there appears as it were two *aortas*, or two roots of the *great arterie*. This *conduit* likewise in those that come to riper age is attenuated by little and little, and fades away, and at last is quite dried up, and lost, like the *Umbilical vein*. This *arterial conduit-pipe* hath no *membrane* to hinder the motion of blood backward, or forward, for there are in the orifice of that *vena arteriosa*, of which this *conduit-pipe* as I said before is a *branch*, three * *doors* of the fashion of a Σ which appear outwardly and inwardly, and do easily give passage to the blood flowing into the *right ventricle* by this way, but on the contrary hinder any thing which may flow from the *arterie* or the *lungs* into the *right ventricle*, which they shut very close: So that here we have reason to think, that in an *Embryon* when the *heart* contracts it self, the blood must alwayes be carried out of the *right ventricle* into the *arteria magna* by this way.

In answer to that which is commonly spoken, that these two conjunctions, so great, so open, so wide, were made for the nourishing of the *lungs*, and that in those who arrive to riper age, when the *lungs* by reason of their heat and motion require

require more abundant nutriment, they should be tane away, and made up, is an invention improbable, and inconsistent. And that is likewise false which they say of the *heart* of an *Embryon*, that it is idle and does nothing, moves not at all: whence it comes to pass, that Nature was forc'd for the nourishing of the *lungs* to make those passages; when by our own eyes it is made plain to us, that both in an egg whereon a Hen hath sate, and in *Embryons* newly cut out of the womb, the *heart* doth move as in those of riper age; and likewise, that Nature is pressed with no such necessity: Of which motion not only these my eyes have often been Witnesses, but likewise *Aristotle* himself affirms; *The pulse* (says he) *appears at the very beginning in the constitution of the heart, which is found in the dissection of living creatures, and by an egg in the forming of the Chick.* But we also observe, that those passages are open and free, as well in men, as also in other creatures, not only to the time of the birth, which the Anatomists have observ'd, but likewise many moneths after: yea in some for many years, if not all their life-time, as in the *Goose*, and very many Birds. Which thing perchance did deceive *Botallus*, so that he affirm'd, That he had found a new passage for the blood, out of the *vena cava* into the *left ventricle* of the *heart*. And I do confess, That when I my self first found this in a *Rat* of full growth, that I did imagine some such thing. From which it is understood, that in the unripe births of mankind, and likewise in others, in which these unions are not taken away, this very thing falls out, that the *heart* by its motion brings forth the blood from

the *vena cava* openly, and by very patent wayes, by the drawing of both its *ventricles*. For the *right* receiving the blood from the *ear*, thrusts it forth through the *vena arteriosa*, and its branch called *canalis arteriosus*, into the great *arterie*. Likewise, the *left* at the same time by the mediation of the motion of the *ear*, receives that blood, which is brought into the *left ear* through that oval hole from the *vena cava*, and by its *tention* and *constriction* thrusts it through the root of the *aorta* into the great *arterie* likewise. So in *Embryons* whilst the *lungs* are idle, and have no action nor motion (as if there were none at all) Nature makes use of both the *ventricles* of the *heart*, as of one for transmission of blood. And so the condition of *Embryons* that have *lungs* and make no use of them, is like to the condition of those creatures which have none at all.

Therefore in these likewise the truth appears as clearly, that the *heart* by its pulsation brings forth, and transfuses the blood out of the *vena cava*, into the great *arterie*, and by as open ways as if both the *ventricles* (as I said before) were made pervious to one another, by taking away the partition betwixt them. Therefore seeing for the most part these ways are open in all creatures at some times, which do serve for transmission of blood through the *heart*, it now remains that we enquire either why in some creatures, as in men, and those hotter, and of riper age, we do hold that not to be performed through the substance of the *lungs*, which nature did before in an *Embryon* through those passages (at that time when there was no use of *lungs*,) which she seems to have made of force for

want

want of passage through the *lungs*. Or why it is better that Nature (for Nature always does that which is best) hath altogether shut up those open ways, of which she before made use in the *Embryon*, and in the birth, and in all other creatures does make use of, nor in the lieu of them hath found out any other passage for the blood, but hinders it altogether after this manner.

So then the business is arriv'd to this, that to those who search for the veins in men (by which the blood passes out of the *vena cava* in the left *ventricle*, and into the *arteria venosa*) it were more worthy their pains, and wiselier done, if from the dissection of living creatures they would search the truth, why in greater, and more perfect creatures, and those of riper age, nature would rather have the blood to be squeezed through the *streyn* of the *lungs*, than through most patent passages, as in other creatures: and then they would understand that no other way nor passage could be excogitated.

Whether this be, because that greater and perfecter creatures are hotter, and when they come to be of age, their heat is apter to be suffocated and to be inflamed, and therefore the blood is streyn'd and sent through the *lungs* that it may be temper'd by breathing in the air upon it, and freed from over-heating and suffocation, or some such other thing. But to determine and give a reason of this is nothing else but a search for what the *lungs* were made. And thus much concerning them and their use, and all manner of cooling, of the necessity and use of air, and the like, of several and different organs made in *animals*. For this cause although by observation I have found out a great many

many things, yet lest I should seem by straying from my Purpose, of the motion of the *heart*, to go besides my intention, and leave my task to confute the business, and decline it; I shall leave these things fitter to be set forth in a Treatise by themselves; and that I may return to my former purpose, I will go on to prove what remains. And first I prove, that in the more perfect *Animals*, and those come to age, as in Man, the blood may pass from the *right ventricle* of the *heart*, by the *vena arteria*, into the *lungs*, and from thence through the *arteria venosa* into the *left ear*, and from thence into the *left ventricle* of the *heart*, and then that it is so,

C H A P. VII.

That the blood does pass from the right ventricle of the heart, through the streyner of the lungs, into the arteria venosa, and left ventricle of the heart.

IT is well enough known that this may be, and that there is nothing which can hinder if we consider which way the water passing through the substance of the earth, doth procreate Rivulets and Fountains; or if we do consider how sweat passes through the *skin*, or how *urine* flows through the *streyner* of the *reins*: It is to be taken notice of in those that make use of the waters of the *Spaw*, or *de la Madonna*, as they call them in *Padua*, or other brackish or vitriolated waters; or those who in earrowling swill themselves with drink, that in

an hour or two they piss all this through their bladder. This great quantity ought to stay a while in concoction, it ought to flow through the *liver*, (as they confess that the juyce of the nourishment we receive doth twice a day) so ought it through the *veins*, through the *streyner* of the *reins*, and through the *ureters* into the *bladder*.

Those therefore which I hear denying, that blood, yea the whole mass of blood, may pass through the substance of the *lungs*, as well as the nutritive juyce through the *liver*, as if it were impossible, and no wayes to be believed; It is to be thought that those kind of men, I speak with the Poet, where they like, they easily grant, where they like not, by no means: Here where need is, they are afraid, but where no need is they are not afraid to averr. The *streyner* of the *liver*, and of the *reins* too, is much thicker then that of the *lungs*, because they are far thinner woven, and of a spongius substance, if they be compared to the *liver* and *reins*.

In the *liver* there is no impulsive, no strength forcing, in the *lungs*, the blood is thrust against them by the impulsion of the *right ventricle* of the *heart*, by which impulsion there must necessarily follow a distension of the vessels, and porosities of the *lungs*. Besides, the *lungs* in respiration rise and fall, *Galen de usu part.* By which motion it follows of necessity, that the porosities of them and their vessels are open'd and shut, as it falls out in sponges, and all things of a spongy substance when they are constricted and dilated again; On the contrary, the *liver* is at rest, nor is it seen at any time to be so constricted and dilated.

Last

Last of all, Since through the *liver*, there is none but affirms, that the juyce of all things we receive may pass into the *vena cava*, both in Men, Oxen, or the greatest creatures, and that for this reason, because it must pass some way into the *veins* if there be any nutrition, and there is no other way, and for that cause they are forced to affirm this: Why should they not likewise believe this of the passage of the blood through the *lungs* in men come to age, upon the same arguments? And with *Columbus*, a most skilfull and learned *Anatomist*, believe and assert the same from the structure and largeness of the *lungs*; because that the *arteria venosa*, and likewise the *ventricle*, are alwayes full of blood, which must needs come hither out of the *veins*, by no other path, but through the *lungs*; as both he and we from our words before, our own eye-sight, and other Arguments, do believe to be clear.

But seeing there are some such persons which admit of nothing, unless there be an authority alledged for it; let them know, that the very same truth may be proved from *Galens* own words, that is to say, not only that the blood may be transfused out of the *vena arteriosa*, into the *arteria venosa*, and thence into the *left ventricle* of the *heart*, and afterwards transmitted into the *arteries*; but also that this is done by a continued pulse of the *heart*, and motion of the *lungs*, whilst we breath. There are in the *orifice* of the *vena arteriosa* three shuts, or doors, made like a Σ , or half-Moon, which altogether hinder the blood sent into the *vena arteriosa* to return to the *heart*, which all know.

Galen

Galen expresses the use and necessity of those
 its, in these words, *De usu part. 6. Cap. 10.* In
 (sayes he) there is a mutnal *Anastomosis* or opening of
 veins, together with the arteries, in their kissing,
 and they borrow both blood and spirit from one another by
 invisible and very narrow passages. But if the very
 mouth of the *Vena Arteriosa* had always stood open, and
 nature had found no device to shut it; when it was re-
 sistite, and to open it again, it could never have come to
 that by those invisible and little kisses, the Thorax
 contracting the blood could be transfused into the ar-
 teries. For every thing is not from any thing extracted
 and emitted after the same manner; for as that which is
 light is easilier attracted than that which is heavy, by
 dilatation of the instruments, and by the constriction is
 squeezed out again; so any thing is easier attracted through
 a broad passage, than through a narrow passage, and so
 it forth again. But when the Thorax is contracted,
 the *Arterie venosa* which are in the Lungs, being on e-
 very side pulsated, and compress'd together strongly, do
 squeeze out very quickly the spirit that is in them, and do
 throw through those fine touches a part of the blood, which
 could never come to pass, if through that great o-
 pening, such as is the *Vena Arteriosa*, the blood could re-
 turn back to the Heart: Now the return of it through
 that great mouth being stop'd, some of it through those
 small orifices does drop into the Arteries, it being press'd
 every way. And a little after in the following Chap-
 ter, how much the more the Thorax endeavors to squeez-
 out the blood, so much the more those *Membranes*, that
 to say those three *Sigma* like doors, do closlier shut the
 mouth of it, and suffer nothing to return. Which he
 sayes likewise in the same tenth Chapter a little
 before. Unless there were doors there would follow a
 three-

threefold inconvenience, for so the blood should make such a long journey but in vain, by flowing in the Diastoles of the Lungs, and filling all the veins in them, in the Systoles, as it were a neap tide; like Euripus reciprocating its motion again and again, hither and thither, which would not be convenient for the blood: But this may seem no great matter, but that in the mean time it should weaken the benefit of respiration, this is no more to be counted a small business. And a little after, And likewise the third inconvenience would follow, no slight one, when in our breathing our blood should return backwards, unless our Maker had ordained the natural position of those Membranes. Whence he concludes Chap. 2. Indeed the use of all the shuts or portals is the same, to hinder the return of the matter; and either of them have a proper use to draw matter from the heart, that they may return no more, and to draw matters into the heart, that they may go no more from thence. For Nature would not have the heart to be wearied with needless travel, nor send thither whence it was better to extract, nor extract from thence again whither it was better to send. For which cause there being four orifices onely, two in either Ventricle, one takes in, the other draws forth. And a little after. Furthermore, when one of the vessels consisting but of one Tunicle is implanted into the Heart, and the other consisting of a double Tunicle is drawn forth from it, viz. (The right ventricle Galen means, so do I the left ventricle by the same reason,) It was needful that there should be as it were a cistern to both, to which both of them belonging, that the blood might be drawn out by one, and sent out by the other.

That argument which Galen brings for the passages of the blood through the right ventricle out of the

the *vena cava* into the *lungs*, we may more rightly use for the passages of the blood out of the *veins* through the *heart* into the *arteries* changing only the terms.

It does therefore clearly appear from the words and places of *Galen*, a divine man, father of Physicians, both that the blood doth pass from the *vena arteriosa* into the little branches of the *arteria venosa*, both by reason of the pulse of the *heart* and also because of the motion of the *lungs* and *thorax*: See the commentarie of the most learned *Hofmannus* upon the sixth Book of *Galen de usu part.* which book I saw after I had written these things.

Furthermore it was necessary that the *heart* should receive the blood continually into the *ventricles*, as in a pond or cistern, and send it forth again: and for this reason it was necessary that it should be served with four locks or doors, whereof two should serve for the intromission and two for the emission of blood, lest either the blood like an *Euripus*, should inconveniently be driven up and down, or go back thither from whence it were fitter to be drawn, and flow from that part to which it was needful it should have been sent, and so should be wearied with idle travel, and the breathing of the *lungs* be hindred. Lastly our assertion appears clearly to be true, that the blood does continually and incessantly flow through the porosities of the *lungs*, out of the *right ventricle* into the *left*, out of the *vena cava* into the *arteria magna*; for seeing the blood is continually sent out of the *right ventricle* into the *lungs* through the *vena arteriosa*, and likewise is continually attracted out of the *lungs* into the *left*; which appears by
that

that which has been spoken, and the position of the Portals, it cannot be, but that it must needs pass through continually.

And likewise seeing that always, and without intermission, the blood enters into the *right ventricle* of the *heart*, and goes out, (which is likewise manifest, of the *left ventricle*, both by reason and sense) it is impossible but that the blood should pass continually through, out of the *vena cava* into the *Aorta*.

That therefore which is apparent to be done in most, and really in all whilst they are growing to age, by dissection through most open passages, is here likewise manifest to come to pass in those when they are arriv'd to full age, by the hidden porosities of the *lungs*, and touches of its vessels both by *Galens* words, and that which has been spoken: From whence it appears, that albeit one *ventricle* of the heart, that is the *left*, were sufficient for the dispensation of the blood through the whole body, and the education of it out of the *vena cava* (as it is in all creatures which want *lungs*;) Yet Nature desiring that the blood should be strained through the *lungs*, was forc'd to add the *right ventricle*, by whose pulse the blood should be forc'd through the very *lungs* out of the *vena cava* into the receptacle of the *left ventricle*: and so it is to be said that the *left ventricle* was made for the *lungs* sake and not for nutrition only; seeing in such an abundance of victual, adding to it the help of compulsion, it is no ways to be believed that the *lungs* should rather want so much aliment, and that of blood so much more pure and full of spirit, as being immediately convey'd from the *ventricles* of the *heart*,

heart, then either the most pure substance of the brain, or the most resplendent and divine constitution of the eyes, or the flesh of the heart it self, which is more fitly nourished by the *vena coronalis*.

C H A P. VIII.

Of the abundance of blood passing through the Heart out of the veins into the arteries, and of the circular motion of the blood.

Thus much of the transfusion of the blood out of the veins into the arteries, and how it is disposed of and transmitted by the pulse of the heart, to some of which those perchance that were heretofore moved by the reasons of *Galen*, *Columbus*, and others, will yield; now as concerning the abundance and increase of this blood, which both pass through, those things which remain to be spoken of, though they be very considerable, yet when I shall mention them, they are so new and unheard of, that not only I fear mischief which may arrive to me from the envy of some persons, but I likewise doubt that every man almost will be my enemy, so much does custome and doctrine once received and deeply rooted (as if it were another Nature) prevail with every one, and the venerable reverence of antiquity enforces: Howsoever, my resolution is now set down, my hope is in the candor of those which love truth, and learned spirits. Truly when I

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had

had often and seriously considered with my self, what great abundance there was, both by the dissection and living things, for experiments sake, and the opening of *arteries*, and many wayes of searching, and from the Symetrie, and magnitude of the *ventricles* of the *heart*, and of the vessels which go into it, and go out from it, (since Nature making nothing in vain, did not allot that greatness proportionably to no purpose, to those vessels) as likewise from the continued and carefull artifice of the *doors* and *fibers*, and the rest of the *fabrick*, and from many other things; and when I had a long time considered with my self how great abundance of blood was passed through, and in how short time that transmission was done, whether or no the juyce of the nourishment which we receive could furnish this or no: at last I perceived that the *veins* should be quite emptied, and the *arteries* on the other side be burst with too much intrusion of blood, unless the blood did pass back again by some way out of the *veins* into the *arteries*, and return into the *right ventricle* of the *heart*.

I began to bethink my self if it might not have a *circular motion*, which afterwards I found true, and that the blood was thrust forth and driven out of the *heart* by the *arteries* into the habit of the body and all parts of it, by the beating of the *left ventricle* of the *heart*, as it is driven into the *lungs* through the *vena arteriosa* by the beating of the *right*, and that it does return through the little *veins* into the *vena cava*, and to the *right ear* of the *heart*, as likewise out of the *lungs* through the *arteria venosa* to the *left ventricle*, as we said before.

Which

Which motion we may call *circular*, after the same manner that *Aristotle* says that the rain and the air do imitate the motion of the superiour bodies. For the earth being wet, evaporates by the heat of the *Sun*, and the vapours being rais'd aloft are condens'd and descend in showrs, and wet the ground, and by this means here are generated, likewise, tempests, and the beginnings of meteors, from the circular motion of the *Sun*, and his approach and removal.

So in all likelihood it comes to pass in the body, that all the parts are nourished, cherished, and quickned with blood, which is warm, perfect, vapourous, full of spirit, and that I may so say, alimentative: in the parts the blood is refrigerated, coagulated, and made as it were barren, from thence it returns to the *heart*, as to the fountain or dwelling-house of the body, to recover its perfection; and there again by natural heat, powerfull, and vehement, it is melted, and is dispens'd again through the body from thence, being fraught with spirits, as with balsam, and that all the things do depend upon the motional pulsation of the *heart*.

So the *heart* is the beginning of life, the *Sun* of the *Microcosm*, as proportionably the *Sun* deserves to be call'd the *heart* of the world, by whose vertue, and pulsation, the blood is mov'd, perfected, made vegetable, and is defended from corruption, and mattering; and this familiar household-god doth his duty to the whole body, by nourishing, cherishing, and vegetating, being the foundation of life, and author of all. But we shall speak more conveniently of these in

the speculation of the final cause of this motion.

Hence it is, seeing the *veins* are certain wayes or vessels carrying the blood, there are two sorts of them, the *Cava* and *Aorta*. Not by reason of the side, as *Aristotle* says, but by their function; and not, as is commonly spoken, by their constitution, seeing in many Creatures (as I have said) a *vein* differs not from an *arterie*, in the thickness of the *Tunicle*, but by their use and employment distinguishable, a *vein* and an *arterie*, both of them not undeservedly called *veins* by the Antients, as *Galen* has observed, because that this, viz. the *arterie*, is a way carrying the blood from the *heart* into the habit of the body, the other a way carrying it from the habit of the body back again into the *heart*. This is the way from the *heart*, the other the way to the *heart*. This contains blood rawish, unprofitable, and now made unfit for nutrition, the other blood digested, perfect, and alimentative.

CHAP. IX.

That there is a Circulation of the blood from the confirmation of the first supposition.

BUT lest any should think that we put a cheat upon them, and bring only fair assertions, without any ground, and innovate without a cause; there comes three things to be confirm'd, which being set down, I think this truth must needs follow, and be apparent to all men.

1. First, That the blood is continually, and without any intermission, transmitted out of the *vena cava* into the *arteries*, in so great abundance, that it cannot be recruited by those things we take in, and infomuch that the whole mass of blood would quickly pass through.

2. In the second place, that continually, duely, and without cease, the blood is driven into every member and part, and enters by the pulse of the *arteries*, and that in far greater abundance then is necessary for nourishment, or then the whole mass is able to furnish.

3. And likewise thirdly, that the *veins* themselves do perpetually bring back this blood into the mansion of the *heart*.

These things being prov'd, I think it will appear that it doth go round, is returned, thrust forward, and comes back from the *heart* into the extremities, and from thence into the *heart* again, and so makes as it were a circular motion.

Let us suppose how much blood the *left ventricle* contains in its *dilatation* when its full, either by our thought or experiment, either $\text{z}ij$, or $\text{z}iij$, or $\text{z}j\text{f}$, I have found in a dead man above $\text{z}ij$.

Let us suppose likewise, how much less in the contraction, or when it does contract it self, the *heart* may contain, and how much less capacious the *ventricle* is, and from thence how much blood is thrust out of the *arteria magna* for in the *Systole* there is alwaies some thrust forth, which was demonstrated in the third Chapter, and all men acknowledge, being induced to believe it from the *fabrick* of the vessels, by a very probable conjecture we may averr that there is sent in of this. into the *arterie* a fourth, or fifth, or sixth, at least an eighth, part. So let us imagine, that in a Man there is sent forth in every pulse of the *heart*, an ounce and a half, or three drams, or one dram of blood, which by reason of the hindrance of the portals cannot return to the *heart*.

The *heart* in one half hour makes above a thousand pulses, yea in some, and at some times, two, three or four thousand; now multiply the drams either a thousand times three drams, or two drams or five hundred ounces, or such a proportionate quantity of blood, transfus'd through the *heart* into the *arteries*, which is a greater quantity than is found in the whole body. So likewise in a Sheep or a Dog if there pass (I grant ye) but one scruple, in one half hour there passes a thousand scruples, or about three pounds and a half of blood; in whose body for the most part is not contained above four pounds of blood, for I have tryed it in a Sheep.

So our account being almost layd, according to which we may guess the quantity of blood which is transmitted, counting the pulsations, it seems that the whole mass of blood does pass out of the *veins* into the *arteries* through the *heart*, and likewise through the *lungs*.

But grant that it be not done in half an hour, but in a whole hour, or in a day, be it as you will, it is manifest that more blood is continually transmitted through the *heart*, than either the food which we receive can furnish, or is possible to be contained in the *veins*. Nor is it to be said, that the *heart* in its contraction sometimes does thrust out, sometimes not, or as much as nothing, or something imaginary. This I refuted before, and besides its against sense or reason. For if in the dilatation of the *heart* it must needs come to pass that the *ventricles* are filled with blood, it is likewise necessary that in its contraction it should alwaies thrust forth, and that not a little, seeing the conduits are not small; and the protrusion not seldome: its very convenient likewise in every propulsion, the proportion of the blood thrust out should be a third part, or sixth part, or eighth part in proportion to that which is before contain'd in the *ventricle*, and which did fill it in the dilatation, according as the proportion of the *ventricle* being contracted is to the proportion of it being uncontracted; and as in the dilatation it never comes to pass, that it is ever fill'd with nothing, or something meerly imaginary, so in the contraction it never expells nothing, or that which is imaginary, but alwaies something, according to the proportion of the contraction. Wherefore it is to be con-

cluded, that if in a Man, a Cow, or a Sheep, the *heart* doth send forth one dram, and that there be a thousand pulses in one half hour, that it shall come to pass in the same time that there shall be ten pounds and five ounces transmitted, if at one pulse it send forth two drams, twenty pound and $\frac{3}{4}$ 10, if half an ounce forty one pounds and $\frac{3}{4}$ 8, if an ounce, 83 lb, and $\frac{3}{4}$ 4 will come to be transfus'd, I say, in half an hour, out of the *veins* into the *arteries*.

But it may perchance be that I shall set down here more accurately how much is thrust out at every pulsation, when more, and when less, and for what reason, out of many observations which I have gathered.

In the mean time this I know and declare to all men, that sometimes the blood passes in less, sometimes in more abundant quantity, and the circuit of the blood is performed sometimes sooner, sometimes slower, according to the age, temperature, external and internal cause, accidents natural or innatural, sleep, rest, food, exercise, passions of the mind, and the like.

But howsoever, though the blood pass through the *heart* and *lungs*, in the least quantity that may be, it is convey'd in far greater abundance into the *arteries*, and the whole body, than it is possible that it could be supplied by juice of nourishment which we receive, unless there were a regress made by its circuit.

This likewise appears by our sense, when we look upon the dissection of living things, not only in the apertion of the great *arterie*, but (as *Galen* affirms in man himself) if any, yea the least *arterie*

arterie be cut, all the mass of blood will be drain'd out of the whole body, as well out of the *veins* as out of the *arteries*, in the space of half an hour.

Likewise Butchers can well witness this, when in killing of an oxe, they cut the jugular *arteries*, they drain the whole mass of blood in less than a quarter of an hour, and empty all the vessels, which we find likewise to come to pass in cutting off members and tumours, by too much profusion of blood, sometimes in a little space.

Nor does it weaken the force of this argument, that some will say, that in slaughter, or of cutting off members, the blood flows out as much through the *veins* as through the *arteries*, seeing the business is far otherwise. For the *veins*, because they flap down, and that there is no out-driving force in them, and because their composition is likewise with stoppages of portals, as hereafter shall appear, they shed but a very little, but the *arteries* pour out the blood more largely, impetuously, by impulsion, as if it were cast out of a spout. But let the case be tryed omitting the *vein* and cutting the jugular *arterie* in a sheep, or a Dog, it will be wonderful to see, with how great force, how great protrusion, how quickly, you shall see all the blood to be emptied from the whole body as well from the *veins* as from the *arteries*. But it is manifest by what we have said, that the *arteries* receive blood no where else but from the *veins* by transmission through the heart, wherefore tying the *aorta* at the root of the heart, and opening the jugular or any other *arterie*, if you see the *arteries* empty, and the *veins* only full, it is not to be wondred at.

Hence

Hence you shall plainly see the cause in *Anatomy* why so much blood is found in the *veins*, and but a little in the *arteries*, why there is a great deal found in the *right ventricle*, and but a little in the *left*, (which thing perchance gave occasion of doubt to the antients, and of believing, that spirits alone were contain'd in those concavities, whilst the animal was alive) the cause perchance is, because there is no passage afforded from the *veins* into the *arteries* but through the *lungs* and the *heart*, but when the *lungs* have expir'd and leave off to move, the blood is hindred to pass from the little branches of the *vena arteriosa* into the *arteria venosa*, and so into the *left ventricle* of the *heart* (as in an *Embryon* it was before observed, that it was stopt by reason of the want of motion of the *lungs*, which open and shut up the touches, and hidden and invisible porosities) but seeing the *heart* does not leave off motion at the same time with the *lungs* but does beat afterwards and outlive them; it comes to pass that the *left ventricle* and the *arteries* do send forth blood into the habit of the body, and not receiving it through the *lungs*, do therefore appear empty.

But this likewise affords no small credit to our purpose, since there can be no other cause given for this but what in our supposition we have alleged.

Besides from hence it is manifest, that how much the more, or more vehemently the *arteries* do beat it happens in all fluxes of blood that so much the sooner the whole body is emptied.

Hence

Hence likewise it comes to pass, that in all faintings, all fear, and the like, when the heart beats more weakly, languishing, and with no force, that it happens that all fluxes of blood are stop'd and hindred.

Hence likewise it is that in a dead body, after the heart ceases to beat, you cannot out of the *jugular crural veins* and opening of the *arteries* by any means extract above half the mass of blood, nor in a butcher when he hath knockt the ox on the head, and stund him, draw all the blood from him unless he cut his throat before the heart leaves beating.

Last of all, from hence we may imagine that no man hitherto has said any thing aright concerning the *Anastomosis*, where it is; how it is, and for what cause; I am now in that search.

CHAP. X:

The first supposition concerning the quantity of the blood which passes through from the veins into the arteries, and that there is a circulation of the blood is vindicated from objections, and further confirm'd by experiments.

THUS far the first position is vindicated whether the matter be to be reckoned by account, or whether we refer it to experiment, or our own eye-sight, viz. that the blood continually passes out of the veins into the arteries in greater abundance then can be furnished by our nourishment, so that the whole mass in a little time passing through that way, it must necessarily follow that there should be a circulation, and that the blood should return.

But if any here can say that it can pass through in great abundance, and yet it is not needful that there should be a circulation, since it comes to be made up by what we receive, and that the increase of milk in the paps may be an instance, for a Cow in one day gives three, four, or seven gallons, or more, a woman likewise gives two or three pints every day or more, in the nursing of a child or two, which is manifest to be restor'd by what she receives, it is to be answer'd, that the heart is known to send out so much in one hour or two.

But if not as yet satisfied he shall still press further, and say, that although by the dissecting of

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f an *arterie*, and giving and opening a way, it comes to pass besides the course of Nature, that the blood is forcibly pour'd out, yet it does not therefore come to pass in an entire body, no outlet being given, and the *arteries* being full, and constituted according to Nature, that such great quantity should pass in so short space, inasmuch that there must needs be a regrefs; It is to be answer'd, That by laying of an account appears from former reckoning, that how much the *heart* being fill'd does contain more in its dilatation, then in its constriction, so much (for the most part) at every pulsation is sent forth, and for that cause does there so much pass in the body being whole, and constituted according to Nature.

But in *Serpents*, and in some *Fishes*, binding the veins a little beneath the *heart*, you shall quickly see the distance betwixt the *heart* and the *arterie* to be emptied, so that you must needs find the recourse of blood, unless you will deny your own *eye-sight*. The same shall clearly appear afterwards in the confirmation of the second supposition.

Let us conclude, confirming all these with one example, that every one may believe his own eyes: If any one cut up a live *Adder*, he shall see the *heart* beat calmly, distinctly, for a whole hour, and so contract it self, (in its constriction being oblong) and thrust it self out again like a Worm. That it is whitish in the *Systole*, and contrary in the *Diastole*, together with all the rest, by which I said this truth was evidently confirmed, for here the parts are longer and

and more distinct. But this we may more especially find, and clearer then the noon-day.

The *vena cava* enters the lower part of the *heart*, the *arterie* comes out at the upper part, now taking hold of the *vena cava* with a pair of pinfers, or with your finger and thumb, and the course of the blood being stop'd a little way beneath the *heart*, you shall upon the pulse perceive to be presently almost emptied that place which is betwixt your fingers and the *heart*, the blood being exhausted by the pulse of the *heart*; and that the *heart* will be of a far whiter colour, and that it is lesser too in its dilatation for want of blood, and at last beats more faintly, insomuch that it seems in the end as it were to die; so soon again as you untie the *vein* both colour and bigness returns to the *heart*. Afterwards, if you do leave the *veins*, and do grasp or bind the *arterie* a little way from the *heart*, you shall on the contrary see them swell vehemently there where they are grasp'd, and that the *heart* is swell'd beyond measure, and does acquire a purple colour till it be blackish again, and that it is at last oppress'd with blood so that you would think it would be suffocated, but untying the string, that it does return to its natural constitution, colour, and bigness.

So now there are two sorts of death, extinction, by reason of defect; and suffocation, by too great quantity: here you may have the Example of both before your eyes, and confirm the truth which hath been spoken concerning the *heart*, by your own view.

CHAP. XI.

The second supposition is confirmed.

THe second is to be confirm'd by us, which that it may appear the clearer to our view, some experiments are to be taken notice of, by which it is clear, that the blood doth enter into every member through the *arteries*, and does return by the *veins*, and that the *arteries* are the vessels carrying the blood from the *heart*, and that the *veins* are the vessels and wayes by which the blood is returned to the *heart* it self; and that the blood in the members and extremities does pass from the *arteries* into the *veins* (either mediately by an *Anastomosis*, or immediately through the porosities of the *flesh*, or both wayes,) as before it did in the *heart* and *thorax* out of the *veins*, into the *arteries*: whence it is manifest, that in its *circulation* it moves from thence hither, and from hence thither, to wit, from the *centre* to the *extremities*, and from the *extremities* again to the *centre*.

But likewise computation being afterwards made, it appears in the same place, that in regard of the abundance it can neither be recruited by that which we take in, nor is there so much requir'd for nourishment. As likewise concerning *ligatures* it is clear how they attract, that they do it not either by heat, nor grief, or force of *vacuum*, nor any other cause known heretofore. As likewise what convenience and use *ligatures* do bring to Physick, how they stop, or provoke the flux of blood, and how they cause *gangrenes*, and mortifications of the mem-

members, and by this means how they are of use in the gelding of some creatures, and in taking away of *fleshy tumors*, and *wens*. For certainly from hence it comes to pass, that none have rightly understood the causes, and reasons of all these things, though all almost according to the opinion of the Antients, do propound and give their verdict for *ligatures* in diseases, yet few in the administration of them do afford any help by them in their cures.

Some *ligatures* are *strict*; others of a *middle sort*.

A *strict ligature* I call such a one, where the arm is so streightly bound with the *band* or rope, that you cannot perceive the *arterie* to beat any where beyond the *ligature*; such a one we use in the cutting off of members, taking a care of the flux of blood in gelding of *animals*, taking away of *tumors*: by which *ligature* the afflux of aliment and heat being altogether intercepted, the vessels, the testicles, fade and dy, and the great *tumors* of flesh, and afterwards fall quite away.

That I call a *middle sort* of *ligature*; which does compress the member every way, but without pain, insomuch that it suffers the *arterie* to beat a little beyond the *ligature*; such a one as is used in the attraction and emission of blood: for albeit you make the *ligature* above the elbow, yet you shall perceive the *arteries* to beat a little in the wrist if you touch it, if in the blood-letting the *ligature* be made aright.

Now let there be an experiment made in a mans arm, either taking a band, such as they use in blood letting, or by the stronger grasp of the hand it self, which indeed is most conveniently done

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done in a lean body which has larger *veins*; and when the body being heated, the extremities are warm, and a greater quantity of blood is in the extremities, and more vehement pulsations, for when all things will more evidently appear.

If you do make then a hard ligature, drawing it as streight as any can endure it, you may first observe that beyond that *ligature* the *arterie* does not beat in the *wrist*, nor any where else, and then that immediately the *arterie* begins above the *ligature*, has its *Diastole* higher, and beats more vehemently, and does as it were with a kind of tide rise towards the *ligature* (as if it did endeavour to beat through and open its flux which is intercepted) and the passage which is topt, and that it does appear to be fuller there when is convenient. In the mean time the hand retains its colour and constitution, only in process of time it begins to be a little coldish, but nothing is attracted into it.

After that this ligature has continued a while, and that in a sudden it is a little untied into a middle sort, such I say as they use in letting of blood, it is to be observed that the whole hand is streightwayes imbued with colour, and distended, and that the *veins* of it become swell'd and lumpie, and that in the space of ten or twelve pulses the blood being thrust forward and cast into the hand is seen to be extreme full, and that a great quantity of blood is quickly drawn by the *ligature*, without either anguish, heat, or stunning of the *vacuum*, or any other cause heretofore mentioned.

In the mean time, if any one put his finger to
F the

the *arterie*, in the very time of the unbinding, near to the *ligature*, he shall feel the blood as it were passing by under his finger.

Moreover he in whose arm the experiment is made, upon the change of a *streight ligature* into a *middle one* (the impediment being as it were removed) he shall plainly feel the heat and blood enter by pulsation, and perceive something to be breathed by the conduct of the *arterie* as it were immediately, and to be dispersed over all his hand, and that his hand is presently heated and distended. As in a *strict ligature* the *arteries* above are distended, and do beat, and not below, and the *veins* become lesser, so in the *middle sort of ligature* the *veins* swell, and become stubborn, but not above, and the *arteries* become less, nay if you squeeze the *veins*, unless you do it very strongly, hardly shall you see the blood pass above the *ligature*, or the *veins* fall.

So from these things it is easie for any man that will diligently observe, to know that the blood does enter by the *arteries*, for by their *strict ligature* nothing is attracted, the hand retains its colour, nor happens there any distension, but being a little untied as in the *middle or gentle ligature*, it is manifest that the hand is swell'd, and that the blood by the force and impulsion is abundantly thrust in. Where the blood flows forth as in the *gentle ligature* they beat, where it does not flow they beat not at all. In the mean time the *veins* being streightned nothing can flow through them, of which this is a token, that beneath the *ligature*

gature they become much more swell'd, then above, and then they use to be when the *ligature* is taken away, hence it is clearly manifest, that the *ligature* hinders the return of the blood through the *veins* into the superiour parts, and makes those beneath the *ligature* continue swell'd.

But the *arteries* in this case do thrust out the blood beyond the *ligatures* from the inward parts by the strength and impulsion of the *heart*, notwithstanding the *gentle ligature*. This is the difference of the *strict ligature* from the *gentle* one, that the *strict ligature* does not only intercept the passage of the blood in the *veins* but in the *arteries* also, that which is *gentle* doth not hinder the pulsifick vertue, but that it stretches it self and drives out the blood into the furthest parts of the body.

So that we may reason thus; when in a *gentle ligature* we see the *veins* swell'd and distended, and the hand to be very full of blood, whence comes this? For either the blood comes through the *veins*, or through the *arteries* beneath the *ligature*, or through the hidden pores; Out of the *veins* it cannot, by hidden passages less, therefore needs must it be by the *arteries*, as we have said. That it cannot be by the *veins* is apparent, when the blood cannot be squeezed back above the *ligature*, unless you take the *ligature* quite away: Then you may see the *veins* fall and disburthen themselves into the upper parts, and the hand grow white, and all the formerly gathered swelling and blood to vanish apace. He him-

self will better perceive it, whose body or arm has been so bound a good while, and his hands by that means become swell'd, and made colder, I say, he shall feel somewhat that is cold to creep up to his elbow or arm-pits, to wit, with the return of the blood, which return of cold blood to the heart after blood-letting, after the untying of the band, I did imagine to be the cause of fainting, which we likewise see come to pass in strong men, and most after the untying of the *ligature*, which commonly they say comes to pass from the turning of the blood. Besides, when presently upon the untying of the *strict ligature* into a *gentle* one, we see, that by the immision of blood through the *arteries*, the *veins* comprehended beneath the *ligature* do swell up, and not the *arteries*, it is a sign that the blood does pass out of the *arteries* into the *veins*, and not on the contrary; and that there is an *Anastomosis* of the vessels, or that the pores of the flesh and solid parts are pervious to the blood. It is likewise a sign that very many *veins* do communicate together, when a *gentle ligature* being made about the arm many of them do swell together, but passage being open'd out of one little *vein* with the *Lancet*, they streightwayes fall all of them, and disburthening themselves all into that one, do almost all flap down.

From hence may every body know the cause of attraction which is made by *ligature*, and perchance of all fluxes, *viz.* as in the hands, when the *veins* are drawn together by that *ligature*

gature which I call *gentle*, the blood cannot go forth; in the mean time if it be driven violently through the *arteries*, that is to say, by the force of the *heart*, of necessity the part must be fill'd and distended.

For otherwise how could it be? for *heat*, *anguish*, and *force* of the *vacuum* do indeed attract, but so as the part may be full, not that it should be distended, and swoln beyond its natural constitution. But for the in-thrusting, and straight in-driving of the blood, it is neither to be believ'd nor can it be demonstrated a member can be suddenly oppressed, the flesh suffer a solution of its *continuum*, and the vessels be seen to burst, that this can either be done by *anguish*, *heat*, or *force* of the *vacuum*.

Moreover it so falls out, that there is an attraction made by the *ligature*, without all *rief*, *heat*, or *force* of the *vacuum*. But if by any *anguish* the blood should chance to be attracted, which way should, beneath the *ligature*, the hands, and the fingers, and the *veins* swell, and become swell'd, the arm being tyed at the elbow, seeing that by reason of the compression of the *ligature* the blood could not come thither through the *veins*? and why should there no sign appear above the *ligature* either of *tumour* or *repletion*, neither any sign of attraction or a flux at all?

But this is the manifest cause of attraction beneath the *ligature*, and of swelling beyond measure in the hand and fingers, to wit, that the blood does enter forcibly and apace, but cannot get out again.

Hence is all the cause of *tumour*, and of all oppressive redundancy in any part; because the wayes of ingress are open, and the wayes of regrefs shut: hence it must needs follow, that the *humour* should abound, and the part be raised with swelling.

Whether may it not be from hence hat in swellings which are inflam'd, so long as the swelling receives increase, and is not in its highest estate, there is a full pulse felt in that place, especially in hotter *tumours*, in which the increase uses to be on a sudden, shall be for our after-search; as likewise whether that happens from hence, (which by chance I had experience of in my self) I falling out of a Coach, and being somewhat hurt in my forehead, there where the little branch of the *arterie* creeps out of the temples, I felt a swelling about the bigness of an egg in the space of twenty pulses, without either heat or much pain, viz. because of the nearness of the *arterie*, the blood was abundantly and more swiftly driven into the bruised place.

Hence does it appear for what cause in *Phlebotomie* when we would have the blood leap out further and with greater force, we bind it above the cutting of the *vein*, not below; but if it flow in so great quantity through the *veins* from the superiour parts, that *ligature* would not only not help, but hinder: for it were more likely that it should be bound below, that the blood being hinder'd might go out more abundantly if it did flow thither, and descend from the upper parts into

into the *veins*. But since from somewhere else, it is driven by the *arteries* into the lower *veins*, in which regrefs by reason of the *ligature* is hindred, the *veins* swell and can squeeze it out, and throw it further through the *orifice*, but see, the *ligature* being unty'd, and the way of egress being open, the blood doth no longer come, but drop by drop, and that which every body knows, If in *Phlebotomy* you either untie the band, or bind it below, or bind the member with too *strict* a *ligature* it comes not forth, as if all force were taken from it, because forsooth the way of entrance and influx of blood through the *arteries* is by that *strict* *ligature* intercepted, or a more free regrefs is granted through the *veins*, the *ligature* being untied.

CHAP. XII.

That there is a circulation of the blood, from the confirmation of the second supposition.

Seeing these things are so, it is certain that another thing which I said before is likewise confirm'd; that the blood does continually pass through the *heart*. For we see in the habit of the body, that the blood flows continually out of the *arteries* into the *veins*, not out of the *veins* into the *arteries*: We see moreover, that from one arm the whole mass of blood may be exhausted, and that too by opening but one cuticular *vein* with a lance, if the ligature be handsomely made: We see besides, that it is powred out so forcibly and so abundantly, that it is certain that not only that which was comprehended in the arm beneath the *ligature*, before the section, is quickly and in a little time evacuated, but likewise the blood out of the whole body, as well the *veins* as the *arteries*.

Wherefore we must confess first that by strength and force it is furnished, and by force it is driven beyond the *ligature* (for with force it goes out, and therefore by the strength and pulse of the *heart*) for the force and impulsion of the blood is only from the *heart*.

Next, that this flux comes from the *heart*, and that

that it flows by a passage made through the heart out of the great *veins*, seeing below the *ligature* the blood enters by the *arteries*, not by the *veins*, and the *arteries* at no time receive blood out of the *veins*, unless it be out of the left *ventricle* of the heart. Nor could there any otherwise so great abundance be exhausted out of one *vein*, making a *ligature* above, especially so forcibly, so abundantly, so easily, so suddenly, unless the consequents were atchieved by the force and impulsion of the heart, as is said.

And if these things be so, we may very openly make a computation of the quantity, and argue concerning the motion of blood. For if any one (the blood breaking out according to its usual effusion and force) suffer it to come so for half an hour, no body needs doubt but that the greatest part of it being exhausted, faintings and soundings would follow, and not only the *arteries*, but the greatest *veins* would be likewise emptied: Therefore it stands with reason, that in the space of that half hour there passes so much out of the great *vein* through the heart into the *aorta*. Further, if you should reckon how many ounces flow through one arm, or how many ounces are thrust within the *gentle ligature* in 20 or 30 pulsations, truly it would minister occasion of thinking how much may pass through the other arm, both the leggs, and both the *coluses*, and through all the other *arteries* and *veins* of the body: and that the flux which is made through the *lungs* and the *ventricles* of the heart, must continually furnish of necessity new blood, and so make a circuit about the

the *veins*, since so great a quantity cannot be furnished from those things we eat, and that it is far greater than is convenient for the nutrion of the parts.

It is to be observ'd further, that in the administration of *Phlebotomie* this truth chanches sometime to be confirm'd; for though you tie the right arm, and lance it as it should be with a convenient *orifice* and administer all things as they ought to be, Yet if fear, or any other cause, or sounding do intervene through passion of the mind, so that the *heart* do beat more faintly, the blood will by no means pass through but drop after drop, especially if the *ligature* be made a little streighter. The reason is, because the pulse being but faint, and the out-driving force being but weak, the enfeebled part is not able to open the passage and thrust out the blood beyond the *ligature*, yea nor to draw it through the *lungs*, or to remove it plentifully out of the *veins* into the *arteries*. So after the same manner does it come to pass that *Womens flowers* and all other fluxes of blood are stop'd. This likewise appears by the contrary, for fear being remov'd, and the spirit recollected, when they do return to themselves, the *pulsifick strength* being now increased, you shall streightway see the *arteries* beat more vehemently in that part where they are bound, and move in the *wrist*, and the blood leap out farther through the *orifice*.

CHAP. XIII.

The third supposition is confirm'd, and that there is a circulation of the blood from the third supposition,

Hitherto concerning the quantity of blood which passes through the *lungs* and *heart* in the centre of the body, and likewise from the *arteries* into the *veins* and habit of the body; It remains that we do explain which way the blood flows back from the extremities through the *veins* into the *heart* and how the *veins* are the vessels that carry it from the extremities to the centre, by which means we think those three grounds propounded will be true, clear, firm, and sufficient to gain credit.

But this shall be plain enough from the *portals* which are found in the concavities of the *veins*, their use, and from ocular experiments.

The most famous *Hieron. Fabr. ab aqua pend.* a most learned Anatomist, and a venerable old man, or as the most learned *Riolanus* would have it, *Jac. Silvius* did first of any delineate the membranous *portals* in the *veins* being in the figure of a Σ , or semilunary, the most eminent and thinnest parts of the inward tunics of the *veins*: Their situation is in distant places, after a various manner, in diverse persons they are connate at the sides of the *veins*, looking upwards towards the roots

roots of them, and in the middle capacity both of them (for they are for the most part two) looking towards one another, equally and duly touching one another, insomuch that they are apt to stick together at the extremities, and to be joynd; and lest they should hinder any thing to return from the roots of the *veins* into the little branches, or from the greater into the less, they are so plac'd that the horns of the hindmost are stretched towards the middles of the body of it which is before, and so interchangeable.

The finder out of these *portals* did not understand the use of them, nor others who have said lest the blood by its weight should fall downward: for there are in the *jugular vein* those that look downwards and do hinder the blood to be carried upwards. I (as likewise others) have found in the *emulgent veins* and branches of the *Mesenterie*, those which did look towards the *vena cava*, and *vena porta*; add to this moreover that there are no such in the *arteries*, and it is to be observ'd that dogs and cattle have all their *portals* in the dividing of the *crural veins* at the beginning of the *os sacrum*, or in the *Iliac* branches near the *Coxendix*, in which there is no such thing to be feared by reason of the upright stature in man. Nor are their *portals* in the *jugulars*, as others say, for fear of *Apoplexie*, because the matter is apt in sleep to flow into the head through the *sopral arteries*.

Nor that the blood may stand still in *divarications*, and that the whole blood should not break in into the small branches or those which are more capacious: for they are likewise plac'd where

where there are no *divarications* though I confess they are more frequent where *divarications* are.

Nor that the motion of the blood may be regarded from the centre of the body; for it is likely that it is thrust in leisurely enough of its own accord, out of the greater into the lesser branches, and so that it is separated from the mass and fountain: But the Portals were meerly made, lest the blood should move from the *greater veins* into the *lesser* and tear or swell them; and that it should not go from the centre of the body to the extremities, but rather from the extremities to the centre. Therefore by this motion the *small Portals* are easily shut; and hinder any thing which is contrary to them; for they are so plac'd and ordain'd, that if any thing should not be sufficiently hindred in the passage by the *hornes* of the formost, but should escape as it were through a chink, the convexity or vault of the next might receive it, and so hinder it from passing any further.

I have often tryed that in dissection if beginning at the roots of the *veins* I did put in the *Probe* towards the small branches with all the skill I could, that it could not be further driven by reason of the hinderance of the *Portals*: On the contrary, if I did put it in outwardly from the branches towards the root, it passed very easily. In many places two *Portals* are so interchangeably plac'd and fitted, that when they are elevated in the middle of the concavity of the *vein*, they close with one another to a hairs bredth, and in their extremities and convexities are united interchangeably that you can neither see with your eye.

eye-sight nor any way discern any crevice or conjunction : on the contrary from outwardly putting in a *Probe* they easily give way (and like those gates or sluices by which the course of rivers is stopt) they are easily turn'd back to intercept the motion of the blood from the *vena cava* and the *heart*, and being closely lifted up in many places whilst they are interchangeably shut they do quite hinder and suppress, nor by any means suffer the blood to move neither upwards to the head nor downwards to the feet, nor to the sides or arms, but do stop and resist all manner of motion of the blood, which is begun in the *greater veins* and ends in the *lesser*, yet do obey any which is begun by the *small veins* and ends in the *greater*, and does provide a free and open way for it.

But that this truth may the more clearly appear, let the arm of a man alive be tyed above the Elbow, as if it were to let blood, A A will appear at distance especially in country people and those who are swoln vein'd, like little nodes or swellings : And B C D E F not only where the *divarication* is E F, but likewise where there is none C D, and these nodes are made by the *portals*. They thus appearing in the inside of the hand or cubit, if you draw down the blood with your thumb or finger from the node O to H in the second figure, you shall see that none can follow (the *portal* quite hindring it) and that the part of the *vein* H O of the second figure, drawn down betwixt the swelling and the finger, is quite obliterated, and yet full enough above the knot or *portal* O H : Nay if you do retain the blood so
drove

drove down and the blood emptied H, and do press downward with tother hand the upper part of the *vein* O, in the third figure, being full you shall find that by no means it can be forc'd or driven beyond the *portal* O; But how much the more you do indeavour to do this, so much the more shall you see at the *portal* or swelling of O, of the third, the *vein* swoln and distended, and yet that H O of the third figure is empty below.

Hence, since a man may make experiment in many places, it appears that the function of the *portal* in the *veins* is the same as that of the *Sigmoides*, or three pointed *portals*, which are made in the orifice of the *aorta* or *vena arteriosa*, to wit that they may be closely shut up, lest they should hinder the blood to return back again.

Besides tying the arm again as before A A, and the *veins* swelling, if you hold the *vein* below any swelling or *portal* at any distance L of the fourth and afterwards with your finger M drive the blood upwards above the *portal* N, you shall see that part of the *vein* L N to remain empty, and that it cannot return by reason of the *portal* H O 2. but taking away your finger H 3. or L in the fourth figure, you shall see't again fill'd by the lower *veins*, and be like D C of the 1. so that from hence it appears plainly, that the blood does move towards the upper parts and the *heart* in the *veins*, and not on the contrary; and albeit in some places which are not closely shut, or where there is but one *portal*, the passage of the blood from the centre seems not to be quite hindered, yet for the most part it appears so, or at least that which is negligently perform'd in some

some places is recompens'd by the *portals*, in order following, either through their number, diligence or some other way, insomuch as the *veins* are the open and patent wayes of returning the blood to the *heart*, but quite stop'd in its going out from thence.

This is moreover to be observ'd, tying the arm as before, and the *veins* swelling, and nodes or *Portals* appearing, if below any *Portal* in any place where you find the next you place your finger, which may hold the *vein*, that no blood may go from your hand upwards, then squeeze with your finger the blood from that part of the *vein* L N above the *Portal* as was said before, then taking away your finger L suffer it to be fill'd up by those under, as D C, and then pressing again with your thumb in the same place, squeeze out of the blood L N and H O, and do this a thousand times in a little space.

Now if you reckon the business, how much by one compression moves upwards by suppression of the *portal*, and multiplying that by thousands, you shall find so much blood pass'd by this means through a little part of a *vein*, that you will find your self perfectly perswaded concerning the circulation of the blood, and of its swift motion.

But lest you should say, that by this means Nature is forc'd, if you do this in *portals* far distant, and do observe, taking away your thumb, how soon, and how swiftly the blood returns and fills the lower part of the *vein*, I do not doubt but you will find the very same.

C H A P. XIV.

The Conclusion of the demonstration of the circulation of the blood.

NOW then in the last place we may bring our opinion, concerning *the circulation of the blood*, and propound it to all men.

Seeing it is confirmed by *reasons* and *ocular experiments*, that the blood does pass through the *lungs* and *heart* by the pulse of the *ventricles*, and is driven in and sent into the whole body, and does creep into the *veins* and porosities of the flesh, and through them returns from the little *veins* into the greater, from the circumference to the centre, from whence it comes at last into the *vena cava*, and into the *ear* of the *heart* in so great abundance, with so great flux, and reflux, from hence through the *arteries* thither, from thence through the *veins* hither back again, so that it cannot be furnished by those things which we do take in, and in a far greater abundance than is competent for nourishment: It must be of necessity concluded that the blood is driven into a round by a *circular motion* in creatures, and that it moves perpetually; and hence does arise the action and function of the *heart*, which by pulsation it performs; and lastly, that the motion and pulsation of the *heart* is the only cause.

C H A P. XV.

The circulation of the blood is confirmed by probable reasons.

BUT it will not be amiss likewise to add this, that according to some common reasons it is convenient, and it ought to be so. First (*Arist. de respir. & lib. 2, 3. of the parts of creatures*) seeing death is a corruption which befalls by reason of the defect of heat, and all things which are not being alive, are cold when they dye, there must needs be a place and beginning of heat, (as it were a Fire, and dwelling house) by which the nursery of Nature, and the first beginnings of inbred fire may be contained and preserved; from whence heat and life may flow, as from their beginnings, into all parts; whither the aliment of it should come, and on which all *nutrition* and *vegetation* should depend.

And that this place is the *heart*, from whence is the beginning of life, I would have no body to doubt.

There is therefore a motion required to the blood, and such a one as that it may return again to the *heart*; for being sent far away into the outward parts of the body (as *Arist. 2. part. de A-ni n.*) from its own fountain, it would congeal and be immoveable. (For we do see, that by *motion*, *heat* and *spirit* is ingender'd, and preserv'd

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in all things. and by want of it vanishes.) Seeing therefore, that the blood staying in the outward parts is congealed by the cold of the extremities, and of the ambient air, and is destitute of *spirits*, as it is in dead things, it was needful it should resume and redintegrate, by its return again, as well heats, as spirit, and indeed its own preservation, from its own fountain and beginning.

We see, that by the exterior cold, the extremities are sometimes chill, insomuch as nose, hands, and cheeks, do look blew, like those of dead men, because that the blood stands still in them, (as it does in carcases in those parts which are down tending,) whence it comes, that the members are nummed, and hardly moveable, so that they seem quite almost to have lost life. They could certainly by no means (especially so soon) recover heat, and colour, and life, unless they were by a new original, a Flux, and appulsion of heat, again cherished. For how can they attract in whom heat and life are almost extinct? or those that have their passages condensed and stopt with congealed blood, how could they receive the coming nourishment and blood unless they did dismiss that which they before contained, and unless the *heart* were really that beginning from whence heat and life (as *Arist. respirat. 2.*) and from whence new blood being passed through the *arteries* imbued with spirit, that which is enfeebled and chilled might be driven out, and all the parts might redintegrate their languishing heat and vital nourishment almost extinct?

Hence it is that it may come to pass, that the

heart being untouch't, life may be restored to the rest of the parts, and soundness recovered; but the *heart* being refrigerated or affected with some heavy disease, the whole *animal* must needs suffer, and fall to corruption. When the beginning is corrupted, (as *Arist.* 3. *de part. Anim.*) there is nothing which can afford help to it, or those things which do depend upon it.

And hence perchance the reason may be drawn, why in those that with grief, love, cares, and the like are possessed, a consumption or continuation happens, or cacochymie, or abundance of crudities, which cause all diseases and kill men. For every passion of the mind which troubles mens spirits, either with grief, joy, hope, or anxiety, and gets access to the *heart*, there makes it to change from its natural constitution, by distemperature, pulsation, and the rest, that infecting all the nourishment, and weakning the strength, it ought not at all to seem wonderful if it afterwards beget divers sorts of incurable diseases, in the members, and in the body, seeing the whole body in that case is afflicted by the corruption of the nourishment, and defect of the native warmth.

Besides all this, seeing all creatures live by nourishment inwardly concocted, it is necessary that the concoction and distribution be perfect, and for that cause the place and receptacle where the nourishment is perfected, and from whence it is derived to every member. But this place is the *heart*, since it alone of all the parts (though it has for its private use the *coronal vein* and *arterie*) does contain in its concavities, as in cisterns, or a celler, (to wit *ears* or *ventricles*) blood for the publick

lick use of the body ; but the rest of the parts have it only in vessels for their own behoof, and for private use. Besides, the *heart* only is so placed and appointed, that from thence by its pulse it may equally distribute and dispence (and that according to measure, and the concavities of the *arteries*, which are to supply every part) to those which want, and deal it after this manner, as out of a treasure and fountain. Moreover to this distribution and motion of the *blood*, violence, and an impulser is required, such as the *heart* is. To this add, that the blood does easily concentrate, and joyn of its own accord, to its beginning, as a part to the whole, or as a drop of water spilt upon the table to the whole mass, as it does very swiftly, for slender causes, such as are *cold*, *fear*, *horror*, and the like. Besides, it is squeezed out of the *capular veins* into the *little branches*, and from thence into the greater, by the motion of the members, and *muscles* : Likewise the blood is apter to move from the circumference to the centre, than otherwise though the *portals* did not hinder. From whence it follows, that if it do leave its beginning, and move against its will, and enter into places narrower, and colder, that it has need of violence and an impulser, such is the *heart* only, as we said but now.

C H A P. XVI.

The circulation of the blood is proved by consequence.

THERE are likewise Questions, which from this supposed verity, for creating of belief, as arguments *à posteriori*, are not altogether unuseful. These though they be envelop'd in much doubtfulness and obscurity, yet easily admit of the assignation of causes and reasons.

We see in contagion, in poisoned wounds, or in the bitings of *Serpents*, or *mad doggs*, in the *French Pox*, and the like, that the part touched being not hurt, it so falls out that the whole habit of the body is vitiated. The *French Pox* sometimes bewrays it self by the pain of the head, or the shoulders, or other Symptoms, the genitals having no hurt at all. The wound made by the biting of a *mad dogg* being cured, we have notwithstanding observed, that a *feaver*, and other horrible Symptoms have ensued: Because the contagion being imprinted into the part, it appears, that it is from hence carried to the *heart* with the blood returning, and can afterwards infect the whole body. In the beginning of a *tertian feaver* the morbidick, cause going to the *heart* makes them breathless, sighing, and lazie, because the vital beginning is oppressed, and the blood is driven against the *lungs*, and thickned, and finds no passage

sage (I speak this, having had experience from the dissection of them that have dyed in the beginning of the accession) then the pulsations are always frequent, little, and sometimes disorderly: But the heat being increased, and the matter obtenuated, the wayes being open, and passages made, the whole body grows hot, the pulses become greater and more vehement, the Paroxysm of the *feaver* growing higer, to wit, the preternatural heat being kindled in the *heart*, is diffus'd from thence by the *arteries* into the whole body, together with the morbidick matter, which by this means is overcome and dissolved by nature.

Likewise, seeing medicaments outwardly applied, ever use their force within, as if they were taken outwardly; (*Coloquintida* and *Aloes* loosen the belly; *Garlick* applyed to the soles of the feet, causes *expectoration*; *Cantharides* move urine, and cordials do corroborate, and infinite of this kind.) From hence it is constantly averred, perchance not without cause, that the *veins*, through their *orifices*, draw a little of those things which are outwardly applyed, and carry it in with the blood, after the same manner as those in the *Mesenterie* do suck the *Chylus* out of the *intestines*, and carry it to the *liver*, together with the blood.

In the *Mesenterie* likewise, the blood entering into the *Cæliac arterie*, the upper and neather *Mesenteries*, goes forward to the *intestines*; by which, together with the *Chylus* attracted by the *veins*, it returns through the many branches of them into the *Porta* of the *liver*, and through it in-

To the *vena cava*; so it comes to pass, that the blood in these *veins* is imbued with the same colour and consistence, as in the rest, otherwise than many believe: for we must needs believe, that it very fitly and probably comes to pass, in the stem or branch of the *capular veins*, that there are two motions, one of the *Chylus* upwards, another of the blood downwards; but is not this done by a main providence of nature? for if the raw *Chylus* should be mixed with the concocted blood in equal proportions, no concoction, transmutation, or sanguification should from thence arise: But rather since they are interchangeably active and passive, from the union of them being altered, there should arise a mixture, and a thing of a middle nature betwixt the two; as in the mixing of wine and water, there is begotten a wine-foyl: But now, when with the great quantity of blood which passes by, a part of the *Chylus* is mixed after this manner, and as it were in no remarkable proportion, that doth (as *Aristotle* says) more easily come to pass; as when one drop of water is put into a Hog-shead of wine, or on the contrary, the whole is not mixed, but it is either wine or water; so in the *Mesenterick veins*, being dissected, there is found a *Chylus*, not the *Chylus* and blood a part, but mixed, and the same both in colour and consistence to the sense, as appears in the rest of the *veins*; in which notwithstanding, because there is something of the *Chylus* concocted, although insensible, Nature hath placed the *liver*, in the *Meanders* or crooks of which it is delayed, and receives a fuller transmutation,

tion; least coming too soon raw to the heart, it should overwhelm the beginning of life. Hence in *Embryons* there is no use of the liver where the *Umbilical vein* doth apparently passe through the whole, for there stands out of the *porta* of the liver a hole or *Anastomosis*, that the blood returning from the *intestins* of the birth, passing not through the liver, but the forementioned *Umbilical vein*, might go to the heart, together with the mothers blood returning from the *Placenta* of the womb; from whence likewise, in the first forming, of the birth, it comes to passe, that the liver is made last. We likewise in a womans untimely birth, have observed all the members shaped, the *Genitals* distinctly, and yet scarce any foundation of the liver to have been laid. And truly so long as the members (as likewise the heart it self in the beginning) are all whole, and that there is no rednesse contained in the veins, you shall see nothing but a rude collection as it were of blood, without the vessels, instead of the liver, which you would think to be some bruse or broken veins.

There are in an *Egg* as it were two *Umbilical* vessels, one passing through the whole liver, from the *white*, and going directly to the heart; the other going from the *yolk*, and ending in the *vena porta*. For so it is, that a *Chick* is first only nourished and found by the *white*, and afterwards by the *yolk*, after its perfection and exclusion; for the *yolk* may be found to be contained in the belly of the *Chick* many dayes after the hatching, and it is answerable

rable to the nourishing of milk in other creatures. But we shall speak of these things more conveniently in our observations concerning the forming of *births*, where there may be many enquiries of this nature, why this is first made and perfected, and that afterwards; and of the principality of Members, what part is the cause of another; and many things likewise concerning the *heart*, As why (as *Arist. de part. Anim. 3.*) it was made the first consistent, and seems to have in it life, motion, and sense, before any thing of the rest of the body be perfected: And likewise of the blood, why before all things, and how it has in it the beginning of life, and of the creature; why it requires to be moved and driven up and down; and then for what cause the *heart* seems to have been made.

After the same manner in the speculation of pulses, to wit, why such are deadly, others not; and in all kinds by contemplation of their Causes and Presages, what those signify, and what these, and why.

Likewise in the *crisises* and *expurgations* of Nature; in nutrition, especially in distribution of the nutriment; and likewise in all fluxions, &c.

Lastly, in all parts of *Physick*, *Physiological*, *Pathological*, *Semeiotick*, *Therapeutick*, when I do consider with my self how many questions may be determined, this truth and light being given; how many doubts may be solved, how many obscure things made clear,

I find a most large field, where I might run out so far, and enlarge my self so much, that it would not only swell into a great Volume, which is not my intention, but even my lifetime would be too short to make an end of it.

Therefore in this place; that is to say, in the following Chapter, I shall onely endeavour to refer those things to their proper uses, and causes, which do appear in the Administration of *Anatomie*, about the *fabrick* of the *heart*, and *arteries*: for there where I intend to address my self, very many things are found which receive light from this truth, and do in return make it more clear, which I desire to adorn, and confirm by *Anatomical* arguments, beyond all the rest.

There is one thing, which although it ought to have place too in our observations concerning the use of the *Milt*, yet will it not be impertinent to take notice of it here by the by.

From the *splenick veins* drawn down into the *Pancreas*, there arise *veins* from the upper part of it: the *Coronal*, *Postick*, *Gastrick*, and *Gastræpiploick*; all of which, with very many branches and tendons, are dispersed into the *ventricle*, as the *meseraicks* are into the *intestines*: Likewise from the inferior part of this *splenick*, down as far as the *Colon* and *Longanon*, the *Hæmorrhoidal vein* is deducted. The blood returning through those *veins* by both wayes, and carrying the rawest juice with it (hence from the *ventricle*, that which is waterish and thin,

thin; the chilification being not as yet perfected; from thence that which is gross and terrestrial) in this branch of the *splenic*, by the permixtion of contraries, it is conveniently tempered; and Nature mixing those two juices of more difficult concoction, by reason of their contrary indispositions, with great abundance of warm blood, which (by reason of the abundance of *arteries*) flows abundantly from the *milt*, it brings them, being now better prepared, to the *porta* of the *liver*, and supplies and recompences the defect of both by such a structure of the *veins*.

Chap.

CHAP. XVII.

The motion and circulation of the blood is confirmed by those things which appear in the heart, and from those things which appear in Anatomical dissection.

I Do not find the *heart* in all creatures to be a distinct and separate part; for some, as you would say *Plant-animals*, have no *heart*; Colder creatures of a softer make, and of a kind of similar constitution, such as are *Palmer-worms*, and *Snails*, and very many things which are ingendered of putrefaction, and keep not a *species*, have no *heart*, as needing no impulsor to drive the nutriment into the *extremities*: For they have a body connate and of one piece, and indistinct without members; so that by the contraction and returning of their whole body, they take in, expell, move and remove the nourishment, being called *Plant-animals*; such as are *Oysters*, *Muscles*, *Sponges*, and all sorts of *Zoophytes*, have no *heart*; for instead thereof they use their whole body, and this whole creature is as a *heart*.

In very many, and almost all kinds of *Insects*, by reason of the smallness of their Corpulency, we cannot rightly discern; yet in *Bees*, *flies* and *wasps* we may by the help of a perspective glass. You may likewise see something beat in *lice*, in which moreover you may clearly see the passage
of

of the nourishment through the *intestines* (this Animal being transparent) like a black spot, by help of this multiplying glass. But in those that have no blood and are colder, as in *Snails*, *Shell-fish*, *Crusted-Shrimps*, and the like, there is a little part which beats (like a *little bladder*, or an *ear*) without a *heart*, making its contraction and pulse seldomer, and such a one as you cannot discern but in summer, or in a hot season.

In these creatures this particle is ordained too, that there is a necessity of some impulsion for the distribution of the nourishment, by reason of the variety of the *organick* parts, or the thickness of their substance: but the pulsations are made seldomer, sometimes not at all, by reason of their coldnesses, as it is meetest for them, being of a doubtful nature, so that sometimes they seem to live, sometimes to dye, and sometimes to live the life of an *animal*, sometimes the life of a *Plant*.

This is likewise contingent to those *Insects* which do lurk in the Winter, and are hid as if they were dead, and do only lead the life of a *Plant*; but whether this do likewise happen to some creatures that have blood, as to *Frogs*, *Snails*, *Serpents*, *Swallows*, we may not without reason make a question.

In creatures which are a little bigger, and hotter, as having blood in them, there is an impulsion of the nutriment required, and such a one perchance as is endued with more force; therefore in *Fishes*, *Serpents*, *Snakes*, *Snails*, *Frogs*, and others of the like nature, there is both one *ear*, and one *ventricle* of the *heart* allotted, whence rises that most true Axiom of *Arist. de part. Anim. 3.* That no creature

ure having blood does want a *heart*, by the impulsion of which it is made stronger and more robust; and the nutriment is not only stirred up and down by the *ear*, but likewise is thrust out further and more swiftly.

That in creatures yet greater, hotter, and more perfect, (as abounding with a great deal of hotter blood, and full of spirit) there is a stronger and more fleshie *heart* required, that the more strongly, more swiftly, or with greater force the nutriment may be thrust out, by reason of the bigness of the body, and thicknels of the habit.

And moreover, because that more perfect creatures need more perfect aliment, and a more abundant native heat, that the nutriment of them may be concocted, and acquire a further perfection, it was fit that these creatures should have *lungs*, and another *ventricle*, which should drive the nutriment through them.

So in whatsoever creature there is *lungs*, there is likewise in them *two ventricles* of the *heart*, the *right*, and the *left*, and wheresoever the *right ear* is in any, there is the *left*, not on the contrary, that where the *left* is, there is the *right* one too; that I call the *left ventricle* which is distinguished in place, but not in use from the tother, which doth diffuse the blood into the whole body, not into the *lungs* alone, hence the *left ventricle* seems to make up the *heart* of it self, being placed in the middle, and so fenced with higher ditches, and framed with greater diligence, that the *heart* seems to have been made for the *left ventricle's* sake, and the *right ventricle* seems as it were a servant to the *left*, and does not reach to the

top

top of it, and is made up of a thinner threefold wall, and it has, as *Aristotle* says, a kind of articulation above the *left*, and is more capacious, as administering not only matter to the *left*, but giving nourishment likewise to the *lungs*.

But it is to be observed in *Embryons* these are far otherwise, and that there is no such great difference of the *ventricles*, but like two kernels in a nut they are almost equal, the corner of the right reaches the top of the left, so that in them the *heart* hath as it were a double top at the point. These things come to pass because in them whilst the blood does not pass through the *lungs*, as it does pass from the *right bosome* of the *heart* to the *left*, both the *ventricles* do perform alike the office, bringing the blood through from the *vena cava* into the *arteria magna* by that oval hole and arterious passage, as hath been said, and do equally divide it into the whole body, whence proceeds an equal constitution. But when it is time that the *lungs* should be used, and the foresaid unions begin to be stop'd, then does this difference of *ventricles* begin to be in their strength, as likewise in the rest, because the *right* drives only through the *lungs*, the *left* through the whole body.

There are besides these in the *heart* also *tendons*, as I may so say, or fleshie twigs, and very many *fibrous connexions*, which *Arist.* in his book *de respir.* and *de part. anim.* 3. calls *nerves*, of which some apart are stretched with divers motions, and are partly hidden in furrows with deep ditches about them in the walls and *mediastin*, and they are like a kind of little *muscles* which are underordained,

dained, and superadded to the *heart*, as auxiliaries, for the further expulsion of blood, that like the diligent and artificial provision of tackling in a Ship, they might help the *heart* contracting it self every way, and might squeeze out the blood more fully and forcibly out of the *ventricles*.

And this is manifest from hence, because some *animals* have them, some not, and all which have them are stronger in the *left ventricle* than in the *right*; some *animals* have them in the *left*, and not at all in the *right*, in men there are more of them in the *left* than in the *right*, and more in the *ventricles* than in the *cars*, and in some *ears* almost none; there are more of them in brawnie, muscular and rural bodies, and such as are of rougher habit of body, than in those which are tender, and in Women there are fewer.

In those creatures in which the *ventricles* within are smooth, altogether without *fibers* and *tendons*, and which are not cleft into ditches (as almost in all little birds, *Serpents*, *Frogs*, *Snails*, and the like, in the *Partridge* likewise and the *Hen*, and the greatest part of *Fishes*) in them neither those *nerves* or *fibers* mentioned, nor the three-fork'd portals are to be found in the *ventricles*. In some *animals* the *right ventricle* is smooth within, the *left* has those *fibrous* connexions, as in the *Goose*, *Swan*, and greater birds: In them the same cause is alledged as in all, seeing their *lungs* are spongy and soft they need no such force to impell the blood through them; therefore in the *right ventricle* either they have no *fibers*, or else fewer and weaker, nor are so fleshy and comparable to

Muscles, but in the *left* they are stronger and more in number, more fleshy and musculous, because the *left ventricle* hath need of more strength and force, by reason that it ought to pursue the blood farther through the whole body.

From hence it is likewise, that the *left ventricle* possesses the middle of the *heart*, and hath a wall threefold thicker, and is stronger than the *right ventricle*. Hence all creatures, men likewise, by how much the habit of their flesh is harder and more solid, and by how much more their outward members are more fleshy, and farthest from the *heart*, and brawnie, so much more *fibrous*, thick, robust, and musculous a *heart* have they; and this is necessary and clear on the contrary, by how much the more they are fine-spun, of a softer habit, and of slenderer bodies, so much the softer, flagging, and less *fibrous heart* within (or not at all) have they.

Likewise consider the use of the *portals*, which were made for that cause, lest the blood once let out should be returned to the *heart*, and as well in the *orifice* of the *arterie*, as of a *vein*, they are up-lifted, and enterchangeably joining, they make a three square line, such as is imprinted by the biting of a *Swallow*, that being shut more closely they may hinder the reflux of blood.

There are three forked *portals* in the entry of the *vena cava*, and *arteria venosa*, lest that when the blood is most driven out it should fall back, and for that cause they are not in all creatures, and in those in which they are, they do not seem to be made by the same

Of the motion of the Heart, &c. 96

iligence of Nature, but in some they are
 out more exactly, in others more carelessly
 and negligently; therefore in the *left ven-*
tricle, that for the greater impulsion there may
 be a closer stoppage, there are only two like a
 Mitre, having *tendons* reaching out far, even
 to the *conus* of it, through its middle, that
 they may be most exactly shut. This perchance
 receiv'd *Aristotle*, in making him believe that
 his *ventricle* was double, the division being
 made athwart, lest the blood should fall back
 gain into the *arterie*, and by that means the
 strength of the *left ventricle* in driving forth the
 blood into the whole body should be destroy-
 ed, therefore these *portals* do much surpass in
 signess, strength, and exact shutting, those
 which are placed in the *right*. Hence likewise
 of necessity, no *heart* is seen without a *ventri-*
cle, since it ought to be the well-spring, foun-
 tain, and cellar of blood. The same does not
 always happen in the *brain*; for almost all sorts
 of birds have no *ventricle* in the *brain*, as it ap-
 pears in the *Goose* and *Swan*, the *brains* of
 these, although the *brains* of a *Conie* be almost
 as big, yet the *Coxie* hath *ventricles* in the *brain*, the
Goose has not.

Likewise, wherever there is one *ventricle*, there
 hangs by it an *ear* flagging, cuticular, hollow
 within, full of blood; where there are two
ventricles, there are likewise two *ears*; on the
 contrary, there is only one *ear* in some crea-
 tures, or at least a *bladder* answerable to an *ear*;
 or the *vein* it self dilated (but not the *ventri-*
cle of the heart) making a pulse instead of the

heart, as it appears in *Hornets*, *Bees*, and other *Insects*, whom I believe I can demonstrate by some experiments, to have not only a pulse but a respiration likewise in that place which they call the tail; whence it happens that it is lengthened and contracted, sometimes oftner, sometimes more seldome, according as they seem more panting or to be more indigent of air; but of this in the treatise of Respiration. It is likewise manifest that the *ears* do beat and contract themselves, as I said before, and cast the blood into the *ventricle*, whence it is that wheresoever there is a *ventricle* there an *ear* is requir'd, not only (as is commonly believed) that it may be the receptacle and cellar of blood, (for what needs there any pulsation for the retaining of it?) but the first movers of the blood are the *ears*, especially the *right*, being the first thing that lives, and the last that dies, as before is said; for which cause they are necessary, that they may serve to pour the blood into the *ventricle*. But the *ventricle* immediately contracting it self, doth more conveniently squeeze out; and more violently thrust forth the blood, being already in motion; as when you play at ball, you can strike it farther, and more strongly, taking it *a la volee*, than you could only throwing it out of your hand. But likewise, contrary to the vulgar opinion, because neither the *heart*, nor any thing else can so extend it self as that it can attract any thing in its diastole (unless in its return to its former constitution, being before squeezed like a sponge, but it is certain, that all local motion comes first and did take its beginning, from the contraction

Of the motion of the Heart, &c. 101

f some particle; therefore by the contraction of the *ears*, the blood is cast into the *ventricles* as open'd before, and by the contraction of the *entricks*, it's thrown farther and removed.

Which truth concerning local motion, and that the immediate *motive organ* (in all creatures in which a motive spirit is primarily) is contractable, *Arist.* sayes in his book *de spirat.* and elsewhere, and that *Aristotle* did know the *muscles* when he did refer all the pains and motion in creatures to the *nerves*, or that which is contractable, and therefore call'd those *tendons* in the *heart*, *nerves*; I hope it shall be made clear if at any time I shall have liberty to demonstrate concerning the *motive organs* of creatures, and the fabrick of the *muscles*, from my own observations.

But pursuing our purpose concerning the use of the *ears*, which we did demonstrate was to fill the *ventricles* with blood, we see it comes to pass, that the thicker and more compact the *heart* is; and of a grosser wall, the more *nervous* and *musculous* the *ears* are to draw in and fill it; and in those in whom they are contrarywise, it does appear in them as a bladder of blood, or a membrane containing blood, as in fishes, for there the bladder which is in lieu of the *ear* is very thin, and so large that the *heart* seems to swim above it; but in those fishes in which this bladder is a little more fleshie, it seems very precisely to emulate and counterfeit the *lungs*, as in the *Barbell*, *Tench*, and others.

In some men, to wit such as are brawnie, and of a rougher habit of body, I have found the *right ear* so strong and so neatly made up within, with

the various contexture of *fibers*, that it did seem to be equal in strength to the *ventricles* of other men; and truly I did wonder that in divers men there should be such difference. But it is to be observed, that in the birth, the *ears* are far greater than they are in it proportionated, because before the *heart* is made, that it may do its own function, (as before was shewed) they do the office of the *heart*.

But the things that I observ'd concerning the forming of the birth which I made mention of before, and *Aristotle* confirms in an *egg*, do add a great deal of credit and light to the business; first, whilst the birth is as it were a tender worm and whilst it is yet (as is usually) spoken in the milk, there is in it a little *bladder* or *bag* which beats, and as it were a portion of the *umbilical vein*; afterwards, when the birth being shaped, begins to have a stronger corpulency, this little *bag* becomming more fleshy and robust (changing its constitution) turns into *ears*, above which the body of the *heart* begins to spring, as yet executing no publick office; but the birth, when 'tis already form'd, and that the bones are distinct from the flesh, and it is a perfect creature, and that it is felt to have motion, then the *heart* is both found beating within, and does transfuse the blood as I have said out of the *vena* into the *arterie* through both the *ventricles*.

So Nature being perfect and divine, and making nothing in vain, neither gave a *heart* to any where there was no need, nor made it before there was any use for it, but by the same degrees in the form-

forming of all *animals* passing through the constitutions of all creatures (as I may say in the *egg*, *Worm*, and birth) it acquires its perfection in them all. These things shall be confirmed elsewhere by many observations in the forming of the birth.

Lastly, *Hippoc.* in his Book *de Cord.* did not without reason call it a *muscle*, seeing the action and function of both is the same, *viz.* to contract it self, and move somewhat else, that is, the blood.

Moreover, from the constitution of the *fibers*, and their motive frame, as likewise in the *muscles*, we may see the action and use of the heart. All Anatomists have observ'd with *Galen*, that the body of the *heart* is made with several draughts of *fibers* streight, thwart, and crooked, but in a *heart*, being boyl'd the structure of the *fibers* is found to be otherwayes.

For all the *fibers* in the walls and in the inclosure are circular, as they are in a *Sphincter*, but those which are in the *tendons* stretched out in length, are crooked; so it comes to pass that when all the *fibers* are contracted, it happens that the top is brought to the bottom by the *tendons*, and the walls are inclosed in a round, and the *heart* is contracted every way, and the *ventricles* strengthened. Wherefore since the action of it is contraction, we must needs imagin that the function of it is to thrust blood out into the *arteries*.

Nor must we disagree from *Aristotle* concerning the principality of the *heart*, and that it does not receive motion and sense from the *brain*, nor

blood from the *liver*, but that is the beginning of the *veins*, and of the blood, and the like; Seeing those that endeavour to confute him omit that chief argument, to wit, That the *heart* is the first subsistent, and that it hath blood, life, sense and motion before the *brain* or *liver* were made, or appear'd distinctly, at least before they could perform any function. To this add, That the *heart*, as a certain internal *animal* consists longer, as if Nature by the making of this first, would have the whole *animal* afterwards to be made, nourish'd preserv'd, perfected by it, as its own work and dwelling place. The *heart* is as it were a Prince in the Commonwealth, in whose person is the first and highest government every where; from which as from the original and foundation, all power in the *animal* is deriv'd, and doth depend.

But besides very many things about the *arteries* do likewise evidence and confirm this truth; when it is consider'd why the *arteria venosa* does not beat since it is numbred amongst the *arteries*; or why there is a pulse found in *vena arteriosa*, since the pulse of the *arteries* arises from the impulsion of blood; or that the *arteries* in the thickness of their *tunics*, and the strength of them, do differ so much from the *veins*, because they bear the force of the impulsion of the *heart*, and breaking out of the blood.

Hence, since Nature who is perfect, makes nothing in vain, and is sufficient in all things, the nearer the *arteries* are to the *heart*, the more they differ from the *veins* in their constitution, and are more robust and full of ligaments, but in the furthest dispersions of them, in the *hand*, *foot*, *brain*,
mesenterie

mesenterie, and *spermatick vessels*, they are so like in their constitution, that earnestly viewing their *tunics*, it is a hard business to know one from the other.

And this is so for just causes. For the further the *arteries* are distant from the *heart*, by so much less strength a great deal are they struck, the stroak of the *heart* being weakned by the great distance. Add to this, that the impulsion of the *heart*, since it must needs be sufficient in all the trunks and branches of the *arteries*, it is lessened at every partition, as being divided, insomuch that the last divisions of the *capillares arteriosae* seem to be *veins*, not only in constitution, but likewise in function, or do not give a sensible pulse, or none at all, or else not alwayes, unless the *heart* do beat more forcibly, or some little *arterie* be dilated, or more open in some part. Hence it comes, that sometimes we may find a pulse in the teeth, sometimes in the gums, and sometimes we cannot. From hence I did certainly observe, that Boys whose pulses are alwayes swift and frequent were in an undoubted Feaver, by this one token; as likewise in tender and delicate people by griping of their fingers, I could easily perceive by the pulse of their fingers when the Feaver was in its strength.

On the other side, when the *heart* beats faintly, not only not in the fingers, but neither in the wrist, nor in the temples can any pulse be felt, as in fainting, hysterical symptoms, defect of pulse, weak people, and those that are departing.

Here Chirurgions are to be admonished, lest they be deceived; because in the cutting off of members, the cutting away of fleshy tumors, and
in

in-wounds, the blood does indeed come forcibly out of the *arterie*, but not alwaies with leaping, and that the small *arteries* do not beat, especially if they be tyed with a *ligature*. Beside, that the *vena arteriosa* hath not only the constitution and *tunicle* of an *arterie*, but that it does not differ so much in the thickness of the *tunicle* from the *veins* as the *aorta*. The reason is, because the *aorta* abides a greater impulsion of the blood from the *left ventricle*, than that does from the *right*; therefore it has the constitution of the *tunicles* so much the softer than the *aorta*, by how much the *right ventricle* of the *heart* is weaker than the left: And by how much the contexture and softness of the *lungs* does abate from the habit of the body and flesh, so much does the *tunicles* of the *vena arteriosa* differ from that of the *aorta*.

All these things do constantly keep proportion in men, for the more brawny, musculous, and of harder habit of body they are, and the stronger, thicker, and more fibrous heart they have, so much the more answerable *ears* and *arteries* proportionably they have in thickness and in strength. Hence in those creatures, the *ventricles* of whose *hearts* are smooth within, without roughness, *portals*, and with a thinner wall, as in *Fishes*, *Birds*, *Serpents*, and very many sorts of creatures, in them the *arteries* differ very little or nothing from the thickness of the *veins*.

Besides, the *lungs* have such large vessels, their *vein* and *arterie*, that the trunk of the *arteria venosa* does exceed both the *crural* and *jugular* branches, and are so full of blood, as by experience and my own eye-sight (nor was I deceived in the inspecti-

on of those things which I saw in dissected creatures) that upon the wounding of them, all the whole blood has run out; the cause, by reason that in the *lungs* and in the *heart* is the fountain, cellar, and treasure of blood, and store-house of its perfection.

Likewise we see in Anatomical dissection, that the *left ventricle* and the *arteria venosa* does abound with so great a quantity of blood, and indeed of the same colour and consistence with that with which the *right ventricle* and the *vena arteriosa* is filled, alike black and clotted, because the blood passes hither from thence continually through the *lungs*.

Lastly, the *vein* called *arteriosa*, commonly has the constitution of an *arterie*, the *arteria venosa* of a *vein*, because in truth, both in function, constitution, and all things else, that is an *arterie*, and this a *vein*, otherwise than is commonly believed; besides, the *vena arteriosa* hath such a wide *orifice*, because it carries a great deal more blood than is necessary, for nourishing of the *lungs*.

All these *Phænomena's* to be observed in dissection, and very many more, if they be rightly weighed, seem to clear the foresaid truth abundantly, and indeed to confirm it, and withall to go against the common opinion: Seeing it is very hard for any to demonstrate by any other way than we have done, for what cause all these things are appointed.

on of those things which I saw in dissected crabs (curves) that upon the rounding of them, all the whole blood has run out; the cause, by reason that in the lungs and in the heart is the fountain, cellar, and treasure of blood, and store-house of its perfection.

Likewise we see in Anatomical dissection, that the arteries and the veins does abound with a greater quantity of blood; and indeed of the same colour and consistence with that with which the veins are filled; and the arteries is filled with black and clotied; because the blood passes faster from thence continually through the

last, the vein called artery, commonly has the continuation of an artery, the vein is somewhat a vein, but in truth, both in function, constitution, and all things else, that is an artery, and is a vein, otherwise than is commonly believed; because it carries a great deal more blood than is necessary, for nourishing of the lungs.

And the Phlegma, to be observed in dissection, and very many more, if they be rightly weighed, seem to clear the fore-said truth abundantly, and indeed to confirm it, and will to go against the common opinion: seeing it is very hard for us to demonstrate any other way than we have done, for what cause all these things are so

32, 232.

THE
DISCOURSE
OF

JAMES De BACK,
Physician in Ordinary to the
Town of ROTTERDAM,

In which he handles,
The nullity of spirits,
Sanguification,
The heat of living things.

There is premised,
A Speech to the READER ;

And annexed,
An Addition , in Defence of
HARVEY's Circulation.

L O N D O N, Printed by T. R. 1673.

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A
S P E E C H
TO THE
READERS:

In which are handled the honours and reverence done to the Inventors of Arts, the liberty of opinion more esteemed, Truth is the foundation of the Art of Physick, Harvey is the Author of the Circulation of the Blood, by which many Positions of the Antients are overturned; the reason of the Authors writing a brief rule of the compend of Physick.



OW much those were esteemed, who amongst the Antients earnestly endeavouring for the common good, and watchfully caring for the safety of their Countrymen, did communicate their inventions and labours to their coevals and posterity,

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rity ; Rewards of old propounded, and Honours conferred upon them do sufficiently shew. The Inventers of Physick were number'd amongst the Gods ; those that did excell in their Studies, and in the Liberal Arts, being number'd amongst the Muses, and the inhabitants of *Parnassus*, were all adorned with divine honours. This was alwayes the care of Cities, Commonwealths, and founders of Kingdoms, to incite the wits of their Subjects by such rewards, as with a delight and prick to the best Arts and Sciences : Nor were they content with this, but in diverse places by their great pains houses have been built, by which they might allure strangers who were excellent in learning, who were to be entertain'd upon the charges of the Publique, with the addition likewise of rich rewards. There are likewise Colleges erected for the teaching of youth, which being imbued by the learning of Masters, and tending to the like honours, were invited to add their own Inventions to those of the Antients, by new rewards. Neither by the careful diligence and endeavour of posterity, was there any thing thought to be derogated from the deserts of the Inventers of Arts, as if they had not taught the Art intire and absolute in all points : Better it was that the ground-work was laid by them, upon which, as upon a path or way, the Sons of

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of Art might walk, that they might fitly be taught in Sciences, or being inflam'd with the love or desire of knowledge, they might be advanc'd to higher things. The old Man begins his positional doctrine, *Art is long, life is short*, well considering the business, the length of our Art hath not only vanquished one mans life-time, but all ages; which having as yet not received perfection, will in the time of our posterity, perchance, never find it. So ready are occasions for search, and so great the difficulty of judging, especially if being bound by the certain rules of the mind, they be hinder'd to run out further for the search of the truth. The never-enough esteem'd Interpreter of *Hippocrates* in his 3. B. *Nat. Facult. Cap. 10.* *Whosoever*, sayes he, (not speaking any thing of the perfection of Art) *desires to know any thing more than ordinary, ought to excell others, not only in the rudiments of learning, but also be possess'd with a mad love of truth, endeavouring day and night, to learn those things which are taught by the most famous men, judge, spend much time in searching, and consider what things agree with those things which are obvious to the sense, and which do disagree.* Besides the same *Galen* does so much esteem the freedom of searching out of the truth, that in 6. *Epidem. Aphor. 7.* He call'd it a tyranny that any body should be restrained to any

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one opinion without handsome demonstrations. Likewise 6. *Epid. Sect. 2. Aphor. 17.* he does sharply reprove those that bequeath and give themselves over to their masters without examination. *Whosoever*, sayes he, *does confess themselves to be the servants or waiters of any person, those so soon as they find any thing written by him, presently approve of it, both rashly and unadvisedly.* From hence it is manifest, how candidly those clear lights of Physick did love the light of truth, to the adorning of Physical art and common safety of all; so that they prefer the freedom of enquiring after truth, sifting of reasons, and giving opinion concerning any thing, (though themselves were the guides) to tyranny and servitude, for the prisons of these being broken, a free spirit is master of it self;

*The lively force o'th' Soul o'recame, and past
Beyond the walls o'th' flaming world at last,
And o're this vast in soul and thought doth drive:
Whence victor, he relates what may arrive, (pow'r
What not, how, and by what means t' all things
A bound is set, they cannot pass their hour.*

Being instructed, and as it were bred from my youth in the doctrine that these Heroes left behind them, I did earnestly embrace the precepts given by them, and that had as it were

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were a strong tye upon me to defend them, and for good reason, seeing the fathers of that art did create us sons of the same, and we owe it to them that we have profited in the art, and we are forced to confess, that we have gain'd the knowledge to which we are risen, by their assistance, and the help of these things which we receiv'd from them. Besides, the sonnes of art are tyed by an Hippocraticall oath to esteem one another as brothers, and to esteem of those of whom they learn'd the art, as of their Parents; if then a son owes honour and reverence to his father, why should not we, who are the sons of art, reverence and respect our patrons and parents?

Upon their advice, I did set down and resolve in my mind, having taken the degree of Doctor, to essay nothing in the practick, unless being induced to it by a tryall of reason, or if I heard any thing well done or spoken by another, that I should endeavour to search the reasons of the thing as it came to hand, that I might at least satisfie my self; I being thus prepared in mind, it so happened about 15 yeares agoe that the Anatomicall exercise of *William Harvey*, concerning the motion of the *heart* and blood, did fall into my hands, after it had been out about five or six years, having drawn a great many

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learned men to his opinion in this Treatise, he leaving very many Positions of the ancient doctrine on which I had grounded my self, he was pleas'd to say, that the blood did not move through the *veins* from the *liver* for the nutrition of every part by their attraction, but that the same was driven from the *heart* through the *arteries* for the aforesaid use, and that the superfluous part did return through the *veins*, that being again refresh'd in the *heart*, and imbued with new spirits, it might be again carried back to all the members, and that it might be returned again often through the same way by a continual circular motion. This new thing I did examine, which at the first entrance did seem very easie to be refuted, but being weighed in a just ballance, and having added to reason my own eye-sight, it was found inexpugnable, nay, (the very prick of truth enforcing) to be embrac'd with both arms ; what should I do ? must *Hippocrates* be left, *Galien* slighted ? no, if we follow the truth fenced with reason and our sense, we are still *Hippocrates* his, we are still *Galens*. *Nothing to be contemned*, sayes the old man, *nothing to be judged rashly*. Hence he commands us to examine the writings of the most famous men, when they are obvious to our senses, or disagree from them. Rational and
dogmatical

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dogmatical Physick consists in true grounds, nor is any thing to be thought firm and establish'd, but what is approved by truth. This Heresie, first thought to be so in Physick, grew daily, so that it walks not only through the Universities of *England*, his native Countrey, but likewise through those of *Germany*, *France*, *Italy*, and our Universities of the *Low-Countries*, and besides a great company of learned men, it tied also the Professors to it in many places, of whom, some in their publick Lectures and Disputations, as also by Books written to that purpose, did at last divulge this opinion, with the great applause of Students, that you shall scarce find a Doctor created, who knows not, yea does not approve of the Circulation of the blood. But as from one true Position a thousand consequences are taken agreeable with reason, and a thousand leaning upon one which is confuted do totter and fall; so did it come to pass, that by setting down the Circulatory motion of the blood, innumerable axiomes of ancient writers were overturn'd; whence it comes, that all the order of teaching is troubled, and the doctrine of Physick is endeavour'd and learned altogether preposterously and confusedly, without any certain method, which ought to be established by Positions link'd together, and marshall'd in due order.

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This is the reason that all doe somewhat disagree in one thing or other, either in the Cause of the motion of the blood, or in the Manner, or in the Effect, or leave it as a thing too laborious or hatefull to their Collegues, not searching farther in it, after they had receiv'd, and by their Books published, approv'd of the invention of *Harvey*, concerning the Circulation of the blood, being thereto perswaded and convinced by reason, and their owne eye-sight. But it being not handsome for me to neglect the scrutiny of this business, or to stand in a doubtfull condition, I did undertake to search into, and examine the reason, the action, and use of the parts, and did endeavour through carefull search to piece up and illustrate in a little method that order which had been destroyed. But this was not done with so great silence, but that there did often arise discourses of it amongst my Collegues and other my familiars, as likewise, sometimes those things which did chance to concern the Circulation of the blood were in our Anatomical demonstrations handled and canvass'd; whence it happened, whilst some did search after these things, and that seriously, new doubts alwayes occurring, they did earnestly and friendly entreat me, that I would publish for common use such things as in this matter I had

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had studied : which although it was troublesome to me now growing old, it being two and thirty years past, since I gave my self to practice, and (as it is usuall) I had in a manner left all the Theorick part, (if this matter concerning Circulation had not waken'd it) there could be not time enough for me (being both busied with my own affairs, and with my practise) to bestow upon this work. Yet that I might please my friends, I suffer'd my self, refusing and unwilling, at last to be entreated, insomuch, that I might adde something to the Treatise of Doctor *Harvey* of the *heart* and *blood*, which might be to the same purpose; which Book *Arnoldus Leers* a vigilant Stationer hath lately given to the Press: I did therefore undertake to write a Discourse concerning the *heart*, partly because it agrees with Doctor *Harveys* purpose, and partly because I thought that the scrutiny of the *heart* was more accurately to be handled, and with a more diligent care to be enquir'd after. For the believ'd excellency and splendour of it hath so bewitched the minds of both Ancient and Neoterick Philosophers, and so blinded their eyes, that not seeing the clear light of truth, they receive nothing but things obscure and conceiv'd in their own imaginations for truth. Therefore, whilst I endeavour to take away those mists & cataracts from their eyes, I do

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earnestly entreat that I be not blam'd for such a one as endeavours to take away from the Ancients their proper honour, and from the Fathers of the Art the reverence which is due to them, and as if I would diminish brotherly concord amongst the Sons of Art, if I expose that little which I have conceiv'd in my mind, being call'd to counsell, whilst the reformation of the Method of Physick is in hand; and lest I be accused as if I would further disorder it, (it being not enough for me that by bringing in of the Circulatory motion, the natural and vital faculties are confus'd) and reject *Hippocrates* his ancient *Oeconomy* of the body, hitherto received of all, and overturn the foundation of that doctrine; I hope it will be a remedy for that evil, if I excuse and free myself of it in the very entrance. Since the Analytick Method of teaching did alwayes seem most commodious to the most eminent in Physick for the explication and search of humane nature, they took a division out of *Hippocrates* writings, by which they do divide the body, into things containing, things contained, and things impelling or impulsive: things containing, they call the solid parts; things contain'd, they call humours; things impelling, they call spirits. But because the subtilty of substance which is ascrib'd to spirits, may infer indeed a mobility or promptness

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ness to motion, but not an active motion; besides that, if there be any such, they must pass amongst things contain'd, and being also destitute of life, they must needs be impell'd by some other thing; if they will have their division firm and established, some other thing must be thought on, to which this force and power of impulsion may be more competent and agreeable. This will come to pass, if you divide a living Man into that which contains, that which is contained, and that which is impulsive, understanding by that which is contain'd, the solid mass of the body, as it is by the Anatomists handled as a subject; by that which is contain'd, the blood, or nutritive humour, as it is contain'd by the solid substance of the body. Nor did we infer that there are more humours in a Mans body, when all of them do make a part in the constitution of the blood; for either they do concur as parts constitutive, or in the excretion of it are separated from it as unprofitable excrements. By the name of the impulsive, not the spirits, but the incorporeal soul is to be called, which is all in all, and all in every part, not containable by it, and all force and impulsion, this enlivening and impelling, the order'd parts do perform and execute their actions.

I call the generall doctrine of man *Anthropology,*

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pologie, the parts of which, I do ordain to be, according to this division, *Psychologie*, *Somatologie*, and *Hematologie*, into the doctrine of the soul, body, and blood, for in man all functions which are seen, as well hidden as open, are perform'd by the soul, as impulsor, by the body dispos'd operating, by the blood helping and concurring as a medium.

Psychologie is a doctrine which searches out mans Soul, and the effects of it; this is the part of man which is the implanted cause of all motions and functions, without which a man cannot consist.

Hence perchance an *animal* is call'd *animale*, whatsoever hath the beginning of motion in it. According to the diversity of actions, and effects appearing in the body, we set down divers powers and faculties of the soul.

A faculty is a force and aptness of the soul to act and perform its functions, shewing it self in the actions of the body.

We see that the soul does chiefly endeavour three things in the body, to wit, life, a better and more commodious life, and at last eternall life: according to these three actions we ascribe unto it three faculties, under which afterwards we do comprehend the rest as subservient.

Whilst

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Whilst the soul does procure life to the body, we call, that the vital natural, or likewise the Vegetative faculty.

This faculty we divide into preparative, dispensative, and assimilative, which for the greater part shall be canvass'd in this our discourse.

It bestows a better life upon the body when it adorns it with motion, sense, and most of all with the benefit of reason; that we call the Animal power, by which it distinguishes Animals from Vegerables, but from these we call a man Rational.

The soul, since it cannot preserve life in the Individuall, by reason of the unfitness of the substance of which it is compos'd, it does endeavour to perform that in another, which faculty we call Procreative.

Those parts are appropriated to the powers of the soul, by which they are shown, which (as the humours likewise) are wrought and acquire their perfection from it.

Wherefore, since after the enumeration of the faculties, the number of the functions or actions of the parts is likewise clear, and upon them their works and effects do ensue, if I do bind up the order of *Psychologie* in few words, I hope I have perform'd the same in all the rest.

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I do think that this *Anthropologicke* Science, because it is meerly Physicall, is to be called Physiological, but that which does comprehend the doctrine of Diseases, whether they be natural or preternatural, is to be called *Pathology*. By the one the actions of the body are very well perform'd, by the other they are hurt; In this range sickness and its causes and accidents are handled; in that, health and its causes and accidents likewise; but the Physician performeth his cure by preserving the health, and restoring it (if it so please God) when it is lost.

This narration of a compendious method we have set before our Book, that it may be known, that those things which in it were subject to the tryal, do not come out without due order; in which we also did endeavour to be so brief, that those things which are set down and clearly enough explained by others in the descriptions of things obvious we did pass by, thinking it unnecessary to repeat them, and doe onely mention those things, which being back'd by reason are different from the vulgar opinion. These things might have come abroad in a Philological dress, and adorn'd with a more eloquent style:

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*But we so learned must not be,
Our Muse hath more austerity.*

Nor is it decent that this purpose so far different from the vulgar opinion, should be spoken like a Fable that were to be related, as those do that take great delight to extoll abstract things, a Gnat, a Lowse, or an Afs, with rare eloquence, and highest praises; or things absurd and false by the judgement of all the senses, as that women are not *homines*; or do endeavour not only to defend things far more absurd, but by dawb'd & sophistical arguments endeavour to cloath them with a likelihood of truth, that by these things they may show the quaintness of their wit, and the excellency of their learning. I had never such an intention, nor being mov'd by any other reason than the entreaties of my friends, neither for any arrogance or desire of contradiction, but meerly thereto induced by the love of truth, do I bring these things to the touchstone of truth, which is alwayes uniform and alike to it self, the most general rule of all, being neither darkned with any sophistical arguments, or with unknown and feigned words: which, if they be not fenc'd with true reasons, and ocular testimonies, reject them, but if you think them worthy your consideration, and to be received, enjoy them, and farewell.

To



To the Reverend and most
Learned Man, *William Harvey*,
Kings Physician.

Considering with my self under
the safeguard of whose name
this our Discourse of the Heart
being to see light, might more
creditably and handsomely come abroad,
thought it could not be dedicated better
and with more reason, yea more adorn'd
by none, most learned Harvey, than by
being consecrated to your immortal name
It was fit it should be offer'd to none
besides you, you only have power over it

o you alone it owes the beginning of its
ife, without you it had not seen the light,
nor had it ever come abroad to publick
iew; I confess ingeniously, had I not been
owz'd and allur'd by your invention,
no occasion ever had been offer'd me,
neither to pass the ancient bounds of
Learning, nor to make further search
into the parts of Nature. Therefore
villingly and deservedly do I dedicate
and offer it to you; in which (methinks)
I perform two things, for I shew the
gratefulness of my mind, and a most
learned man does reap a part of the fruit of
that Learning which was acquir'd by the
acuteness of his own incomparable Wit. There
does but a little by this our Offering
accrew to your Name, which is already
extoll'd to the Heavens, being known
over all Europe, even to the Indies,
and the most remote parts of the World.

We

We know we are indebted further, but because in great matters good will is enough. let it suffice that a gratefull mind is presented to you with this Discourse, seeing we are able to do no more: We adjoyn, to this Present, a Petition, earnestly entreating you, that you would vouchsafe to make us partakers of those innumerable Observations concerning the Fabrick of Mans Body, which you have by you, found out by your own diligence, as from the disquisition you put forth is known, to publish them for common use, and further oblige to your self all lovers of Truth, especially him who is yours,

J. De Back.

CHAP.



C H A P. I.

Of the First Section of
JAMES De BACK, his Discourse
of the H E A R T.

He that is to give his opinion in any business what manner of man he ought to be ; the heart as yet not thoroughly searched ; how much the Antients did esteem it ; the exposition of its Etymology ; there is no rule of one part over another ; the Heart is a servile part ; Faculties are not influxive.

HE that is to give his opinion concerning the truth of any business, ought not to be moved by the authority of any famous man, nor with the love of an opinion received heretofore, nor with the desire of any thing, but only trust those things which are seen with his eyes; known by his touch, and are confirmed by reasons drawn from ocular testimony : that which is the invention of the Imagination only, and grounded upon no sense, although it be commonly received by all, yet he is not so
K bound

bound to adhere to it, but that he would rather embrace those things which are evident, and approved by perceptible and sensible reasons.

But let him especially resolve upon this, whosoever undertakes to examine the motion, frame, and use of the *heart* by true and certain reasons.

Momus reprehending the works of *Jupiter*, amongst the rest, required that there might be a window made in the *breast* of man, through which his *heart*, and that which lay hid in it, might be seen: But notwithstanding the whole *breast* being opened, and the heart it self being seen again and again, both live and dead, as likewise being assisted by the diligence, and accurate observations of most learned men, yet there has been a difference before our age, even to this time, nor as yet can grave and famous men for their learning agree, concerning the use, cause, and effect of its motion. There are some who never forsaking their once received opinion had rather err with a great many, than think well with a few; others leaving ocular testimony chuse rather to follow such things, which were never seen nor never found out by any of the senses; upon which notwithstanding, as upon foundations they build a great many things, which being vented as undoubted truths by men indeed skilful and learned, they do embrace with might and main, and go every one of them stiffly with great fervency, and alledging of reasons, to defend

Of the Heart.

defend their own positions; so that you may justly doubt to which part to adhere.

Dr. *William Harvey* the King of *England's* most expert Physician, and most excellent professor of *Anatomy* in the Colledge of *London*, has shewed the means lately by his finding out the motion of the *heart* and *blood*, to get out of this labyrinth, as it were with *Ariadnes* thred, if it had not been that the Author being too curious in the observation of the *tenets* of the Antients had too religiously worshiped that Principality which they attribute to the *heart*.

Besides, this age fertile in the production of most acute wits, who do excell both in our art, and in Philosophy, has furnished us with a man of an incomparable ingeny, being indeed a stranger, but remaining here in the Low Countries, who in his most learned writings, rejecting many of the *tenets* of the antient Philosophers, and giving us other rules more clear than the noon day, has framed us a new opinion concerning the cause of the motion of the *heart*, departing a little from the purpose of the venerable Doctor *William Harvey*, and though he do agree with him in the invention of the circular motion of the blood, yet does he not agree with him in the cause of the motion of the *heart*; whether or no he have reason so to do, amonst other things which have been heretofore spoken concerning the *heart*, I shall begin to examine.

Since many ages the *heart* has had the report, not only to be the principle, or only beginning of life, but of the whole body, in which the Soul has taken up its dwelling house, and from which as from a fountain all the vital faculties and spirits do flow. *Plato* calls this the seat of the *Intelligible Soul*: *Aristotle* calls it the seat of *Vegetative, Sensible, and Ratiocinative Soul*. Besides it vaunts it self to be the store-house of our moisture, the fire and nutriture of our native heat, the Sun of our body, by whose influx all the bowels are warm and refreshed: Moreover, here they say that artificial fire of *Zeno* is contained, here the Divine and celestial heat is preserved, which the *Poets* feign *Prometheus* to have stole from heaven, that he might put life in man; therefore it is called the first moving, and the first mover, and the first if not the only store-house for making of blood.

And for so many gifts and so many dignities, it is called the most noble part of the body, which having the chiefest seat, is proclaimed as Monarch, it only administering the Government of the Empire.

Its naught when many reign lets have one King.

Hence they derive *Cor* from the Greek word *κῆρ*, being contracted from *κέαρ*, which comes from *κέω* to burn, and the Greek word *καρδία*, they will have to sound as much as *Κεάρτεια*, from principality, or government,

vernment, when it is rather derived from the verb *Karδaiw*, which is to move or shake: It is very well called HART in our language, which in the latine signifies hard, because it is the hardest amongst the soft and fleshy parts, or (for HARDEN is as much as to endure) because it continues in its action and motion without any fatigue.

With these titles of honour, and more, if not divine and supernatural (for, it is thought, by the heat of the *heart*, without the help of the Soul, that all the actions in the body, Thinking only excepted, are performed) like *Æsops* crow, the *heart* is adorned as it were, cloathed and decked with the feathers of other birds, with so much confidence and zeal, that it were impiety to speak any thing to the contrary: But let us see whether or no (as she, when the rest of the birds did with good reason require back their own feathers, did dance naked) it will have any thing else besides leaping left, when the Soul and other parts have received their own.

Æsop of *Phrygia* does explode the dominion of one part over another, in his Fable concerning the contention of the members about Principality.

But seriously how shall it command, which it self serving for an instrument for the actions of the Soul is made to serve the whole body at all times without intermission, and goes on just like an Ass drawing a mill, either slower or quicker, according as it is, pricked forward?

A Discourse

But you will say we cannot want the help of the *heart* in our life, and that life begins with the motion of the *heart*. This same comes to pass in playing upon an Organ, where the Servant first blows up the pipes with a pair of bellows, nor without that blowing can they play, yet he is not said to play, but he that tunes the notes right.

The greater dignity or primacy and perfection does not therefore suit with any part, if the Soul do want its assistance first, or that it be made before other parts. The Navel-gut and the Secundine shew this, being form'd before other members, and the *heart* it self, for they are parts of the birth too, but the birth being perfected, and brought forth into the world, they are thrown away as unworthy and unprofitable.

Things do not become perfect at the first, but become such by delay and longer time.

It is an imaginary thing, if not different from reason, to assert, that Faculties do flow from any part; for they are the powers of the Soul, which is present every-where: it is judged to be in the whole body, and every part of it, with all its faculties, and its granted that like an Artisan it does perform all the actions of the body, if it find fit instruments.

The Members being Organs of the same Soul, cannot refer their aptitude to do any thing more to the *heart*, than the rest of the parts, with whom they have life in common.

common. I believe no man thinks that the temper of similaries, and the conformation of dissimilarities consisting in fit form, place, number, and magnitude, and the agreeable union of both, flows from the heart, or out of any one part into another.

These and other things are slight, nor much to be esteemed as unprofitable cavils: but if being Author of the perfection of blood, the elaborating of spirits, and the more peculiarly implanted heat, and of these two first actions, as likewise of all the rest (as they think) be proved unfit to be attributed to the heart, all those great prerogatives pinned upon it will easily be overturned and fall.

Chap.

C H A P. II.

The acception of the Etymology of spirit; the antients Definition of it; no such thing is found in the body; as there is a threefold substance in every part, so likewise in the blood; spirit and heat are ill confused; spirituous substance inseparable from the blood; spirit is not the tye of the Soul and body, nor the nearest instrument of the Soul; The animal faculty is not drawn into action by the spirits; how sensations are made.

THe Etymology of *spirit* is diversly taken, but that which is here to be considered, is Defined by some to be, A very thin and subtle body, hot and most pure, begotten of the thinnest and most sincere part of the blood, or according to others, It is a substance very thin and small, made up of air and the vapour of our blood, being the first and nearest instrument of the Soul in undergoing its functions.

From which Definitions is gathered, that the *spirit* is a certain substance divers from the blood, subsisting apart, and by it self; because it is made up of its finest and thinnest part, or because it is said, that it is made up of its vapour and air.

But

But I beseech you where was there ever a-
ny such thing found in the body? it should
be found in the habit of the body, or con-
tain'd in the vessels which are ascrib'd to it,
the *arteries*, *veins*, or *nerves*, which to affirm
imaginary, nor is it confirm'd by any de-
monstrations.

In the habit, or indeed in any part of the
body, there is a threefold substance consid-
ered, that which is spirituous, humorish,
or solid, but to separate these were to dis-
solve the frame of the part, no less than if
one should dissolve any thing consisting of
the four Elements, into substances existent
to the sense; this tye of substance being
dissolv'd, it does not only leave to be a
part of the living creature, but likewise a
part of the body.

If it be found in the *vessels*, it will be there
where it is thought that there is the greatest
abundance of it, that is to say in the *heart*
and the *arteries*. but the authority of *Galen*,
and experiment drawn from sense it self,
which is most of all to be trusted, teaches
the contrary, that nothing but blood is con-
tain'd in the *arteries*.

If you tie the *arterie* above and below,
and open it betwixt the two *ligatures*, you
shall find nothing but blood, and so much
of that flowing from thence; as the capa-
ciousness of the *arterie* was able to com-
prehend; If any say that it flows with the
blood, and that it is the thinnest part of
that blood which is contain'd in the *arte-
ries*

ries and *veins*, that we easily grant: But in the mean time we conclude, that it is no any thing separable from the blood, for how can it be separated from the blood, that together with the blood is driven with so swift a motion?

It is to be believ'd that it is the aerial part of the blood, of which when it is destitute it is called dead blood, atter, or goar, altogether unfit to perform the function of blood, for it is part of its substance. The likewise in the blood is threefold, as we as in all other parts (to wit the gross part or thickning the humour, and spirit) but is separable without the destruction of the form of blood.

They that discourse of *spirit*, do so confound it with *heat*, that they deny that one can be without the other; as likewise they averr that they are really and substantiall the same, and do only rationally differ, and that it ought to be positive that there are as many *heats* as there are *spirits*; even as a certain *heat* fix'd to every one of the parts innate at our first beginning, by the aid of which all natural actions are perform'd, & likewise that there is a *spirit* infix'd and implanted at our first birth, which does administer all functions; for that cause they do conclude that how many parts soever there are different in their substance and temperature, there are so many fix'd *spirit* distinguishable in their *species*.

But because this *heat* and *spirit* of every part

Heart does vanish very readily, and constantly, there ought say they, from the principal parts another be sent, call'd the influent, by the continual access of which, the loss of the former may be repair'd.

Which being granted (though we do not grant that *heat* does so well agree with spirituous substance) I ask you, for alike are nursed by alike, and refresh'd by it, why the blood which flows in the vessels shall not be said to be of a threefold substance, and that unseparable seeing it does nourish and refresh the parts that are made up of it?

Nor do I think that it can be certain, that the spirituous substance can be refresh'd in nutrition, without both the other two, unless they likewise receive their part according to just proportion.

I do likewise ask, seeing the *spirit* or spirituous substance belongs to the constitution of the parts, as likewise of the blood, why it should be considered apart? for to multiply entities without cause, is beyond the axioms of all Philosophers, and is repugnant to reason.

But let us see for what good end, or to what use they think that *spirits* were given to living creatures; that there may be, say they, a connexion of the body with the Soul, because the incorporeal and immortal Soul of man could not be conjoyned with a frail body but by the intermediation of *spirit*.

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Forsooth indeed as if an incorporeal substance could not agree with a solid body but by the intervening of something more subtile; when notwithstanding it has no greater agreement with one than with the other, that assertion seems altogether vain.

They say moreover that it is the next instrument of the Soul, by which it performs its actions: but whether is this spoken of that which is influent or implanted? That which is implanted is of the substance of the part, or its spirituous substance, which being combin'd with others performs no actions apart. The Soul is given to the parts to perform actions as an impulsive, not as an implanted spirit: But an influent spirit whilst it is not living but a substance inseparable from the blood, unless it pass into the substance of the part, cannot immediately help any thing in the performance of any action.

For the part being prepar'd with a just temper, a fit frame, a right union, being enlivened by the power of the Soul, and being warmed and made movable by the circular motion of the blood, does in my opinion perform any actions.

There may be a great difficulty rais'd as concerning the *animal faculties*, which are perform'd both by sense and motion, through mediation of the *nerves*, those being stop'd, held or cut, the part it self remaining whole, yet notwithstanding sense and

nd motion is taken away, as they affirm, because the passage of the spirits is stopped.

For they being most thin substances, and quickly passing and repassing through the pores of the *nerves*, to carry and bring back the facultie to the member, and the sensible *species* to the brain; The business being well look'd into and rightly consider'd, that going and returning of the spirits, even of the lightest air, though free cannot be so sudden even in imagination.

Why do, we multiply Entities and fly to those things which are not demonstrable? we must follow things evident, which may be perceiv'd by the sense.

It is better in my opinion not to expect that from the interception of the spirits, but rather from the hindring of that action, which is both common to the *nerves* and brain, by the mediation of a certain humour with which they are imbued from the brain.

For it is to be thought here are likewise as in other places, a spirituous substance, of which the *nerves* and the nutritive juice with which they abound as well as other parts, and the blood itself are compounded, and which being altogether inseparable from the fleshy and solid parts, cannot subsist a part.

But lest any should doubt of the existence of this humour; if a *nerve* be but only touch'd with a very prick, so great abundance

dance of it sometimes flowes out, that it can be hardly stop'd by an unskilful Chirurgion. For it is to be observ'd, that as the body is continually and uncessantly refresh'd with new nutriment, so the *nerves* are refresh'd continually without intermission, not with blood immediately passing out of the *arteries*, which perchance belongs to the flesh alone, but with a juice which they have in common with the brain, from which they receive it in great abundance, aswell that it may be nutritive to them, as that it may be communicated to other parts endued with sense.

They do evidently demonstrate that the *nerves* have their nutriment prepar'd by the brain; first of all, because they are joyn'd to the brain, as likewise the spinal marrow, and inseparable from it without hurt, and as a portion drawn over the *meninges* of the brain, insomuch that you would say that the brain were extended over all the body.

Besides they have neither *arteries* nor *veins* which are any ways visible.

Nor is there any difficulty to be made of the abundant increase of this humour, which is continually by pulse driven into the *nerves*, nor of the impulsive force which moves it into the remotest parts, as if the soft brain were not endued with so great power, yea since in so great abundance the blood is carryed by the *vena carotides* into the brain, much more than it stands in need of, if it were

ere not for common use, that with this continual pulsatory motion it beats without rest, even like the *arteries* themselves, and does likewise deposite into the *nerves*, the juice (the superfluities of which the *veins* do receive) being separated by its own segregatorie power, and press'd by its own weight and mov'd forward by the motion of following pulses.

These being once set down, it is easily conceived how the senses are mov'd, or how sensations are made.

The brain being in continual motion, and having the *nerves* joyn'd to it, and dispers'd through all the sensible parts, whilst it does through them move the nutritive juice, it does apprehend the least touch even in the most remote part which is stirr'd up by the sensible object.

Scarce is either any part touch'd, nor the net of the eye affected with any visible object but from thence the motion of the brain is altered; as in the stretching of a string if it be held whilst it is in play, we see the sound of it alter.

This action being so sudden, yea much swifter than the going and returning of the spirits can be, and so evident and perceptible, who will not more plausibly think, and that it ought to be resolv'd with greater reason (since this continued action is common to all the *nerves*, being scattered through the sensible parts, together with the brain, which is environ'd with the *meninges*, by the mediation

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on of this nutritive humor) when through the obstruction, compression, and incision of a *nerve* the action of a part is hurt, that which proceeds from the action of the brain which is hurt, which was common with the *nerves*, rather than to fly to the mission and remission of spirits, which appear nowhere for the immission of nutriment being stop'd the brain can neither perceive beyond the *ligature*, nor advance its benevolence thither.

Therefore I conclude, that since there is neither any such substance in the whole body to be found, which will agree with the definition of spirits, or which is agreeable with any end which is attributed to spirits, that there are neither any spirits, nor can they be elaborated in the *heart*; for which thing more reasons will offer themselves when we shall be employed in refutation of the *Hematosis* of the *heart*, to which before we come, it seems worthy our pains to relate in what manner I think it is perform'd.

SECT. II. CHAP. I.

the definition of the blood; what sanguification is; how it is begun in a birth; the aptness to nourish, not colour, is that which makes blood; Sanguification is not performed in one part alone; Concoctions come to be by addition and detraction.

Blood is an humour familiar to the nature of Animals, contain'd in the *veins* and *arteries*, containing in it matter fit for the nutrition of the parts, administering heat to the whole body, together with nourishment for the sustentation of life.

The Elaboration of this humour is called *Hæmatosis*, or Sanguification. This is perfected in two manner of ways; according to the first manner the *Hæmatosis* is perfected in the parts themselves, or in the habit of the whole body, when the blood again and again passing about the body in a circular motion, and affording succours to many places, and at last receiving a similitude of the parts (for it cannot receive a similitude from any better than from those to which it is to be assimilated) it is prepared that it may be fitted into its substance.

The other is the preparing of the nutriment, meat and drink newly receiv'd, that being mix'd with the other, it may pass without hurt to the innermost parts of the body, that it may be fitted to nourish and perform the rest of the functions of the blood.

L

This

This is not perfected without the intervening of the blood prepared according to the former manner; for that which is newly come in becomes not such, but with requisite addition in divers places, much dilution, and afterward it is jumbled with a perfect mixture: It is certain, that by the first life is begun, by the second it is sustained and receives its encrease.

In the first beginning of a creature, when all things are imperfect, and so small that they are known to God alone, by reason of their smallness they appear not to our sense: I do imagine, that so much moisture as its smallness can well suffer coming from the mother is added to the Primogeneal, or first imbred humour at times, and that by the Homogeneal heat congregative, and the Heterogeneal heat disgregative, it is mix'd and united so, that at last a part of it falling to be the beginning of a vein, it raises it up into a little bladder, which, whilst in its resistance, makes an apparent beginning of life.

It being gone thus far, and a little more coming still which is mix'd and made familiar with the former, the *Hæmatosis* is begun, and the Animal increasing it continues to the end of life.

I do not think that any will deny the name of blood to this humour, which is fit for a tender body whilst it is white, and had not as yet required redness; for an aptness of nourishing and not redness makes the blood. The blood of most creatures is not red; That which is in the *veins* of those which are come to age, should

be more or less blood, as it is more or less red.

The other *Hematosis* begins when the nourishment receiv'd is turn'd into blood, for that this altogether different from the nature of a creature, should be made familiar and alike to it by divers mutations, which they call concoctions, that it may pass into the substance of the body, is well enough known.

All these concoctions serving for one end, that is to say, to fit the nourishment that it may turn into blood, which is the aliment of the body, may be called the causes of sanguification: but since functions so distinct are not done by one part; it is an absurd thing to ascribe sanguification to one part.

Galen being witness, in his sixth book concerning the *Placits* of *Hip. & Plat.* l. 6. c. o. *That no great and perfect work is done by one endeavour, and can receive its refining from one natural action;* I resolv'd to recite the narration of these concoctions, that is to say, in what order and manner they are perform'd according to my judgment; undertaking only such things which deserve credit, because they seem to be sent'd by ocular testimony, and sensible demonstrations, and reasons sufficient for proof.

First of all, I would have it known, that the aliment suffers no manifest or continuing mutation of its colour or consistence, unless that come to pass either by the addition of some thing profitable and convenient, or by the detraction of some thing unprofitable and repugnant to Nature; and that there cannot be said, that in any part or member there is a concoction be-

longing to an *Hematosis*, or furthering its perfection where either addition or detraction, or both of them, is not manifestly perform'd.

These things being premis'd, it shall very easily be known, and be more clear then the light; in what parts coctions are, and in what parts they are not done; what things are ayding to the *Hematosis*, which not; as likewise what things can give perfection to the blood, and which cannot at all. The following Narration shall bring its proofs along with it, together with every Period.

CHAP. II.

The first concoction of nutriment by the mediation of the moisture of the stomach, not by heat or contaction; The drink is not sufficient for the dilution of the meat, which ought to be diluted it self also; The acide juice in the stomach is not from the spleen; whether there be any thing carried out of the stomach into the spleen; the use of it.

THe nutriment being received, and a little imbued with the spittle of the mouth, that so it may the more easily receive the moisture of the mouth by the help of the tongue, and parts of the mouth, it is sent into the *Oesophagus*, and by the help of its *muscles* and its *fibers*, down into the stomach, there is it besprinkled with the moisture which sweats always out of the inner *tunicle*, and mix't by the
force

force of the contraction of the stomach, and jumbled as much as it can be. The foresaid *tunicle*, the more it is distended seems to be the thinner, and the pores of it more open; and so on the contrary: Wherefore there is a greater quantity of this moisture pour'd in when it contains any thing in its capaciousness or distention, which is to be diluted, than when it falls, for then it is thickned, and the necessity of dilution is not so pressing.

I do not believe that it has been seen by any Natural operation, that the colour or consistency have been changed without the addition or detraction of substance; there seems another colour to be brought upon the Looking-glass, according to the representation of the object, and water is dilated by heat, yea by it grease is melted; but the object going away, and the heat being tane away, that which is dilated or melted returns to its natural consistence.

I do believe that heat furthers concoction, insomuch as it congregates Homogeneals, and disgregates Heterogeneals; albeit fishes, whose inwards, and their very blood is cold, do digest their food being swallowed down whole, and are ravenous without measure.

If any one desires to see the truth of this opinion with his very eyes, let him look into the stomach of a fish, of ordinary bigness, when he has swallowed another for food, whose body, because it is not all at one time consumed in the digestion, but the exterior parts, and those that are nearest to the bottom of the stomach, after a little while he shall see the reliques of

the swallowed fish, and about them the part digested, and near to the walls of the stomach a certain juice (waterish indeed, but not so much mix'd with the food) newly come out of the pores of the inmost *tunicle*, like sweat, that being more diluted than that which appears almost digested, it might be thrust into the *bowel* through the *Pylorum* by the force of the contraction of the stomach.

Indeed it behoves that that which is strange should be diluted with much and familiar moisture, deprompted from the body it self, and which is continually and incessantly recruited by the new nutriment, lest passing into the inwards in a dissimilary condition, it should offend the parts that were to be nourished. Moreover, if the meat be not well mix'd with moisture in the stomach, (since there is no such moisture any where else, nor any such convenience for the mixture of it as in the *ventricle*) the fault of the first concoction will not be helped by the second.

But lest any one should think that this is done by drink, it is certain that it is likewise mixt with this juice before it goes out of the *ventricle*, but that it needs not so long time for it, because sooner, and rather soft and liquid things are digested then gross things, for being vomited up a while after it has been received, it appears thicker and more slimie, unless the stomach be diseased, and be weak of concoction, then it comes up thin, and sour; because all that goes in wanting that favourable juice, becomes sour, and is corrupted.

Most

Most do attribute this four juice to the *milt*,
ruly without reason, since nothing is carried
from it to the stomach, neither slime, nor hu-
mour, nor acide spirit, to further digestion, or
provoke appetite, or for any other cause; the
reason is, because there is no way, nor no im-
mediate passages from the *milt* into the sto-
mach.

It is a hard thing to say, whether any thing
be carried from the *milt* to the stomach. I know
that grave men, and of no contemptible judg-
ment, do think that the smaller portion of the
chylus does insinuate it self into the *Pores* of its
tunicles (after the same manner as they believe
that the thin which is seperated from the gros-
ser left behind by straining it after its egress, is
admitted or received by the membranes of the
intestines and the *meseraick veins*) and that it is
drawn together by the blood returning, it is
led through the small branches of the *Gastrick*
veins into the *milt*, and mixt with the blood
passing out of the abundance of *arteries* in that
place into the *veins*, and mix'd with the
heat of the said *milt*, and then that it flows
through the splenick passage with the He-
norroidal blood into the *vena porta* and the li-
ver.

These things, since they are obscure, and not
apparent, I neither dare give credit to them,
nor contradict them. The *tunicle* of the sto-
mach seems to be so much taken up in emitting
of moisture, that I do suspect, that it cannot
serve two motions so contrary, to send out of
the *pores* of the *tunicle* into its hold, and out

of its hold into the *pores* of the *tunicle*, at on and the same time, especially since it staves to be chyliſied there.

It proves nothing that in a living creature tying the *veins* which go to the *milt* they ſwe towards the *milt*; for this is common to all *vein* which are tyed, to fall towards the roots, and ſwell towards the branches.

As to that, that the *gaſtrick veins* are graſte into a branch of the *splenick*, and whilſt it as yet in the *milt* hid, but the blood which ſent through them does not touch the ſubſtance of the *milt*, only it is mix'd with that which comes out of it, and with a quick motion it is carried into the *porta* to dilute the *chymus* which there it meets with, coming out of the *glandules* of the *meſenterie*.

I do think that the *milt* was made for this uſe alone, though more attributed to it by moſt learned men, and prime Phyſicians, that it may depoſite into the *porta* that blood which it receives in abundance from the branch of the *celiac vein* (nor does it receive any thing beſide blood, nor any thing from any other part) being firſt conſtrain'd through its thin and ſpongy ſubſtance, that it may there dilute the *chymus*, which is but little, in regard of the blood which flows to it, with its abundance, together with that which returns from the nutrition of the reſt of the bowels, which is ſo neceſſary, that when the *milt* is obſtructed, and the paſſage of the blood is ſtop'd, & the *chymus* is not well diluted, the whole body by depravation of the nutriment is extenuated, and the *milt*

milt swells into a greater and more troublesome bulk by the restagnation of the blood,

CHAP III.

The use of the Venæ Lactææ, what is the use of the Pancreas and Glandules of the Mesenterie; the Chymosis is the ruder part of sanguification begun; what Chymus is; the preparation of blood in the jecur Uterinus; the order of nature in nourishment.

AFTER the *chylus* is let down into the *intestines*, that which is gross is always mov'd further by a Peristaltick motion, but that which is thin is squeez'd through their finer body, being diversly perforate by *arteries* and *veins*, as well milkie as ordinary ones.

These *venæ lactææ* opening themselves in the midst of the bowels (especially the biggest of them running out in length through the middle of the *pancreas*, with a manifest and open mouth, which it has common both to it, and the biliary passage) do receive this same being white like milk into them, and then endeavouring to free themselves from distention, the others do move it forward to be refin'd in the *glandules* of the *mesenterie*, and this into the *pancreas*. This is manifest to any body, who with diligence and attention does observe in the opening up the *abdomen* of a living dog; so that you need to believe no body but your own eyes.

The *pancreas* or *callicreas*, called by some the

A Discourse

the *pandenon*, its called the *laētes* by some for its whiteness and softness: it is a fleshie body, made or plac'd near to the first joynt of the *loins*, three or four fingers broad, lying from the *milt* in length under the hinder part and the bottom of a mans stomach, and its stretch'd out lying upon the *reins* near to the *intestinum duodenum*, and the concavity of the *liver*; Besides its glandulous and soft flesh, it has a *membrane* with which it is cover'd, *arteries* from the *celiac veins* joyn'd to the *porta*, and *nerves* it has which spring from the sixth pair; it has likewise a passage through its flesh diversly distributed and divided.

The greatest of the *venæ lacteæ* drawn hither with that great opening which it has common to it, together with the biliarie passage, begins here very manifestly from the *intestinum jejunum*, and is stretch'd out according to the breadth of the body, and length of the *pancreas* almost as big as a goose quill: in a dead corps, when it is open'd, it has nothing in it like the rest of the *lacteæ*: all which notwithstanding by reason of their smallness, and because they are so like the *membranes* that do uphold them, do vanish and cannot be seen by us; but here by reason of its bigness, and because it runs along the flesh, from which it is easily discern'd, it is conspicuous enough; in a living creature, open'd some hours after repast, it is swell'd being full of white juice; being bound with a *ligature*, it swells most towards the *intestinum*, but beyond the *ligature* it is presently empty.

For what end I beseech you? that it may become

come a nutriment to the *Pancreas*? has arteries from the branch of the *Celiac* fit for that business, yea, far greater then the small quantity it requires; which is an evident token that they serve for another use, and for a greater, that is to say, the common good. For the milky juice deposited in its soft and spongy flesh, being with the blood (which flows thither in great abundance for the cause aforesaid) mix'd and jumbled, and having acquired the colour and the consistence of it, is carried into the veins.

We may think no other ways of the *Chylus*, being pass'd by this opening, out of which the *Chymus* is squeez'd by the forcible contraction of the *intestines*, and the compressive weight the *bowels* lying upon it, as also by the continual motion of the *muscles* of the *abdomen*, and is receiv'd by the *venæ lacteæ* to be deposited in the *Glandules*; whence being turn'd into food in manner aforesaid, it enters into the *pillar veins*, out of which sliding, it is diluted by great store of blood flowing every where from the *vena porta*, but especially from the *spleen* destin'd to that use.

This is the more imperfect preparation of food, which (if for its redness deserves in any sense the name of blood) is to be called *Hæmatis*; but because it has not as yet gained all which are requisite to the constitution of food, but only the first disposition, it is rather to be called *Chymosis*.

Chymus is the earthy and dry part mix'd with moisture, or the strained juice of them by the

the mediation of heat; such may that matter be said to be, which is contained in the *Vena Lactea*, and is separated from the grosser substance of the *Chylus*. But because this is taken by the prime Physicians for the *Chymus* in that being separated from the *Chylus*, and continuing in the *Meseraick veins*, it is (as they say) dyed by the liver with a crimson colour. We do likewise think that this matter, after it is passed the *adenes* of the *pancreas* and *mesenterie*, and received into the little branches of the *vena porta*, may be called *Chymus*: For by the mixture of things drie with moisture a taste, or rather that which has a taste is made up; so likewise out of the thinner part of the *Chylus*, being diluted with blood, the *Chymus* or saporie juice is made fit to be wrought into blood, being equal to that red *Chymus* of the Ancients, which is in the *veins* of the *mesenterie*.

To this *Chymosis* answers that preparation of the blood in the *Placenta*, or *liver* of the Womb, whilst the birth is as yet in the womb (for it slides down like the white of an Egg not in the form of blood, which both ocular testimony, and the disposition of the vessels do demonstrate; for that of the Mother reaches not beyond the womb, that of the Child not beyond the *Placenta*) is diluted with blood brought through the *Umbilical arteries*, both for nutrition, as likewise for the performance of this work, and is mixed, and acquires the first disposition of blood.

The industry of careful Nature in this is admirable;

able; for like a good Mother being solici-
as of the sustaining of the life of the crea-
re, receiving first into the *ventricle*, she mixes
with a little mixturable juice (little in re-
rd of that which comes after) into a thick,
t soft paste, from which a convenient and
ore fit portion, by expression, as it were
rough a strainer, being seperated, she throws
r the dreggs into the Draught.

These being preserved and purified white as
ilke, in the *Adenes*, with blood powred to it,
e labours it and moves it up and down after
e manner of our Apothecaries or Cooks, who
ft pour a little liquor into that stuff of
hich they are about to make a medicament
broth, the better to mix it, and adding to it
e relish and the rest of the liquor, they mix
as it ought to be: So likewise in the *adenes*
ature pours in more blood to that matter
hich was before diluted with blood, adding
oler as a seasoning to it. But lest any thing
ould pass unmixed, and should enter and de-
e the chamber of the body, being sifted
rough the small and innumerable windings of
e liver, it is at last moved forward into the
vena cava, to be delivered to the heart with the
ft of the blood returning.

CHAP. IV.

Choler the condiment of blood, and not the excrement of the liver; The Syntaxis of the bladder of choler; how choler is generated in the necessity of it; by the biliarie passage it carried to the liver, and by another passage when it is to be mixed with blood; of the Vena Porta, and Vena Cava; the use of the liver.

I Shall perhaps, be thought to speak a Paradox, when I set down that the *choler* is added to the blood in manner of seasoning, which was thought by all the Ancients and Moderns to be an excrement, (though profitable for the expelling of filth) as being contrary to the nature of Animals, which rejoice in sweet things and are nourished by them: But I believe that the reasons which shall be brought will demonstrate it by ocular testimony, that *choler* is not an excrement of the *liver*, nor is thrust out from thence into the gall chest, but severed by the membranous body disposed thereto from the blood brought to *cystic arteries*, the originals of the *celiac* branch, into its proper hollowness, as a storehouse, that from thence, necessity requiring, it may be added to the blood and help the *hematosis*.

The *choler* chest, the biliarie bladder, or the gall chest, consists of a *membrane* substance, which may be contracted and extended; besides that which is common to the rest of the

intrais,

entrals, it has a strong *tunic* of its own, strengthened with all manner of *fibers*; it has a round figure, yet somewhat long, and at last ending in a longer point, which does make up a concavities inaccessible to the view; for it has but one passage or draught, open within, but shut without, for it is enclosed with *portals* giving egress to the *choler* going out, but altogether hindring the return of it.

To this are little *bladders* given, besides *nerves* from the *sextum par*, there are *arteries* and *cystick veins*, those springing from the branch of the *celiac*, these from the *vena porta*, those carry blood unto it, these carry that which is superfluous after it has done its work back again into the *bladder* of the *porta*, which all may take notice of by the motion of the blood, the nature of the vessels, by the constitution of the *portals*, and by adhibition of ligature in a living creature.

Besides these, although it has no constitutive parts, it throws out the swelling *choler* (by which it is alwaies distended and full) either by being pressed, or contracted, or stirred up by the abundance of it, into a passage which is joyned to it, which notwithstanding it neither receives nor could receive from any neighbouring or remote part.

The *urinary bladder*, though it seems close on all sides to one looking upon it, insomuch as blown up to the utmost extention of it, it is not so much as pervious to the wind, yet it has *ureters*, in passages grafted obliquely into its membranous body, which carries the *urine* be-
ing

ing disgregated by the force of the *veins* from the blood; but this *bladder* has no passages by which it can receive any thing, besides the *arteries* which bring such blood to it as is contained in the vessels.

These things being proved, I believe it is to be concluded, that the *choler* is not the excrement of the *liver*, nor that it is separated from the blood by its segregatory force: because neither is there any place for its separation, nor is there any way found by which it may be conveyed into the *bladder* after separation.

And again, since *choler* is not brought to this little *bladder* from any where else, nor any thing else besides blood (which the *arteries* do afford to it in great enough abundance) is admitted into its *tunicle*; I believe that it is to be thought, that by the proper contraction of its own *tunicle*, *choler* is separated from the blood, and is as it were by sweating through its *pores*, laid down into its concavity, and there reserved for use.

Let not I beseech you this seem wonderful or imaginary to any person; for so does our spittle distil into our mouth; so does the innermost *tunicle* of the *ventricle* sweat out its moisture in the preparation of the *chylus*; so is *urine* deposited into the bosom of the *reins*; so diverse sorts of matter is heaped up in the little skins of the abscessions, according to the nature of the part from whence it did flow.

I think that this gathering of the *choler* into this *bladder* is from hence easily demonstrated, because

because it is in all creatures, insomuch as it is proverbial, that the *Emmet* has her *choler* too : but let us see if it follows of necessity that it is added to the blood according to the manner of its evacuation.

The narrow neck of this *bladder* stretched out in length makes up the billiary passage, called the *cholidocal pore*, in this are placed *portals*, which besides that they hinder any thing to enter into the *bladder* through this passage, they hinder the return of the *choler* it self after its once out : which appears when with our fingers we endeavour to squeez back the *choler* which we have squeezed out of it, for by no means can it be thrust back again.

This passage is divided into two leadings, of which the one, being first divided into two, then into more, and afterwards into many sprigs, passes through the strainer of the *liver*, that the *choler* being divided into very little parts may be moved forward into the *vena vasa*, passing through the *liver*, together with the blood which flows from the *vena porta*.

The other going further is obliquely grafted into the beginning of the *jejunum*, being drawn down betwixt both the *tunics* of the *intestines* about the length of two inches, so that it makes one hole in the *intestines*, together with that leading which runs through the *pancreas*, that it may mix the *choler* with the milkie humour, and give it to the *pancreas* through the aforesaid passage, or being passed through the hole to the *venae lactee* to be prepared with the juice of the *chylus* being passed.

A Discourse

It seems to me absurd, yea impossible, that two liquors should meet without mixture; that the *intestines* should squeeze out the grosser, and the *vena lactea* receive it, and yet not receive that which is thinner.

It is fit that *choler* should be added to this insipid and sweet liquor, both that its sharpness and surpassing yellow colour, should be tempered with this raw white and inconcocted juice in the *adenes*; as likewise that its dull, slow constitution should be excited and moved.

If the other, that is to say the passage which goes to the *intestines* be stopped, or by external compulsion be so streightned, that the way of the *bilis* to the *intestines* be hindred, it so comes to pass that its colour and fierceness is not appeas'd in the *pancreas* and *glandules* of the *mesenterie*, and therefore (for by the tother passages it is carried in greater abundance into the *liver*, and from thence together with the mass of blood into the habit of the whole body) an *icter* is caused, and the whole body turns yellow.

They that drink more enough (for it goes out of the stomach sooner then meat) then the effusion of this *choler* can mix with, their piss is like water and of no dye: likewise we piss whiter a little after meat, for which, the drink most part of it being passed, the quantity of *choler* is more unequal then when it moves forward the gross *chylus*.

It happens likewise that those whose passage is stopped for some cause, and the *choler* not exonerated, but at some times, that they piss waterishly

erishly with no colour, but afterwards they
 ois coloured urine, the passage being opened or
 exonerated.

By these reasons and examples, I do per-
 swade my self that the *choler* is not an excre-
 ment of the *liver*; but being made for a bet-
 ter and for a common use, it is first heaped up
 in the bladder, and in its own time is both
 mixed with *Chylus*, and bestowed upon the
liver.

There meets in the *vena porta* a great quan-
 tity of blood sent from the *milt*, the *Chymus*
 having suffered some alteration in the *pancreas*,
 together with that which is prepared in the
adenes of the *mesentery*, and blood now made
 useless after the nutrition of other bowels,
 likewise that which flows thither from the
hemorrhoidal veins, and at last some part of the
choler, which being only confused, and not
 duly mixed together, could bring no little
 harm to the body; which most wise Nature
 foreseeing, added the *liver*, by the inward
 part of which, as through a sieve, those confus'd
 things which we mentioned are rendred so
 small and so mixed that they are brought into
 one mass, which after this manner being made
 wholesome, is added to the rest of the blood in
 the *vena cava*.

For in the *liver* the roots of the *vena porta*,
 and a great many twigs of the great branch of
 the *cava* are stretched out, which passing
 through its strainer are at last joyned, and do
 stick close together; so that you would say
 that they were a *vein* which had been divided

into many branches before, and joyned together again.

This will appear, if you blow up the *vena porta*, putting a pipe into it, till the *cava* swell up: with ones very eyes these conjunctions may likewise be seen, if you take from a *liver* being sodden, all the flesh warily with a comb, which being separated and washed away, the substance of the *veins* does open themselves very well to be seen, so that the small divisions and meetings may easily and exquisitely be discerned.

It is therefore the function of the *liver*, with the help of its own *veins*, being fenced with the *parenchyme*, to bring the matter elsewhere prepared (that is to say, the *chymus* and the *choler*, with blood for the dilution of it, chiefly from the *milt* flowing, and the rest of the parts which are to be nourished, adding to that through the small *arteries*, the superfluous part of that which is brought for the nourishing of the *parenchyme*) into one liquor familiar to nature, which is to be added to the other mass of blood. without any delay or manifest concoction.

This some endeavour to prove from the branches of the *veins*, lurking in the *liver*, and not conjoyned (whilst they believe that there stays a part of the blood here to be attenuated) albeit they be only little *veins* answerable to the little branches of the *arteries*, through which, as through all the rest, the blood passes with a sudden motion.

They do affirm that the blood being altered with

with these divers mutations, and being mixed with that in the *vena cava*, which returns from the whole body, is alimentory and fit for the nutrition of the body, who do aver that it is distributed by the *veins* into the whole body; but seeing this assertion, as I think, is sufficiently convinced by the reasons of others, I shall not meddle with it.

A birth does likewise confirm this example, for in the womb it is nourished with such blood, when notwithstanding it is necessary for every thing that is born, not only to enjoy the free air, but likewise, without its admixtion, blood cannot nourish.

CHAP. V.

That there may be a nutrition of the blood, two things are necessary; whence its mobility; what manner of blood the birth requires; what is the reason it comes forth; what is the use of air in the body; why an Infant being stopp'd in the passage of his excrement, or water, dies quickly; the blood of the veins unfit for nourishment of the parts; which way nutrition is performed; how much air is needed for nutrition; its divers effects in mixed things.

THat the blood may be turned into nourishment for the body there are two things very necessary, mobility and something pressing it, by the help of which it may flow

or be moved to the places which are to be nourished; since this does not depend on the blood, but is different from it, as that which moves from that which is moveable, it contributes nothing to the *Hematosis*. Indeed this fluxibilitie or mobilitie pertaining to its constitution ought to arrive from the Sanguificative virtue, and be reducible to the *Hematosis*.

Whey, or water, or air, that is mixed with the blood, make it moveable; of which this deservedly is called the first moistner.

I dare not number Heat amongst these; Hot blood sometimes atters in the body, to wit, when it is out of the vessels; Cold blood does likewise flow in Fishes, and in the *veins* of dead Corps; and that which is drawn out of the *vein* into a bason many times remains fluid, which will be condensed in a thin earthen vessel.

Therefore let the two former suffice, with this distinction, that by the wheyish blood the Members are made flagging, soft, dull; by the aerial (for in the dissolution of any thing air is more easily separated, and passes better away) the more solid parts are made more robust and more veget.

Although this be necessary for creatures, and needful yet for the birth whilst it is in the womb (both that it may pass through the parts that are to be nourished, as also that the conjunction of it being dissolved, that which is fit may the more easily be assimilated, and that which is hurtful be separated and void) yet the wheyish moisture being drawn from the
Mother

Mother is sufficient for the augmentation and nutrition of the tender and flaggish members.

But when it grows bigger, beside that Nature in requiring aliment wants air, it has likewise need of it to facilitate the motion of the *heart* and *brain*: For they are mov'd continually, and are exagitated by an alternating *Systole* and *Diastole*; nor are they hindered by the birth being tender, for the whole breast with the *heart*, and with the *brain* the *cranium* it self cover'd with a film rises and falls again.

The members growing solid in time, the bones do daily acquire more hardness, and are more resisting to the motion: In the mean time the strength of the body and the *heart* growing the pulses and motions of the *brain* become greater; which discord going on, it comes to pass that the birth, instigated by a desire of freer motion, it is incited to change place and seek for air, and so the delivery is hastned.

The infant coming into the World it is seriously to be observed, that the blood is moistened and made more subtle by the attraction of air, whence the excrements, (which in the time of gestation were but few) are augmented, and then the wheyish humour of less avail is avoided in greater abundance; in somuch that it is seen that an Infant which is born without an open passage for his urine or his excrement, is dead in a short time, ere ever he suck or take any spoon-meat, or at least after he has taken a very little.

I being taught by the consideration of these things, do undoubtedly perswade my self, that

neither this blood, nor any other which is contained in the *veins* (for it is thick and useless) is fit for the nutrition of the parts, unless being mixed with a due proportion of air, and enlivened it can be admitted into the very least parts of them; for nutrition is not made by external addition, but when the nourishment is fitly added not only to every part, but duly to every little portion, and assimilated to it.

It is clear enough that this fluxibilitie is given to the blood by the air, which is the first moistner, being a moist thin body, because none is sent into the parts through the *arteries*, unless first being cleansed and purged from its unprofitable fumes, it be well wrought with it; and again, because it is continually drawn without any delay, that it may be mixed with the blood.

If any body say that it is only necessary for the motion and cooling of the *heart*, he is convicted by the example of fishes: for besides, that they are always cold, they do alwayes draw up water at every pulse of their *heart*, and send it out at their *gills*, with which they might be both satisfied for the motion of their *heart*, and for refrigeration if they needed any such; yet to them is given a little *bladder*, in which they carry air along with them, that they may stay under water, not always be forc'd to swim at top to take the air; for if being taken with a Net or Wheel they be kept longer under water, and be hindred to take the air at last, the air in their little *bladder* being spent they are suffocated and die.

Likewise

Likewise the great effects of the air confirms this, matter which may turn into stone, by reason of the combination of the air, being flowing like water, so soon as it comes out of the pores of the Rock it becomes as hard as a stone, without the separation of any visible business: The air being disjoyned by its own accord, or otherwise easily knitting that which is round about it.

*So Coral branches when they touch the air
Grow hard under the waves soft herbs they
(wear.*

We see out of Mans body, that juices flow out through little pores, which scarce passing the superficies of the body, grow thick and limie, and unequal to the little pores from whence they did issue, yet without manifest taking away of any thing; which I do therefore think to be imputed to the air insensibly separated from it

CHAP VI.

The opinion of Columbus concerning the store-house of the vital blood; reasons proving it; the frame of the lungs; concerning the vein and arterie Pnenmonick, that this is not an arterie, nor that a vein; the vein and arterie in a Birth take their rises from the ventricles of the Heart; the cause of their Difference; the ears joyned to the risings of the veins are parts thereof, not of the Heart.

Realdus Columbus, a most famous Anatomicist, was first of the opinion that the mixture of the blood with air was done in the lungs, and that this blood was made vital, in his Book *de re Anat.* 11. Cap. 2. For considering the capaciousness of the *vena arteriosa* by reason that it is too big for the nourishing of the lungs, he thought it was likewise appointed for some other use; then because the substance of the lungs cannot sublist without vital blood, and it is found to be in it, in the mean time (for that blood which is cast up by coughing out of the lungs, comes up of a fresh colour, thin and fair, such as the Physicians do affirm the vital blood to be) he argues in this manner: If the vital blood is not given from any where to the lungs, it is created in it, but it is given to it from any where else; for it has no branch from the *aorta*, nor by the *arteria venosa* (which for the fabrick of its portals receives no blood from the heart, for if it did,

it would beat) does it receive any thing; Therefore, &c. It does likewise follow that it is bred there, since live dissection does demonstrate that the *arteria venosa* is full, not of blood, but of fumes and scum, and is without pulse, which proceeds from the heart.

Being confirmed with these reasons, he says; (ye shall hear his own words) He takes in the air by his mouth and nose; for it is carried to the whole lungs by the conveyance of the *Arteria Aspera*: but the lungs do mix the air with the blood, which coming from the right ventricle of the heart is carried through the *Vena Arterialis*. This blood is driven up and down by the continual motion of the lungs, and made thin, which likewise in this breaking and jussling one with another is prepared: That blood and air being mixed together may be taken in through the branches of the *Vena Arterialis*, and at last may be carried through the trunk of it to the left ventricle of the heart; but they are carried thither so well mixed and attenuated that there is but little work left for the heart.

It is credible that the blood gains there this perfection, where the greatest convenience and occasion for the gaining of it is offered: But there is alwaies air ready in the lungs, and a convenient composition: For their flesh is soft, light, thin, spongiouse, so interwoven with three sorts of vessels, that it is rendred full of holes like froth or a sponge.

The vessels are the *Pneumonick vein* and *arterie*, and the *arteria aspera*, the use of which is easily known from the following relation.

The

The *Pneumonick arterie* (being wrongfully stiled the *vena arteriosa*) rising from the *basis* out of the higher part of the *right ventricle* of the *heart*, scarce enters into the *lungs* (a little above that long passage which is open in Children, but closed up in those of Age, by which it being joyned and inseparable from the *arteria Aorta*, shews the conjunction of both) but it is divided into two branches, of which one goes to the *right*, and the other to the *left*, both of them being again cut in two, which being divided into more, it is spread in very small branches running through it all, even to the utmost of their substance, and contributing blood to this work.

To these he answers, That vessel which is dispersed through the same substance with many divisions of branches being communicated to none of the intrals, called the *arteria aspera*, which is a long pipe, being made up of semiannular grissels called *Bronchia*, and *membranes*, joyned together, alwaies lying open to the air beginning from the lower part of the jaws, first leaning on the *œsophagus*, afterwards being divided likewise in manner afore said, and dispersed through the substance of the *lungs*, and being joyned to the very branches of the *Pneumonick arterie*, adds air to the blood for this purpose, with which, by the motion of the *lungs* being stir'd, it is mixed perfectly and made thin, that the fumes and the grosser excrements, (of which this is expectorated by coughing, and the other by breathing) might be separated and let down into

into the *Bronchia*, and that the blood might pass through for the nutrition of the *lungs*, and enter the small branches of the *vena pneumonia*.

This *vein* is not only alike in substance and constitution to the *vena cava*, but also joyned to it, so that without rending it cannot be dis-joyned, being not well called by the name of *arteria venosa*; it rises from the top of the *left ventricle* of the *heart*, the beginning of it being fleshy and broad (called an *ear* by reason of its resemblance; and the *left ear*, because of the *left ventricle* to which it is joyned) hollow, because contracting it self like a *Spincter*, it lets out the blood being collected into the *ventricle*, as the *vena cava* does on the *right side*. This accompanying the *arterie*, and being divided after the same manner, (together with the *arteria aspera*) it strains through all the parts of the *lungs*, that, like the rest of the *veins* it may carry the blood which it receives in the *capillar veins*, and other its branches, into the great Trunk of it, and so at the contraction of the *ear*, every time when the *heart* is at rest, let it into the *left ventricle*.

In a birth this business is far otherwise, to whom, since the wheyish humour, or that which is made flowing by the air, and the little air which it receives from the Mother (as was said before) is sufficient for its tender and soft members, the use of the *lungs* is at rest; There both the *ventricles* of the *heart*, with one motion as it were (which only creatures have which want *lungs*) serve to move the blood

blood out of the *veins* into the *arteries*

For Nature being forced for an use to come to frame two *ventricles*, gave a beginning both to the *vein* and to the *arterie* that it might thrust out the blood received by both, through both into the *artery*; Hence it comes to pass that as the *arterie* takes its rise from the *right* and the *left*, a *vein* likewise arises from both it divers beginnings tending to one end; yet so that a branch bringing blood from the dexter rising of the *arterie*, and returning that which is superfluous from the left rising of it, shall come to the resting *lungs* (for they ought to be nourished) which when the *lungs* grow greater, and do execute a greater function, growing to be bigger, surpasses the *Anastomosis* much in largeness; and the rather, because those passages which were common, becoming afterwards unprofitable, when the Child is born (that is to say, the *arterial passage* and the *oval hole* are not only obliterated, but leave off to grow yet are they not so much changed, but that their passage, being like a great *ligament* shut up, show clearly enough the conjunction of the *arteria pneumonica* with the *aorta*, and of the *vein* with the *cava*, being only clos'd with a little *membrane*.

Veins do differ in this from the risings of the *arteries*, because these are enclos'd with a large and moveable appendix joyned to the heart; They call it an *ear*, with which it is covered as with a *Spincter*, of which the *right* far surpasses the *left*; the cause perchance is, (for whilst the blood is violently driven toward

the heart, being hindred by the operation and contraction of this, it violently distends the *arteries* because all the motions and contractions of the body are more violent then those of the *veins*.

The *ears* are rather parts of the *veins* then of the *heart*, because they have one cavity common to both, but they are seperated from the bosom of the *heart* by *portals*, and then they are given to the *veins* alone and to no other vessels, into whose substance they with fleshy *fibers* jet out a little; besides, the motions of the *ears* are distinct from those of the *heart*. These things I thought fit not to be omitted, because they give way and light to the search of the truth of the question in hand. There are likewise other parts, besides the *lungs* forefaid, which do immediately assist in the *Hematosis*, because by freeing the blood from things unprofitable and hurtful, (namely the *veins*, *bladder*, *intrals*, the *skin*, the *palat*, the inward *tunicle* of the *mouth*, the *ears*, *nostrils*, *eyes*, &c.) which are so plac'd, that taking that which is most alike to them from the blood which is brought for their own nourishment, the rest which remains profitable they do let down into the *veins* and do discharge that which is unprofitable either into their own bosoms, or into the circumference of the body; but because the relation of them would be tedious, desiring brevity, I shall omit them.

CHAP. VII.

That the Blood ought to be moved to the place which are to be nourished: when, and how life begins; a Bubble turns it self into an Ear, and the Heart coming to the assistance of it; The situation and composition of it; what instrument of the Soul the Heart is.

WE said even now, that there was required some impulsive, that the blood being now moveable, and absolute at all points, might be moved toward the parts which are to be nourished. For the nature of blood and ocular testimony do confirm, that blood flows not thither of its own accord, nor is it attracted by the parts (for all heavy things tend downwards) How this begins from the very first life of the creature, and continues all its life time (adjudged so to be by a diligent searcher) I intend to relate.

Life seems to begin and to take its first rise, when after the first disposition of the creature, a little moisture, by the help of heat gathering together things *homogeneal*, and separating of the *heterogeneal*, creeps into that part which begins already to be firm, and so representing the beginning of a *vein* raises that into a bubble or little bladder, which first resisting and afterwards contracting it self, shakes this moisture into the raw beginning of an *arterie*; this returning back, and the little bladder contracting again and again, the motion, after the

the rude shaping of the members, growing greater, the parts receive nourishment and more perfection, and this liquor acquires the colour and consistence of blood. Out of which, whilst the encrease of the fleshy part flows fast to the little bladder, now receiving the form of an ear (which to some creatures is sufficient all their life-time) the flesh grows, together with the first beginning of the heart, which as a help to the ear is created for the better propulsion of blood.

For this function as was most fit, it is not placed in the middle of the body, where according to *Anatomists* the Navel is placed, but in the breast, a place nearer the heart, that it may more conveniently furnish it with blood, which of its own accord flows downwards, also that in it being environed with the ribs, it might move closely within the *pericardium*.

The flesh of it is hard, yet so that it may be contracted, being of gross workmanship, but so (if in little things we use great comparisons) as a pillar made of *Toscan* workmanship, which being clownishly made, is put as a prop for bearing the weight of the house; this lump of flesh is given to Man by Nature, that it may be able to endure the labour which it is destined by Nature.

This flesh has two bosoms, namely, the left and the right, of which one because it only gives the blood into the lungs which are near it, has not so thick walls, and grows as it were to the right side of the heart, but the left be-

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cause

cause it distributes blood into the whole body is environed with much thicker flesh.

To these receptacles answer their vessels common to them, being fenced with *portals*, namely, the *veins*, with their appendices or *ears* and the *arteries*, of which these are open without and shut within, but the *arteries* are open within and shut without, having so open *orifices* that they evidently shew that the quantity of blood which passes through them is not small.

It has besides these no ordinary vessels either bringing or carrying away, which are fit for that work, only the small *Coronal arteries* rising from the *aorta* before it pass out of the *pericardium*, are grafted into the *basis* of it with their *conjugal veins*, which rising from the *cava*, so soon as it is passed the *heart*, are communicated to the *basis* thereof, that they may gather up the superfluous blood, and restore it to the *vena cava*, to carry it back to the *heart*.

Being so framed, it hangs in the bosom of the *Pericardium*, only in the *basis*, or the part which are broader then the rest (by the mediation of the *Pericardium* and other vessels which arise from it) it is tyed in the middle of the *thorax*. The rest of its body from abroad rises like a *conus* stretching it self forward towards the right side into an *apex* or point, and swimming in the water of the *Pericardium*, which facilitating its motion, is every way free.

Hence it is, that when the *heart* is in action which is performed by the contraction of a

the *fibers* together, the free point is drawn towards the immoveable bottom, and so is lifted up, and making a leap as it were, strikes the breast with a pulse which is felt outwardly.

I do therefore conclude, since the parts do acquire apposition of nourishment, and that no part besides the *heart* has the conveniency to do this (which is evidenced by the agreement of the vessels, the connexion of the *ears*, the disposition of the *portals*, the vastness of its fibrous and contractible flesh, its fit place, the due composition of all things, and the protrusion of blood in creatures living apparent to the eyes) that the *heart* is the instrument dispersing the blood received from the *ears* into the *arteries*, by the subserviency of which, it furnishes nutriment to the whole body.

Those who are more taken and blinded with greater esteem of the *heart*, are not content with this use (the which to gainsay, is to deny credit to ones senses) but they say that it performs many more and better offices, and will have it to be the author and efficient cause of all heat and life; and because this is thought to be performed by the help of *spirits* and life, they think it to be the very warehouse of *spirit* and life.

CHAP. VIII.

The Arguments of Conringius for the Hematosis of the Heart, and the Confutation thereof.

ALbeit from the preceding Narration reasons may be drawn, from which the evidence of the contrary may easily be demonstrated, yet I cannot rest satisfied if I give not answer to the most famous man *Hermannus Conringius*, Professor in the University of *Helmstadt*, a man much to be esteemed, which he brings for the *Hematosis* of the heart. I shall not be unwilling to repeat them in the same order that I took them in out of his *Lib. de generat. & mot. nat. Sanguinis, cap. 24.*

I. 'Tis granted that the Heart is the beginning of the Arteries; and that the Veins are derived from the same beginning, our eyes do sufficiently witness, therefore the Heart is likewise the beginning of all blood, and the storehouse of it.

II. The fluxion of all blood to the Heart, and the flowing of it from the Heart (for neither does the blood go to any other part or bowel, nor does it all of it flow from any other part) but all motion is appointed for the obtaining of good, and therefore all good gains its chiefest good in the Heart.

III. Moreover the Heart is generated first amongst all the rest of the parts, and does both beget and contain blood, no other bowel being as yet formed, as it may be seen in eggs after the
second

second or third days sitting, and it is approved by the authority of most learned men; and this comes to pass by a most certain rule, that the Heart out of fit and disposed matter can make blood without the help of any other of the bowels, yea that the first blood of all, of which the parts of the body are made, and which is so exquisitely elaborate, is concocted only by the Heart.

IV. It is likewise known that blood is generated in some, if the Heart be strong, though the Liver and the Milt be corrupted, insomuch as it is able to recompence the fault of the Liver and the Milt by its heat; as likewise any passion about the temperature of the Heart, doth cause that the blood of the whole body is either well concocted, or otherwise. Therefore by this alone we are able to gather the strength and ability of the Heart in generating of blood.

V. Its aptitude for nourishment is gathered from hence, that no part of the body is nourished but by blood, elaborate before in the Heart; only in a birth that blood which is the matter of the parts is first seen in the Heart, and the very streyner of the Liver in process of time is generated from hence. In vain is all that nourishes first elaborated in the Heart, unless by that working the blood be better prepared, that it may be the fitter for nourishment. It is likewise certain, that that blood which flows from the Liver, often, if not always, is so raw, that it cannot be fit for the nourishment of the parts, neither is that again all concocted by the Liver, or remains unprofitable, therefore it is taken by the Heart that it may be made fit.

VI.

VI. *Because all the heat of the creature is from the Heart alone, it is not to be doubted that the last perfection of the blood is from the Heart, and that therefore the Heart is the prime store-house of the blood.*

I. As to the first, I grant that the *veins* and the *arteries* do arise from the *heart*, it does not follow from thence, that the *heart* is their efficient beginning, nor do I believe that it is the mind of the Author, that one part has its existence from another, seeing all of them receiving their delineation in the beginning, do acquire their perfection in time.

Nor do I believe that it will be maintained by him, that the blood is made because of the *veins* and *arteries*, but that they were made for it, (that they should be vessels for conveyance, and not vessels efficient) nor that he concludes thus, *That which is the efficient cause of the veins and arteries, is likewise the efficient cause of the blood:* but rather taking his argument from the consequence (for there where the beginning of the *veins* and the *arteries* is, there was the first necessity of them, which is for containing of blood) *Where first veins and arteries are found and have their beginning, there first blood is found and has its beginning, and that is in the heart.*

Answ. It does not follow, that there where first blood is to be seen, that there it has its beginning, as if he should argue, from the beginning of the Trunk spring the roots (if we may use this comparison, the *veins* are the roots
of

of the body) therefore they are the juice of the tree which nourishes it.

Blood, as I take it, begins from an invifible beginning, for a juice which is answerable to blood does meet together out of the first beginning particles of the creature through the pores, which are the first achievements of the *veins* or blood rather, agreeing with those parts whilst they are yet tender: This by its extension makes or raises a little bubble or bladder, which in time puts on the form of an *ear*, and stirs its *Diaſtole*, and gives it occasion first of resistance, then of contraction; for the *Diaſtole* is before the *Syſtole*; for how shall any thing contract it self which has not first suffered the extension of the Agent?

Whence it follows, that the concurrence of blood from an invifible beginning, is the efficient principle of this little bladder, and not the bladder of the concursion of the blood; as the many rills that meeting together do make up a river, and the river does not make up the rills.

Therefore it is manifest, that although the beginning of the *veins*, and their apparent rising be from the *heart*, yet therefore the blood does not rise from the *heart*, but flows to it. That which is first in degree may be called the cause of the consequent, but not on the contrary.

In an egg, before the *heart* be formed, there appears first a bladder beating, which being dilated by the blood, looks red, and contracting it self lays down all redness, grows again

white, and disappears, which is a sign that the blood is before the bladder, (which becomes an ear, not a heart) and that it grows red by blood, and that the blood does not grow red by the bladder.

II. This confirms what is said; because the blood flows to the heart, it is certain that it has its beginning elsewhere: give me leave to answer, that the blood flows no sooner to any intral, then to the lungs, and that it does not flow from any place more perfect and absolute at all points, then from the lungs, both reason tells us, and ocular testimony confirms it.

A Birth to which wheyish blood is sufficient, needs not the help of the lungs; nor does it need the heart for the change of it, so that it may only enjoy its dispensative motion.

The blood does not move towards the lungs but to be purified: If a creature arriving to growth, and having much blood could want them, as well as he does when he is in his Mothers Womb, they had not been framed for a future use to the birth.

This purifying is performed not by the intention of the lungs, but by the action of the soul: parts being laden with blood move it further, either by contraction, or their own weight, or by resistance, that they may be freed from it; so the heart by the impulsion of the ear being filled with blood, even to distention moveth it forward, that it may be freed of the trouble of it.

Therefore the motion is designed for the good

that the good of the part moving, and not always of
becomes the moved; which in excrements is apparent:
is red by but parts do not act for own anothers behoof,
row red but for their one convenience, they receive such
things as are convenient for them, and drive
away such things as are hurtful. But in this
cause the number is the *heart* comprehended, whose in-
n that it tention is not when it thrusts the blood into
leave to the *Aorta*, to give nourishment to the parts,
r to any but to put off a trouble which comes upon
does not it self; besides it is the office of the souls go-
ad ablo-vernment to give nourishment to every part,
gs, both the organs being rightly disposed.
confirms

III. Although all the parts have at first an
suffici- obscure delineation, yet there appears at first
nor does a little bladder which beats, which in process
so that of time becoming more fleshy, attains to the
otion. form of both the *ears*, therefore if any thing
he lung deserve to be said to be born before the rest,
ving to it is the *ear*, which is generated before the rest
d want of the parts, which moves first of all, and leaves
s in his motion last of all; and not that fleshy part of
framed which the *ventricles* consist, in whose flesh they
place all motion, and in the disposition of
the in- whose *receptacles* they place all power, and
n of the the fountain of all faculties, although this ve-
move it ry same motion be divers from that which is
ir own seen in an *Embryon*, and in an egg; and is on-
may be ly in consequence to it.

But neither does it generate the blood, but
puls from receives it flowing from the whole body, by
even to which it self is likewise made.

IV. 'Tis certain, that the *liver* or the *milt*
for the being corrupted, but not beyond their bounds,
good

good blood is generated, or else such as is not altogether bad. Nature does at sometimes endure the small default of one part, the rest being all entire, without great damage; but the *liver* or the *milt* being quite corrupted, I do not believe that the body or *heart* can be so whole or strong.

It is certain, that the *milt* being obstructed, because the blood coming from thence is not well diluted, that the *heart* is troubled with beatings; and also those evils which affect the parts which serve the whole body, use to be hurtful to the whole body.

When there are more assistants in an operation, and one or more of them are diseased, if the whole is not abandoned (it is performed faintly and imperfectly,) this is to be imputed to the rest of the parts which are whole; it is inconsistent to attribute it to the heart, since it is certain, that its aid is not as yet required to the sanguification.

It is hard then to assert any passion about the temper of the *heart*, to be the cause that the blood might either be well or otherwise concocted, for indeed there are many parts by whose perverse disposition the whole *Eucrasia* is overthrown, if they are combined together: What hindreth, I pray you, the *heart* being ill affected, that the *lungs* or other parts which belong to the *Hamatosis* by the nearness unto it should be infected also? It hapneth often howsoever, that the temper of the *heart* is often vitiated by the ill disposition of another part, so that the affections of the *heart* are only the

he Symptoms, but not the cause of the disease. From what offended part, the action itself is hurt, from the same it is performed.

V. Its granted, that no part is nourished unless the blood pass the *ventricles* of the *heart*; and I do believe that no man denies, that the nutriment is elaborated, that it may nourish the better; so it is likewise true, that in a birth there appears first blood in a little bladder, and afterwards the *Parenchyme* of the *liver*, yea the very flesh of the *heart* in process of time is thence likewise generated; but by what argument taken from thence it will be proved that the blood either in the *receptacles* of the *ears*, or in the *ventricles* of the *heart*, is any way elaborately altered, or gains aptitude to nourishment, I see not.

Nor does that much press us, that raw blood has often flowed out of the *liver*; it is made fit by being concocted in many reiterated circulations, and being purged from its dregs, nor has it any need to be concocted again in the *liver*, or perfected in the *heart*; only it is necessary that by its aid, after that it has received at every turn a new refining in the *lungs*, it should be driven into the *arteries*.

VI. It is true, that from the *heart* all heat comes to living creatures, not because it is hotter then the rest of the bowels, but by accident, this heat is raised in the parts through which the blood suddenly passes by its motion: which is an evident token that the blood receives not its perfection from heat, and so the *heart* is not the first storehouse of blood.

C H A P.

CHAP IX.

An instance given upon the aforesaid Answer taken out of the Method of Cartesius; why the blood of the veins is more thick then that of the arteries; the heart is not the Organ of Sanguification, neither can the consummation be imposed to it.

FOR an instance to confirm this Answer that shall serve which a most famous and renowned man *R. D. Cartes* brings for the proof of this fire, which he sayes was made by God in the hearts of creatures, being the Author of all motion and action, as likewise of the circulation of the blood, *method. pag. 47.* The difference which is observed in the blood which passes out of the veins, and that which flows from the arteries, can rise from no other reason then this, that passing through the heart it is rarified, and as it were distilled, and so becomes more subtle, lively, and warmer, so soon as it comes out from thence; that is to say, when it is in the Arteries, then it was before it entered into them, that is when it was stayed in the veins. And if one take good heed, it will be found that this difference does not manifestly appear, but near the heart, but less in places distant from it.

The most famous man assumes, that the arterial blood is thinner then that which is contained in the veins; nor without reason, for that which is in the veins growing useless, has

as lost some portion of its aerial substance, and that perchance which it has retained is more full of fumes, and duller, and retains not its former liveliness; to which add, that some portion of the liquor is voided by insensible transpiration, as likewise it is severed and thrown forth by sweat and urine; if it receive any grossness in the outward parts, being refrigerated, I am confident it deposits that grossness together with the cold, before it comes to the heart.

Granting that the *arterial* blood is thinner than that of the *veins*, he denies that this *arterial* blood can become thin, unless it be rarified by the heat of the *heart*, and as it were distilled (we intend to speak of the heat of the *heart* afterwards) his reason is, because passing out, it is alwayes more subtile, lively, and hot, than when it enters. If the most famous man mean the entry of the first, and outlet of the last *ventricle*, we do grant that the consistence of the blood, yea the colour it self doth receive some change, but not in the *heart*, but in the *lungs*, for the reasons aforesaid: but if he speak expressly both of the egress and entry of them both, we deny that the blood does pass out of the *right ventricle* of another substance than it entered; nor will it ever be demonstrated, that the blood doth enter more thick in the *left ventricle*, then it comes out afterwards.

To call the *heart* the Organ of sanguification, how absurd a thing it is, from hence appears, because it is not perfected by one part

or

or instrument, but by many, for since it is fit that diverse things should concur in the constitution of blood, and be diversly wrought, as all ground does not bear all fruit, so cannot one part furnish so many diverse things, or is appointed to perform so many several operations.

If any body say, that the blood is only consummated by the *heart*, I think he will be convinced by these arguments.

First, because in the *heart* nothing is added to the blood, or taken from it; in the *ventricle* there is added to the meat and drink a liquor which sweats out of its *tunics* into the hold; in the *intestines* that which is grosser and unfit is taken away; in the *pancreas* and *adenes* of the *mesenterie*, a just quantity of blood is added to the *chymus*, which for the greater dilution is much augmented in the branches of the *porta*, by the subserviency of the *milt*, and other intrals, that at last after the addition of *choler*, in the mediation of the *cystis*, it may through the *liver* by *Dædalian* windings perfect its course, and so being alike at all points make up one perfect compound.

No such thing happens to the body by the help of the *heart*, since there is no administrative vessel which can either bring any thing to it, or carry away any thing which is separated from it.

I believe, that no man thinks that the *coronal arteries* and the *veins* joyned to them do this, for they are lesser then to be employed in so common and great a work.

Authors

Authors which are prime Physicians, use to calculate very well from the largeness of the vessels, seeing some one part receive a great deal more then it needs for the administration of its nutriment; that such a thing is done for another parts sake, by Nature, which does nothing in vain: so let us argue, taking our proof from the smallness of them, that the *coronal veins* are destined to no other purpose, then for nourishing the *heart*; so much the rather, since it is certain that vessels are allowed to other parts, according to the same proportion.

If perfection were given to the blood from the *heart*, at least from thence it would suffer some change; but since there can none be perceived, but such as the right *ventricle* receives from its *ear*, such does it unload into the *arterie* of the *lungs*, and such blood as the *left ear* likewise affords, the *left* gives to the *aorta*; certainly either the colour or the substance would shew the change.

Those that do ascribe the *Hæmatosis* to the *heart*, do affirm that there is more power in its *left ventricle*; but see what great absurdity would follow from thence, the *lungs* would be nourished with unperfect blood, for they do not receive the least *arterie* from the *aorta*, or *left ventricle*; nor can they have any motion backwards, the motion of the blood, and the semilunary *Portals* hindring them.

Let it then be ratified and confirmed, that the *ventricles* of the *heart* do only afford a passage to the blood, which the *veins* and the *arteries* do likewise, and that their flesh does drive it
more

more forcibly, for since the *veins* being weak could not impel the blood by the help of the *ears*, into members far distant, the *heart* seems to have been added to them as a helper, that being a great deal stronger, it might supply the defect of the *ears*.

SECT. III. CHAP. I.

Whether there be a greater heat in the heart, than the other Intrals; the reasons of the Antients affirming it, are opposed; the opinion of Cartesius concerning heat; what are the things that render this opinion plausible, but the composition of the heart, and reasons withstanding; the first and latter motion of the auricles of the heart.

ORDER leads us to examine our third Proposition, whether or no there be greater heat in the *heart*, then in other intrals? The Antients do so much appear for the affirmative part of this Question, as also the Philosophers of this age, that as an axiom it is not called in question by any, and as many is commonly valued at an even rate, with that which is best known: just so they do all build unanimously the preheminance of the *heart*, and principality of it upon this, as upon a firm ground, and very well known to all, above all other parts; and upon the same all the powers granted in all former ages, and even in our times.

Aristotle in his Book of Youth and Old age,
Cap. .

Cap. 4. says, *That the beginning of heat depends upon the heart, and that the soul is as it were set on fire in that part.*

Galen in his Book of the formation of a Birth, Chap. 3. says, *That creatures received the heart as a fire for warmth.* They commonly do aver, that from hence the heat, through which the body of an Animal seems hot to the touch, is spread through the whole body.

But touching can give judgment as concerning heat; nor must you refuse to trust it, since it returns report concerning its proper object; the breast of a living creature being opened, so much great heat is found by touching, nor by search is it found greater then that of the rest of the intrals.

Physicians judge as far as they can by sense, and that which is not to be perceived they judge to be nothing at all; is not a greater heat denied in the heart, because it is perceived by the touch? we must not infer that the skin of the hand is too thick, or that it is colder, for in a little time that would be shown; for those that are very cold do not suddenly feel the heat of a good fire at first, which afterwards they are not able to endure.

We must likewise take notice of the substance of the heart, whether it be fit for such heat: there ought to be an apt subject answerable to a powerful agent, flesh is not fit to endure such heat, if the humours should beyle out of it, it might be easily roasted or boiled; oyl is not enough in a lamp, but there is

is likewise a wick required, which may subsist and continue in the flame.

This heat in the *heart* is either imbred or acquired, this would quickly be diminished and extinguished by the adventitious juice, for nothing could be added that were so hot, for by the *heart* is ought to be heated, as fire by kindling, and all agents must needs endure the reaction of their patients, by which it is at last blunted; and it is likewise known, that which is luke-warm asswages that which is very hot.

This adventitious heat must come from some other place, and from whence I pray you? shall it be sent from a part that is less hot? or shall it be sustained by exteriour food? the *heart* receives no other thing for its nourishment then that which comes through the *arteries Stephaleides*; nor is their blood any other, then that which is afforded as nourishment to the whole body.

Perchance it might stir the like heat, or a greater in other parts, for there are other parts fitter for the conception of heat, as being dryer; and heat is the more intense, by how much the thicker the substance is in which it has its residence.

Renatus de Chartes a most famous man, whose wit I do not only admire, but also much esteem of his Philosophie, *lib. method. pa. 42.* says that the Almighty did place or stir up in the *heart* of man a heat or not-shining fire, (not unlike to that by which hay is set on fire, when it is put in recks before it be dry, or

as

as new wine left upon the lees seeth's up) which exercises all the actions of the body, but thinking, which amongst all other creatures he guesses to be only proper to man, as proceeding from his reasonable soul.

He says that the drops of blood which fall into the receptacles of the heart, are presently inflated and dilated by this heat (like other liquors when they are let fall drop after drop into some vessel, which is excessive hot) whence he avouches, that as well the *arteries* (for some he says falls into them likewise at the same time) are lifted up together with the walls of the heart, and that the three pointed *portals* in the middle are opened, and that over all the *Diastole* is stirred up; but that the blood falls again, because in the *arteries* it is cooled, and that the foresaid *portals* are shut, and that there is a *Systole* brought upon the heart, as well as the *arteries*, and that the *Sigmoides* or *semilunarie portals* are open'd, that make free access for new blood.

He says that this motion of the blood must necessarily follow from the disposition of the organs, which we see with our eyes, by heat which to the fingers is perceptible, and from the nature of blood, which we may know by experience.

This axiom has pleased many: truly it is more plausible to gather the cause of motion in creatures from things evident, then to have our refuge to the Soul, of whose nature we are forced to confess that we are ignorant; besides, that it is evidently seen that the life of a

creature is begun with heat, and is terminated by cold: But to say that the circulation of the blood is known from the disposition of the organs, perceptible heat, and the nature of blood, (to whose judgment seat this famous man appeals) if we will rightly weigh the business as in a scale, the motion of the blood indeed is such and so circulatorie, but proceeding from a far different cause.

Let us see the disposition. There is given to the heart four vessels serving for the common work, two *veins*, and so many *arteries*, being fitted to the two *ventricle* the *right* and the *left*, to either of them there is allotted a *vein* and an *arterie*, and receiving the blood from the *veins* they pass it in a like quantity into the *arteries*. The *veins* are gifted with *appendixes* or fleshy baggs (they commonly call them *articles*) endued with force of contraction, besides innumerable others, which they have for the better advancement of the blood, they have five *portals* in the entrie of the heart, which are opened of their own accord by the blood when it passes through, but shut their selfs against it when it endeavours to return; of which three are the *Sigmoides* of the hollow *vein* at the *orifice* of the *right ventricle*, and two are like half-moons shutting up the *orifice* of the *Pneumonick vein* from the *left ventricle*.

The *arteries* have in their passages neither *portals*, as being unprofitable (for their action is every where the same, for they are all dilated at the same time, and all at an instant tending to their former constitution, are contracted

tracted at the same time, or flag by reason of some weight that presses them outwardly) nor have they any *appendixes* or *ears*, but have instead of them the *heart* made fast to them, in the egress of which from both the *receptacles* there are likewise there three-pointed *portals*, large ones, annexed, which are shut by the blood endeavouring to return, by reason of the contraction of the *arteries*.

The organs being thus fitly disposed, an indifferent judge with his own eyes may see the swell'd *ears* contract themselves, and thrust out the blood contained in them, without the resistance of any *portals*; and that the *heart* from thence swells and rises into a *Dia stole*: This being distended, and endeavouring to discharge its burthen, the *portals* affixed to the *ears* are shut by the compression, which are open before, those which answer to the *arteries* freely giving away.

But because it is not necessary that both the *ventricles* should meet with equal force, the *right ear* deposits the blood into the *lungs* alone, which are neighbouring to it; but the administration of the *left* furnishes the whole body, and gives it to the furthest parts, and at the greatest distance, and even to those which resist it.

Hence the disposition of the *heart* advises us to draw a reason why the left is environed with such a weight of flesh, since the *right* has a thin wall in comparison to it.

'Tis moreover to be observed, that there is given for the same reason to the *portals* of the

heart resisting this operation, unequal *fibers* (little ditches or pits they call them) arising in the folds of the breasts, and engastred in the *portals*, that they may be as ropes or staves which might hinder, lest they in the contractions being stretched beyond their bounds might be unprofitable for the retention of the blood; for in the *left ventricle* they are more and stronger.

The *arteries*, whilst these *portals* are open, being fill'd with blood abundantly leaping in, swell unto great bigness, and advance themselves unto a *Diastole*, and make a pulsation; and they again contracting themselves, the *portals* which are over against the mouthes of them are shut by the weight of the blood compressed, and hinder it from returning to the *heart*.

By reason of the disposition of the *heart* it is easie to perceive, not only by sight, but also by touch, this following order in motion, yea the very action it self, and the manner of performing of it in a living creature, especially in those of a greater sort (because the greatness of the *heart* falling and rising may be the better discerned) and the sooner when it is dying, because then the motions are slower.

One may pretily observe and try by grasp of the hand, that when the *heart* does contract it self, with forced strength leaning on its *Basis*, at that time when it advances its point, and strikes the breast with a pulse outwardly felt, it becomes less in quantity, and when the top of it is raised, besides that it feels more contracted

contracted and hard, its bigness is impaired.

Let us give a reason for this: The actions of all parts are done by contraction, why should we deny this to the *heart*? it consists of contractible flesh, and of such *muscles* as are most firm and strong, and this flesh if it ought to fall and rise by the swelling up and falling of the blood would be very unfit for the purpose, such a great consistence is fittest for a strong and vehement action, and a more flagging consistence fitter for passion.

If the *heart* seems to be uplifted by the foregoing contraction of the *ears*, by which they discharge the blood, the *Diastole* is not to be imputed to a dilatative heat: It most clearly appears from eggs being opened every day, that the motion of the *ears* do precede, and did precede always.

In them there first appears a little bladder which beats, which being changed into the *right ear*, the *heart* is seen afterwards to grow; to which reason advises us, for the *ear* keeps the same number in its pulses which the bladder had before, the *heart* has a distinct and diverse motion from it.

Because the motion of the *ears* is first, it does not depend upon the motion of the *heart*, the *heart* is immediately uplifted by its action, not on the contrary, for they receive nothing immediately from the *heart*.

This is apparent, because when the *heart* beats no more, yea when it is dead, either of the *ears* do still beat in answer to their *ventricles*; after the *left ventricle* leaves off to beat,

the ear which is next to it beats still, which being dead the *right ventricle* continues; which ceasing, the *right ear* supervives still; this abstaining from motion, at least from any that can be discerned, there is a kind of trembling motion observed in the blood, raised as I think in the blood, being moveable, by the weak endeavour of the ear.

CHAP. II.

How many absurdities do follow the opinion of Cartesius concerning the ebullition of the blood.

LEt us see what absurdities follow this doctrine of the ebullition of the blood.

The most famous Man is forced to design the *Diastole* of the heart and the *arteries* at one and the self-same time; which if it be true, the *Portals* that are placed at the entries of them, are of no use, which is absurd to assert, since Nature makes nothing in vain.

It is known that the *arteries* have none, because their *Diastole* and *Systole* begins and ends together through the whole body, which if they were extended through the *ventricles* of the heart *portals* should be as unprofitable there as in the *arteries*.

To this adde, that there would then be no need of those *portals*, because there would then be nothing in the *arteries* to enforce the return of the blood; they have not the force of

of contraction, as the most famous man himself affirms, nor is there in the body any cold which by contraction is repercussive, such as the most famous man does not desire, but only a lesser heat, that the blood may fall and make a *Systole*.

Secondly, it follows, that the three-pointed *portals* joyned to the *arteries* are shut by the blood, being cooled and asswaged, which comes to pass at that time when the blood is not so able to shut them, or has need so to do, namely, when the *arteries* are not so full; and to speak in a word, when they have not power and occasion so to do: for they are not shut by their proper force of contraction, nor by that of the *heart*, (which in his Letters to the Physicians of *Louvain* he denies) nor by the urgency of the *arterial* blood.

Besides, if the *Systole* of the *heart* be then when the blood is refrigerated in the *arteries*; this either comes to pass because the blood in them being condensed there is place left for that which is coming out of the *heart*; or because the blood which is in the *ventricles* of the *heart* is coold together with it, that it may fall together.

If the first be true, the *Systole* of the *heart* will ensue upon that which is in the *arteries*, that is to say, its done at several times; as if you would say, the blood is condensed by cold which is in the *arteries*, and which is made less in the bulk, from thence the *portals* are opened, and out of the *ventricles* there slides other blood, which can not be done all at one time. Thus
it

it is proved, Because if the three-pointed *portals* are presently shut after the *Diastole* of the *heart*, whilst the *arteries* are as yet asswaged (if it did not cease they could not be shut, for the blood passing out, and being no less active then that which comes from without, would not suffer them to close) there would be both an apertion and a shutting of these *portals* in the *Systole* of the *arterie*.

If the last be true, Why is it not refrigerated by the drops of the colder blood which enters afterwards? for that of the *veins* is cooler then that of the *arteries*, being more cold in the *lungs*, and yet the ebullition is encreased by it; whence it follows, that in the very self-same object that which is less cold, performs greater actions then that which is more cold.

Lastly, if that which is liquified and rarified by heat, be likewise hardned and condensed by cold, the blood shall lose that thinness which it did acquire by the heat of the *heart*, by reason of cold; which if it be true, how can there be any difference betwixt the blood of the *veins* and that of the *arteries*? which is objected to Dr. Harvey p. 47. *Method*.

We do not receive the answer (Pag. 136 and in the following Epistle, *Quæst. I. Beverovic.*) which is returned to the objection of the Physician of *Lovain*, (in the same Book Page 124.) in which, besides that the most famous man grants that the blood flowing out of the *arteries* into the *veins* through the re

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intest parts does suffer no mutation, he sayes,
 That there are alwaies some drops in the Veins
 which did not flow from the Arteries, because
 indeed there is alwaies some moisture, which
 pass into them out of the Intestines, and that
 the Veins, together with the liver, are to be
 reckoned upon as one vessel; As likewise against his
 own position, (pag. 47. Method) That the blood
 ought to retain the same qualities, which it ac-
 quires from the Heart, in all the Arteries; that
 the blood in the Liver is made red, and that is
 the reason it is found red in the Veins.

From the intestines to the veins of the body
 there is no way but through the porta and the
 liver, which it self has but a branch from the
 vena porta, whose blood has not learned to swim
 against the stream, neither are the portals more
 open to it, then returning from the habit of
 the body.

Besides, if the blood be thickned and in-
 crassated the more further it goes from the
 heart, how shall it enter the capillar arteries,
 or pass through those which are much less, or how shall it
 pass the pores of the body to nourish it? for
 the very least parts of the body are nourished
 and augmented according to all their dimen-
 sions, not by external apposition.

Likewise the motion of the blood would
 pass on very slowly, if it were to be performed
 by ebullition and refrigeration (swiftness, which
 is given by heat, is taken away by cold) espe-
 cially if it should pass forward drop after drop,
 albeit they are great (if the drops do not out-
 go the bounds of drops.)

But

But why do both the *ventricles* of the blood admit but one drop? nothing hinders but that it may be filled up to the top before it can boy over; there is abundance of blood in readiness, an *ear* pressing, an open way, and *pate* portals; besides that the great mass of the *heart* being augmented and diminished, and the elevation of the *arteries* through the whole body do demonstrate that so much pass through.

The great *arterie* being opened all the blood flows out; which cannot come to pass drop by drop, although the drops were never so big.

Pray what becomes of the blood of the *heart* which enters into the substance by the *coronary arteries*, does it likewise boyling up rise to greater quantity, and move backwards? or is it refrigerated in the flesh of the *heart* where the greatest heat should be? (because that from thence the *ventricles* are hot, and then that from which every thing is of such a nature, it must needs be more of that nature it self) it is not to be believed: *veins* which are answerable to *arteries* in bigness, do receive no other then which returns from other flesh.

To this adde, that the *aorta* being stoped in a living creature by a *ligature*, the ebullition would be seen with our eyes, nor would it give over so soon, especially the *heart* still beating.

If taking the *heart* out of the body, without any regard to the order of the *ventricles*, you cut it in length, or cross, or as you please, into

many pieces, reserving none of the *ventri-*
 (which ought to be shut before the sides
 raised, otherwise the force of your ebulliti-
 would pass into air) every piece of it leaps
 hile, yea by erecting and contracting it
 it endeavours to shake off the trouble of
 surrounding air, and after every leap (in
 which it is easie to see that the pieces are made
 , especially if you look upon the greater
 ces) flaggs, and falls, leaves working, and
 a short resting, it returns first to a short,
 to a longer erection; in the mean time
 if you prick it with a needle, or any other
 wyes molest it, it raises it self with several
 new leapings, that it may oppose it self to
 ward injury, without any sign of heat,
 ullition, or dilation.

Likewise in the body the *heart* being whole
 as to hinder the trouble of the blood distend-
 it by its contraction, and after every acti-
 o desist from working, and rest, in which
 ue it is again filled and overwhelmed by
 ny blood from the *ear*, and then has it new
 oasion of contracting it self.

Heat the author of ebullition and dilati-
 o (of which it appears there follows a much
 contrary effect) cannot be called the cause of
 its contraction. I believe that the body be-
 ing enlivened is driven to contraction by the
 Sal, the moderator of it which is the effici-
 e cause of all actions, according to the opi-
 n received every where, and by all per-
 as.

No actions of the body being disposed are
 performed

performed but when the parts do keep those things which are uncouth and hurtful one part moves and extends another part contraction; in contraction and vicissitude rest life consists, which being begun with contraction, is ended in rest.

The most famous man disputing in his question propounded to the Physician of *Lovain*, concerning the cause of the motion of the heart when it is taken out, does not draw me from this opinion; *Epist. Quest. Beverov. pag. 11.* *How shall that motion depend upon the Soul of man, which is likewise found in the parts of Heart being divided, since it is our belief, that the reasonable soul is indivisible, and has no other, either sensitive or vegetant, joyned to it.* He seems not to derogate from the motion of the Souls of other creatures by this question, he only moves his difficulty concerning man's soul, which troubles me the less, for this being comprehended under no dimension, and being incorporeal, seeing it is not circumscribed by its own body, can neither suffer any division nor circumscription, nor shall it suffer any until that at the last day it arise bounded by its own body to judgment.

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CHAP. III.

f the heat of the blood; the definition of heat; the qualities of the Elements remain in a mixed body; one heat in all, differing only by degrees; how heat may be taken out of the blood.

By this I believe it is approved abundantly, that there are no spirits wrought in the heart; and that the blood suffers no change in, much less gains any perfection there; and lastly, that there is no more heat in the heart, than in any of the rest of the intrals. Let that which is said concerning its principality and government in which it excels, be decided by indifferent judges.

One thing as yet remains to be resolved, and that is, from whence the blood acquires its heat, and from whence lively and refreshing heat comes to the parts, if it have it not from the heart; for it is most certain, that heat, together with the blood, is carryed over all the body, and that from thence the heat of the parts are increased, and that thence they are warmed, and the more blood we have, the hotter we are.

Heat being a tactile quality, and the form of the hot subject, is an effect of the element of fire; it is by the Philosophers defined to be an active quality, gathering *Homogeneals*, and disgregating *Heterogeneals*; these things are performed by motion, by motion the bond of things

things mixed is dissolved, and every thing that has any tye upon it moves to its own beginnings; when fire does stir and disjoyn things mixed, moving of their parts by its active forces (they consisting of the union of contraries) every thing tending to its own, particles of fire are easily joyned, where there is a greater conflux of them, whence fire receiving strength stirs up a greater motion of the little combustible parts.

This, perchance, gave occasion to the most learned man *H. Regius*, that in his *Phys. disp.* 1. *Thes.* 17. & *Physic. fund.* pag. 98. he calls heat a various agitation, or motion of insensible parts.

It seems to me to be no motion nor agitation, but something which is produced by motion out of the subject forementioned; from whence the reason is easily taken, why the stronger and the swifter the motion is, heat is the more easily excited in creatures: for the more and sooner that *Heterogeneals* are separated, fire particles meeting in the sabrick of all things, being joyned with greater convenience, do improve their force, and cause heat, which is augmented, when by dissolving the bond of other things, it adjoyns to it self other fire particles flowing from the same matter.

For all things consist of four Elements, of which every one concurring with their whole strength, when that which is mixed is constituted, keep their qualities entire, and upon occasion do endeavour to show them, and do naturally

naturally show them as much as they can, without dissolution of the creature: and although they are forced to subject them to a more powerful form, yet they do not perish, nor is the one changed into another.

Nullius exitium patitur natura videri.

Nature destruction of all things abhors.

Particles of fire are so much dulled by the concurrency of other Elements, that being as it were asleep, they can show no force, and do not so much as move the sense, yea seem quite extinct, which notwithstanding by motion and contrition, or some other cause assisting, being united, do not only heat, but burn also and raise a fire, especially in the dissolution of the thing.

In a body that is too strongly mixed, so that it cannot be dissolved, they by the help of extrinsecal fire are sometimes so much incensed and moved into action, that they far surpass the other Elementary parts of the mixed body, which notwithstanding, the external agent being removed, do presently return to their natural constitution.

Although the actions of fire, according to the excess of its degree, perform many actions, both in things animate and inanimate, yet there is one and the self-same heat in all, that to say, the Elementary, nor besides this is there any other to be found, whether it be called constitutive, sustentative, or killing, or whether it be called of celestial temperature, or

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natural,

natural, innate, implanted, influent, or preternatural, feaverish, universal, particular, or by what name soever it is designed, it is only distinguishable by its measure, and exsuperance of degrees, not according to its form.

Nor does that differ, which by outward touch is perceived in a living creature, from it, which flows to the constitution of any part whose form continues likewise a while after death, although all perceptible heat be gone before, and the whole corps feel cold, till that its fabrick be dissolved by putrefaction, and every particle return to its beginnings; in which motion the particles of fire being conjoyned do make a heat perceptible to the touch, especially if they are kept from wind; for that coming freely to them they should be blown into the air, before they could be united and make up a sensible heat.

If it come to pass in a living body that something in any part of it being shut up, does putrifie it, swelling at last and making an eruption, and mixed with the rest of the humour increases the heat; for by sharpness or other troublesome qualities irritating the parts, and moving them to swifter propulsion, it begets a swifter motion in the blood, whence greater heat is ingendred: just as if heating meat or drink warmed were received for nourishment, which had many particles of fire in it.

As heat is excited and produced without the body of the creature, to wit, when it is freed from its bonds, so it is likewise begotten

Of the heart.

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in the same motion, and is educted out of the nutriment: This (by the parts vivified and moved by the soul) is agitated, stirred, and divided very small, in which action the fiery atomes (if I may be allowed so to speak) being united, and convening in a swift and indefinient motion, make their strength to appear by a manifest heat.

CHAP. IV.

What things are required to the beating of the blood; from whence blood becomes moveable; how nutrition is caused; blood to be divided into the smallest parts.

THere is required in this action or production of heat in the living creature, first, mobility of the blood, then something moving it, and lastly a disposition of the ways, through which and to which, as to bounds, it may be moved and contained.

It has its mobility partly from the wheyish humour, but most from the air, which is added to the blood in the *lungs*, by the mediation of this, it being divisible into infinite parts, can pass through all, even the most thickest parts.

There is so great affinity betwixt divisibility and mobility, that the more easie a thing is ordained to be divided, or into less parts, it is so much the more moveable. Mobility is extremely necessary to the blood for distributing of nourishment.

For nutrition is the union and assimilation of the nutritive humour to every part; which nutriment, that it may become one living thing, together with that which is to be nourished, is not performed by external apposition, but it ought so to pass the least particles of the members, that according to all their dimensions it may be added and united to them.

It is likewise to be observed, that all that is brought thither is not united, seeing the very self same blood has divers parts in it, of which some are most fit and apt for this part, and other some for another part, yet none do stick to them being apposed, but those that have a resemblance with them, the rest being unfit going farther return to the *veins*; if there be a greater quantity added then is exhausted, there is made an accretion; but if a part that did adhere before be carried away with it, there happens a decrction, and extenuation of the parts.

The very way of its preparation shews the mobility of the blood, for no part of the *Chylus* is admitted into the *vasa lactea*, but the thinner and most moveable part of the *Chylus*, which after it has first passed the glandules of the *mesenterie*, and the *pancreas*, and is wash'd with strained blood, and is mixed with a little *choler*, it runs through the great substance of the strainer of the *liver*; and at last being imbued with air in the *lungs*, it gains its requisite perfection.

But to the nutrition and augmentation which is performed in every part, shews how moveable

able and divisible the blood thus prepared is.

And experience likewise is witness, how much this division contributes to the education of heat; for we see, that bruised and powdered medicaments do act swiftlier, and more powerfully then those that are whole.

We will instance that place of *Galen*, who *Lib. de med. simp. facult. cap. 11.* says thus, *Of those which are confessed to be hot, none at all do heat us, before they be ground very small; whole pepper applyed to the body shews no heat; if like meal it be strewed upon the tongue or skin, it overheats, especially if it be rub'd.*

CHAP V.

Why the blood ought to be moved; the Heart the chief moving Instrument; from whence the abundance of the blood transient may be collected; the Arteries assist the heart; their activating power is proved; what the particular parts do confer to motion.

THIS mobility of the blood is not sufficient alone to the production of heat, for unless it be driven by some impulsive, and be stirred with a swift motion, it should never become hot; for fire particles, unless they be joyned, do not heat, they are drawn out with swift motion, for since they excel in swift-ness beyond the rest, they leap out before the rest, and being delivered from their bonds, do meet, that they may exercise their power.

Albeit the blood be disposed to motion, yet because it is destitute of life (as well as the *spirits*, if there be any in the body) it is no ways able to move it self; for all action proceeds from the soul, nor can any thing but that which has a Soul move it self, or be sensible, it only vivifies the body and its parts, which being orderly fitted, it empowers them with its faculties.

This moving and impulsive Soul does chiefly make use of the *heart*, which having large and contractible flesh, thrusts out the blood received from the *ears* into the *arteries*, without any other intention, but to ease it self of that heavy burthen, with such frequent and swift pulsations, that from them, and likewise by comparing the contractions and dilatations of the *heart*, and the greatness of the floudgates, and the elevation sensible to the touch of all the *arteries*, through the whole body, one may by conjecture easily gather how swiftly by a continual motion the blood passes through all the parts.

The *arteries* and all the parts do second the *heart* in this motion; they being filled and swelled by the force of the action of the *heart*, when they are contracted and oppressed by the weight of the neighbouring parts do dispense it according as occasion is to all the parts; as the *Pneumonick* into the *lungs*, the *aorta* into the whole body, making no distinction of heaviness or lightness; for the lighter does not go upwards, but with one force without any distinction it is moved to the parts most empty or least resistant.

Let

Let no man think because it was said before, that the blood did leap out by the impulsive action of the *heart*, in the *Diastole* of a wounded *arterie*, that therefore the blood has all its propulsive force from the *heart*, and that the *arteries* contribute nothing to it, because it seems to leap out when they are filled.

It will not from thence be concluded, that the blood in the *Systole* of the *arteries* does not move further; for they do fall and are contracted, that they may again rise in their *Diastole*; and though at that time the blood do not flow out of them with so much force as to leap, yet it slides out of them as out of a *vein*, and as much as the closing lips will suffer to flow forth.

It appears how much power the *arteries* have in protrusion of blood, by the ligature, for no sooner by it nay even the great *arterie* is tyed, but immediately beyond the ligature it is emptied in the space of three or four pulsations, although by hindrance of the band there proceed no impulsive force from the *heart*.

All the parts which are to be nourished by the action of the aforesaid *arteries*, are so imbued with blood and nourishment that they are distended and swell, and do naturally endeavour to thrust out all which is strange and hurtful to them; for besides that they are so framed, as by their reluctancy and their own weight to remove the humour which they have received, and do contain within them, because the blood contains many different parts, which cannot be turned and assimilated into any living thing,

they are the more willing to this, because without cease or intermission new may succeed to the former. The abundance of blood shows the truth of this return of the blood out of the habit of the body into the *veins*.

CHAP. VI.

The way destined to the motion of the blood; how it is disposed; wherefore there are Portals for the Arteries, and not for the Veins; and wherefore there are some for the heart. How far the passages of the vessels may be extended; what is to be understood by the habit of the body; The manifest Anastomoses are not necessary for the motion of the blood; The opinion of Cartesius, and of Harvey concerning them.

THe parts which make up the ways through which the blood may pass, and in which as in bounds it may be contained, and its heat preserved, are the *heart*, the *arteries*, the *pores* of the whole mass, and the *veins*, with their *appendixes*.

The *vena cava* with its *ear*, the *right ventricle* of the *heart*, and the *Pneumonical arterie* make up the passage together; as the *vein* of the *lungs* and the *ear* fastned to it, and the *left ventricle* of the *heart*, and the *arteria aorta* make up another. Either of these is joint and undivided, apparent to the view, only in most places it is closed with valvs hindring the regreſs of the blood,

There

There are a great many of these, which are connate in the concavities of the *veins*, both, because there is an inequality in the motions of the body, as likewise because by outward compression they do easily yeild, by reason of the softness of their *tunics*, whence not only the motion of the blood might be hindred, but it to the great endammagement of the body might be pressed backward, unless that were prevented by nature with valvs.

These are framed at the entry and egress of the *heart* only for the first reason, to wit, because the motion of the *ears*, *heart*, and *arteries*, is not the same, but diverse: there are none granted to *arteries*, because at one push they are elevated by the action of the *heart*, and when that ceases, they are likewise contracted, and fall; next, because for the hardness of their substance, they are not so easily squeezed together by the weight of the parts adjoyning.

In these passages the blood gains nothing from the *heart* or *arteries*, but a more swift motion, all that it has is added to it by the *veins*; not that they give any thing of their own, but all, which is contained in their passage or capacity, did flow from the substance of the parts.

The beginning of these described passages begin together with the *veins*, and like marks or bounds end together with the *arteries*, which both parts are familiarie, so called, because they have a similitude one to another, and any part of them is called by a like name, a *vein*, or an *arterie*.

Therefore wheresoever they are so ingrafted
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ed into the substance of the parts, and are so entangled with many divisions and divarications, that they do quite lose both name and similitude, they are taken for substance which flows thither for the nutrition of the parts.

There are passages begin with the *veins*, and end with the *arteries*, and lose their name; and as that which is within them is called blood, so whatsoever is solid beyond the forenamed bounds, is called the habit and substance of the body, which being pervious every where with *pores*, gives passage to the blood through its most hidden recesses, it being first subtilized and made moveable by the *lungs*, that the very least portion of any particle might be nourished according to all its dimensions.

I do not hold it necessary to set down the *Anastomoses* of the *arteries* and *veins* manifest to view, seeing it being exquisitely divided can pass through the very substance of the body swifter indeed through the fleshy part than through that which is more solid, yet with such a harmony of action, that one does not hinder the others action, or forbid it (so long as the body is in health).

The most famous man *DeCartes* makes these *Anastomoses* so necessary, that by them he thinks the way is only open to the circulation of the blood, yea so manifest and patent will he have them to be, that that which out of the *arteries* through their extremities does flow into the *veins*, suffers as he says no change: and if there be any difference of the *venal* or *arterial* blood, he says it gains this by reason that

that something flowed thither from the *intestines* and the *liver* (which we have refuted in few words.)

He says, that the commendation of this *Invention* is to be ascribed to an *English Physician*, which broke that Ice, to wit, resolved that doubt, why the *veins* are not emptied, and the *arteries* not burst, since all the blood which passes the *heart* flows out of these into them.

It is true indeed, that venerable Doctor *Harvey* endeavouring to render his Tenent of the Circulation of the Blood more possible and plain to the minds of those that were averse from it, (because some, as he says, believe nothing, but what they have an authority for) brings that place of *Galen* (*de usu part. 6. cap. 10*) where he says, *That there is a mutual Anastomosis in all, and an interchangeable opening betwixt the veins and arteries, where they touch.*

But the venerable man cites that place only as it may further his purpose, though it be his intention that the blood passes through the habit of the body; and not without reason, since nutrition is performed in manner aforesaid.

Besides, it is manifest, that if any part where no *vein* is to be seen, be wounded, the blood sweats out from thence, or flows out: bones being broken, which are the driest and most solid parts of the body, do shew flesh, which is a sign of blood, at the sides of the breaches, (which we have often seen growing upon moveable fractures) by which they grow together, and are interchangeably knit, this flesh too in time growing to be bone, and acquiring hardness.

CHAP. VII.

It is approved that heat is stirred up by motion as well in living creatures as in things inanimate; Of the place where heat is ingendred The conclusion.

IT is therefore certain, that the blood is very moveable, and infinitely divisible into very little parts; and likewise that the heart does stir it, and powerfully drive it, as likewise the arteries and all the rest of the parts, by a continued, strong, and most swift motion, first through open and clear passages, then through the substance of the body pervious by pores and not hindring the passages of it whilst all parts are sound.

Its manifest that heat is stirred by motion; we see, that those things which are rubbed do grow hot, and that flints knocked one against another do send out sparks; sticks too being mightily moved and stirred take fire; when notwithstanding they are cold, as well as growing trees, metals, and all inanimate things, because they are immoveable.

Likewise lesser and more imperfect creatures, although they live, yet by reason of the slenderness of their motion, are not only not hot, but are cold to the touch, notwithstanding that abundance of fierie particles have been in their composure; which *Palmer-worms* and *Cantharides* do by their example demonstrate; if they be tane inwardly, or outwardly applied

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to mans body, they do burn and exulcerate:

If the body being stirred with running, or with any other Exercise, whence the blood may be raised with a swifter motion, all the body grows hot from thence; which likewise comes to pass, when the parts of the body being reiterated either with sharp or spiced meats, or strong drink, or any other cause, either wholesome or obnoxious, do stir the blood swifter than ordinary.

According to the authority of *Galen. de Morborum causis lib.* All bodies use to be overheated with sinister motion, or by putrefaction, by the neighbourhood of some hotter body, or by a striction, or by hot nourishment.

If any do desire to recite the proxime causes, they are they which joyn fire particles together, or do bring them into action; there is furnished fit matter by aliment for them to work upon, from which they are drawn by motion; by the neighbourhood of hot things they are helped to perform their strengths, the form of the mixt or part thereof remaining; it is forewarned that eventilation might be hindred, lest that they be blown into the air or dissipated.

Its certain then, that by motion heat is drawn out of things, but where, or in what place of creature does that come to pass, whether or in the *ventricles* of the heart? seeing that it is moved without all intermission, and is the first and chief organ serving for the motion of the blood; and again, because all the blood flows to them.

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The *heart* is indeed the first in order, but not the chief organ in the motion of the blood, and that it performeth the office of a Steward by whose power after it is perfected, it is distributed into the whole body for the nourishment of the parts. But because the mass of blood staves there compact and entire, the composition of which, hinders and abhors the increase of heat as much as it can, that cannot be ascribed to the *ventricle* of the *heart*, that they encrease heat in the blood, or that in them is heat drawn from it.

I do believe, that wheresoever nutrition is performed, there this function is most manifestly executed, and that the parts whilst they are nourished, are heated; then the composition of the blood is dissolved, and is divided very small; then also the fire particles freed from their fetters, and being united, do shew their force by heating.

But if it be performed according as the temperature does require, and as may be endured by the composition and union of parts, a gentle and natural heat is thereby excited, and all the actions of the body are performed according to nature, as in a sound man is required.

But if the blood being peccant either in quantity or quality, as well by reason of internal as external qualities, or by reason of immoderate exercise, or greater passions of the mind, and by such things as may cause a swifter motion in the blood beyond measure; then the actions of the body are disturbed, feavers are caused, and symptoms raised in any part, according

ding to the disposition of the temperature and passages: the rehearsal of which, since it exceeds our limits, it is better to have shown that the *heart* in the body of an animal has no rule or principality, nor in the store-house of the *Spirits*, nor the fountain of the blood, because it has no superexcellent heat above the rest of the noble parts.

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An Addition.

Whether Harvy thought that the Ventricles of the heart were so expanded in the Systole that they might receive Blood, and so shut up again in the Diastole that they might thrust it forth. That such a sequel did follow from the supposition of Cartesius; which opinion of theirs is the best concerning the Systole and the Diastole.



See no reason why the most famous *R. de Cartes* should say, That the venerable *Dr. Harvey* did think that the ventricles of the heart were dilated in its *Systole*, that they might receive blood, and were streightned in the *Diastole*, that they might thrust it out into the arteries. Let us consider this business rightly.

The most famous man thinks that the heart, by reason of the ebullition of blood, raised by its implanted heat, does swell, and rises into *Diastole* at that time when the breast is struck, and the pulse may be felt outwardly.

Venerable *Dr. Harvey* says, that the heart at the same time that it strikes the breast, it stretches all the fibers, up-lifts it self, is on all sides contracted, is unfilled and emptied, and is in its *Systole*. The

The same time in which one says there is a *Systole*, another says there is a *Diastole*.

Is it therefore fit for *de Cartes* to ascribe that to *Harvey* which is against his mind? as if he had said that the *heart* was dilated, and did receive blood in the *Systole*, because *de Cartes* is of opinion that the *Systole* is at that time, though he does indeed affirm and demonstrate, that the *Diastole* is then made. *Harvey* by the same right might say the like of *de Cartes*, but let us see who must bear the blame of this.

The venerable Doctor *Harvey*, an exquisite searcher of living creatures bodies, observed two times in the motion of the *heart*; to wit, one time of motion when the *heart* moves it self, and is in action; another time of its rest, in which ceasing from action, its moved and extended by the immision of blood from the *ears*.

He says, that these times may be more manifestly distinguished, and accurately observed in colder creatures, yet best of all in hottest creatures, when the *heart* begins to die, and beat more slowly and faintly.

For then the stops of the times are longer, which in a veget or lively *heart* can hardly be discerned; then likewise the *heart* is seen, after the performance of its *Systole*, to be at rest, and to be (to wit in the creature departing) loose, flagging and weakned, and lie as it were drooping.

He says, that the *ears* at this time do stretch and contract themselves, and by impulsion drive the blood into the *ventricles*, in the di-

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stention of which they make a *Diastole*; which being done, that is to say, when it is extremely distended, begins (says he) the motion of the heart, at which time contracting it self every way, and leaning upon its *Basis*, it is erected, and being lesser in quantity and oblong, it lites up its point, and strikes the breast.

He calls this time the *Systole*, the former the *Diastole*; The first begins when the heart is emptied, and rests from its work, and leaves when the heart is full; The other does begin when the heart stretches all the *fibers*, and contracts them, and ends when that work is performed.

Let any indifferent man judge, if venerable *Harvey* be of opinion that the blood in the *Systole* is received into the dilated *ventricles* of the heart, and thrust out into the *arteries* in the *Diastole*, when they are streightned, especially since the matter being yet in controversie, it is not determined whole opinion is the best.

Let us canvase the most famous mans opinion of the *Systole* and *Diastole*, and try whether or no that will follow from his own writings clearly, which he carps at in others.

Seeing the *Diastole* and *Systole* have their times in which they are measured, and are mutually distinguished one from another, let us see how the beginning of one, and the end of the other, can be discerned, from his supposition.

We know the difference of the *Systole* and *Diastole* by our touch only, by no great help of skil which is most usual in the pulse of the *arteries* or meerly by reason.

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The first way is, because the extension of the heart, as likewise of the ears and arteries, is a *Diastole*; and a *Systole*, the contraction of it: That time which is nighest to the highest extention of the *Diastole*, as likewise that is said to be of the *Systole* which is next to the highest contraction. *Diastole* begins in the middle way towards dilatation; and in the middle way to contraction ends, the rest of the time is ascribed to a *Systole*.

The other way which is by the help of reason, is judged to begin (if it be taken according to the most famous mans opinion) when the ebullition begins, when the heart begins to swell with blood, and the *Systole*, when in the refrigeration of the blood it falls again.

Let it be taken how you will, it follows of necessity, that the blood in the *Systole* is admitted into the *ventricles* of the heart, and that it is sent abroad in its dilatation or *Diastole* into the arteries.

In the first there is no doubt, it remains that we demonstrate it according to the last way, seeing he himself does not aver it openly.

But he says, pag. 44. and in his following book of Method, *So soon as two drops of blood are entred, that is to say, into either of the cavities, which are presently dilated and rarified by reason of heat which they find there; for which cause they make all the heart to swell, and so withal thrust and close the five portals that are in the entry, from whence they flow.*

The most famous man seems to affirm, that the blood is entred before the ebullition begins; for says he, after the drops are entred the

blood is rarified, which makes a *Diastole* whenc it is apparent they came in in the *Systole*.

Consequence likewise teaches us, That the blood enters into the *ventricles* when the *portals* placed at the heads of the *veins* are open but it goes out when they are shut, and those of the *arteries* are open; But the most famous man opens the *portals* of the *veins* in the *Systole* and shuts them in the *Diastole*, therefore the blood does enter into the *ventricles* of the heart in the *Systole*, and not in the *Diastole*.

Besides he imagines, that the *arteries* come to be in their *Diastole*, by reason that the blood entering is dilated, and that they have their *Systole* when it is refrigerated; wherefore in the *arteries*, out of which the causes of the *Systole* are derived, the times of its entry and condensation will be more distinct then in the heart, from which the cause is taken of its *Diastole*, entry and dilatation.

But what need we many demonstrations? The most learned H. Regius, Professor of Physick in the University of Utrecht, and a notable follower of de Cartes his Philosophy, *Fund. Physicor lib. page 183.* in express words says, That the *Diastole* is a part of the pulse, in which the heart, by the rarified blood coming out of the *Vena Cava* into the right *Ventricle*, and out of the *Arteria Venosa* into the left in the *Systole*, according to its depth and breadth is dilated, and swells.

And a little after. Nor is this part of the pulse to be accounted the *Systole* of the heart from thence, because cutting away the point of the heart

heart in a living creature, the ventricles of it are felt in this case, and seem to be strengthened; for the *Diastole* of the heart is not to be reckoned from the dilatation of the ventricles, but from the swelling of the heart it self, which may come to pass when the ventricles are streightned

'Tis therefore to be concluded, That the most famous man does determine, that for they cannot receive blood but they must be dilated, especially by drops, which he says are big enough, because the ways are very wide by which it comes, and the vessels from whence very full of blood, by which they swell in the emptying of the ears) which he carps at in venerable Dr. *Harvey*, that the ventricles are dilated in the *Systole*, that they may receive blood, and are streightned in the *Diastole*, when the blood is thrust out into the arteries.

May not Dr. *Will. Harvey* with good reason say, that the most famous *R. de Cartes* his opinion concerning the motion of the heart, is destroyed by his own proper experiment, in which he strives to confute and strangle the opinion of famous *Harvey*? Because we are come so far to know the different opinions of these most famous men, it will not be amiss in comparing of their Arguments, to see which of their opinions concerning the *Systole* is more plausible.

It being received through all ages, that the *Diastole* of the heart was then performed, when by extension, like a pair of bellows and drawing blood into the ventricles, it was said to be filled, and that that came to pass at such time when it struck the breast, and the pulsation was

felt outwardly: The venerable Doctor *Harvey* did observe, that at that time there was not a *Diastole* but a *Systole* performed, nor was the *heart* dilated, or received blood, (when the *heart* being at rest, and desisting from its labour, was extended into a greater quantity, the blood being thrown into the *ventricles* by the *Systole* of the *ears*) the *Systole* being an action of the *heart* by which it thrusts out that blood which it receives into the *ventricles*, abroad into the *arteries*, and raises them into a *Diastole*.

It is to be taken notice of, says he, that the *heart* when it moves it self is contracted and stretched (like other parts which are contracted in action likewise) whence it comes to be of less compass, which is both apparent to the sight and touch, because it is minorated, and is perceived to be harder, and more resistent.

He proves this consequence by the example of the *muscles*, which when they contract themselves become harder and more resisting; besides the *fibers* being contracted, are shortened and thickned, and so the substance and walls of the *heart* are thickned at that time.

He proves that the *ventricles* are not filled with blood at that time, because they become more narrow, and are more constricted, and are less capacious, as likewise they are seen to be emptied; for upon the inflicting of a wound, the blood comes out leaping, which is thrust out by the contraction of the *heart*. Lastly, the *heart* becomes whiter, which when it is filled is flushed with a red colour, which is most apparent in *Fishes* and colder creatures.

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All the parts when they are in action are evigorated, but resting are flagging and soft; in the time of the Pulsation, the *heart*, because it is in action, is evigorated, contracted, and it erects it self so much, that it strikes the breast.

These are the reasons taken out of the motion of the *heart* and blood of Doctor *Harvey*, by which induced, he endeavours to shew, that there are two times of the motion of the *heart*, one of the motion in which contracting it self it strikes the breast, in which the *Systole* is perfected; another of its rest, in which the *Diastrale* is done, and the *heart* is filled with blood and distended.

The most famous *de Cartes* attributing no action proper to the *heart*, but affirming that its motion is excited by no foregoing power or faculty of the Soul, but artificially by the heat which is implanted in it, which dilates the blood, and strikes up its ebullition, thinks that the *heart* is up-lifted and strikes the breast, moved especially by these reasons, as they are set down in his answer to the Physicians of *Levain*.

In a live Cony, after the top was cut off, the Basis of its heart remaining still fast to its vessels, did beat long enough, and in it I saw very conveniently those concavities that are called the ventricles of the heart to become larger in the *Diastrale*, and narrower in the *Systole*.

And a little while after: You must take notice, that to perform this experiment aright, you must not only cut away the very point, but half

the heart or more, and that you must essay this in a Conie, which is a fearful creature, and not in a dog.

For in dogs the ventricles have several involutions, the concavities of every one of which are so extended by the dilatation of the blood, that in the mean time the general concavities of either of the ventricles is more streightned. Lastly, And when that may by the touch be proved to be dilated, for being taken hold of with the hand it feels a great deal harder in the Diastole then in the Systole.

To these the most learned Doctor Reginus, fund. Physic. pag. 183. addes: If at that time the heart and the arteries be wounded; from the swelling heart, and the dilated arteries the blood is seen to leap out.

Besides in the following page: At what time the impulse of the arterie is felt to cease, at that time we see that side of the heart which looks towards the sternum to fall, and there especially where it answers to the orifice of the aorta; and the right side, and the left, towards the right and left ribs flags, the point recedes from the Basis, and the whole heart, witness your own sense, becomes loose flagging and soft; but wounding the heart and the arteries at that time, no blood comes out of them, and their wounds close.

These are the demonstrations on both sides, almost the same, but to divers purposes, by worthy men; what shall we in this case conclude?

If then these reasons be according to the first way, but briefly considered (as was said how the

the *Diaſtole* and *Syſtole* ſometimes might be diſtinguiſhed,) (that is to ſay, if the *Diaſtole* be when the *heart* is exceedingly ſwell-
led, and the *Syſtole* when it is leſs ſwell-
ed) the Arguments of the famous *de Cartes*, and
moſt famous *Regius*, will ſeem to infer ſome-
thing.

But if you conſult with reaſon, you ſhall find
that the *Syſtole* begins in the height of the *Dia-
ſtole*, to wit, when the *heart* extremely extend-
ed by the blood, ſtretching or contracting the
fibers, thruſts it out into the *arteries*; but it
deſiſts from this action, when not being able
to contract the *fibers* any more, it looſens them,
giving occaſion to a new *Diaſtole*, which be-
gins when the heart leaves action, and is done
whiſt the *heart* is quiet, and till it begin a new
contraction.

The *Diaſtole* and *Syſtole* being thus conſider-
ed, a blind man may ſee that the opinion of the
venerable Doctor *Harvey* is eſtabliſhed with
moſt firm reaſons, and that it muſt be conclud-
ed that whiſt the *Diaſtole* is performed, that
the *heart* is at reſt, that the *ventricles* are filled
and become larger, that the walls are extended
and grow thin, and that it ſelf is augmented
in bigneſs according to all its dimensions: and
that in the *Syſtole* it does move it ſelf by its own
proper action, it is evigorated, by contraction
the walls of it are increaſſated, it ſelf minora-
ted, it advances its point, the *ventricles* are
ſtreightned, and by ſqueezing are emptied, the
blood is thruſt out into the *arteries*, and they
in the mean time advance themſelves into a
Diaſtole

Diastole, at that time when the *ears* are erect-
ed.

These things will be more manifest, if in a lively body you consider, that the sides of the *heart* do not fall, nor that it falls flagging, loose and soft towards the right or left sides, but that this happens only in dying creatures; examples of which venerable *Harvey* alledges, that the time of the proper motion of the *heart*, and its rest might be more evidently distinguished, and that he might the more evidently demonstrate whilst all the actions are slow, that the *heart* does move and contract it self in the *Systole*, and rest from action in the *Diastole*.

By a sound Animal these things are so quickly performed, that scarce has the *heart* done its contraction, but it is streight filled again by the urgency of the blood through those open ways, and contraction of the *ears*, in the twinkling of an eye, and sometimes sooner, so that it is a hard thing to discern the filling and emptying, if not impossible.

True it is, that at the same time blood leaps out of the wounds of the *heart* and *arterie*, in the *Systole* of this, and *Diastole* of that, by the urgency or contraction of the *heart*; for this being empty, whilst it is filled and uplifted by the *ear* into a greater quantity, although the blood come out in the mean time, yet it comes not out with leaping, for the action of the *ear* is not strong enough; then the *ventricles* which are empty, and must be filled again, hinder the leaping of it; but that the more forc-

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cible contractive strength of the *heart*, makes the blood leap out through both wounds, out of its own wound in squeezing out the blood, out of the wound of the *arterie*, when it extends it by impletion.

Let us likewise adjoyn our arguments by which we think Doctor *Harvey's* opinion may be confirmed.

If the blood were rarified, and acquired greater bulk in the right *ventricle* (let the same be said of the *aorta*) Nature ought to have given a greater orifice to the *pneumonical arterie*, which might be wide enough for the passage of the blood; the very quantity which entred in the *Dia stole*, ought to come out in the following *Systole*, the bulk of which, if it be augmented, it should need a greater outlet, according to the augmentation of the blood; no less then we see the hole of the *vena cava* by which it is joyned to the *heart*, answers to the bigness of the part which is above the *heart*, and likewise to it which is below the *heart*.

Moreover it is certain, that according to *de Cartes* his own confession, the *ears* have a contrary motion to the *heart*, and do flag when it is raised, and indeed at that time when the *Dia stole* of the *heart* is according to *Harvey*, they are emptied and fall, but when by its contraction it strikes the breast, they are filled and swelled. From these things it manifestly appears, that it is to be concluded, that at that time when it strikes the breast it moves it self by contraction, it thrusts out

out the blood into the *arteries*, and is in its *Systole*; but when it desists from this action, and is at rest, it is fill'd with blood and extended, the cavities are made larger, the sides made thinner, that all of it in its bulk, and according to all its dimensions, is augmented, and is in its *Diastole* far otherwise then the most famous man thinks.

If the blood were retained, and a great bulk in the right ventricle, the time he had of the heart, Nature ought to have given a greater orifice to the pulmonary artery, which might be wide enough for the passage of the blood; the very quantity which entered in the *Diastole*, ought to

come out in the following *Systole*. The bulk of which, if it be augmented, it should need a greater outlet, according to the augmentation of the blood; no less then we see the hole of the pump cavity which it is joined to the ventricle, answers to the signals of the part which is below the heart.

F I N I S.

Moreover it is certain, that according to the cavity his own condition, the cavity have a contrary motion to the heart, and do lag when it is relaxed, and indeed at that time when the *Diastole* of the heart is according to

the heart, they are constricted and fall, but when by its contraction it takes the breath, they are filled and swelled. From these things it manifestly appears, that it is to be concluded, that at that time when it takes the breath it moves itself by contraction, it thrusts out

TWO

ANATOMICAL EXERCITATIONS

Concerning the

CIRCULATION OF THE

BLOOD.

TO

John Riolan the Son, the most experienced Physician in the University of *Paris*, the Prince of Dissectors of Bodies, and the Kings Professor and Dean of Anatomie, and the knowledge of Simples; Chief Physician to the Queen-Mother of *Lewis XIII.*

The Author,

WILLIAM HARVET, an *Englishman*, Professor of Anatomie and Chirurgery in the Colledge of Physicians at *LONDON*, and Doctor of Physick to the Kings most excellent Majesty.

LONDON, Printed 1673.

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The Author,

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Professor of Anatomy and Chirurgery in
the College of Physicians at LONDON,
and Doctor of Physick to the Kings most ex-
cellent Majesty.

LONDON Printed 1653.



The First

ANATOMICAL EXERCITATION

Concerning

The Circulation of the Blood,

TO

JOHN RIOLAN.



Here did come forth not many moneths agoe a little piece of the most famous *Riolan's* concerning Anatomie and Diseases; for which, as being sent to me by the Au-

thor himself, I returned hearty thanks: Seriously I do congratulate the felicity of that man undertaking a thing very commendable. To open to the view the seats of all Diseases, is a work not to be atchieved but by a divine wit; Truly he undertook a hard task, that has set these Diseases, which are almost obscure to our understanding, before our eyes.

Such endeavours become the Prince of Anatomists; for there is no Science which has not its beginning from foregoing knowledge, nor any knowledge which is not beholding to sense for its original: for which cause the business it

it self, and the example of so worthy a person
 required my pains, and did invite me in li
 manner to put forth and joyn my medicin
 Anatomie, being chiefly fitted for Physicall use
 not with the same intention as he, by demon
 strating the places of Diseases, from the dead
 bodies of healthful men, and rehearsing th
 divers sorts of diseases incident to those place
 according to other mens opinions which I
 ought to have seen there; but that I might
 undertake to relate from the many dissection
 of sick bodies, and the most grievous and wou
 derful diseases of dead persons, in what man
 ner, and how the inward parts of them are
 changed, in place, bigness, condition, figure
 substance, and other sensible accidents, from
 their natural form and appearance, which all
 Anatomists commonly described, and how di
 versly and wonderfully they are affected. For
 as the dissection of healthful and well habi
 ted bodies conduces much to Philosophie and
 right Physiologie, so the inspection of diseased
 bodies conduces chiefly to Pathological Philo
 sophie. For the Physiological contemplation
 of these things which are according to Na
 ture, is first to be known by the Physician;
 for that which is according to Nature is right,
 and is rule both to it self and that which is
 amiss; by the light of which, errors and pre
 ternatural diseases being defined, Pathologie
 is more clear, and from Pathologie the use and
 art of administering Physick, and occasions of
 inventing many new remedies do occur. Nor
 will any man believe how much in diseases, es
 pecially

pecially such as are Chronical, the inwards are changed, and what monstrous shapes of the inward parts are begotten by diseases; And I dare say the opening and dissection of one consumptive person, or of a body spent with some violent or venemous disease, has more enriched the knowledge of Physick, then the dissections of ten bodies of men that have been hanged.

Yet do not I disallow of the most famous and learned Anatomist *Riolan* his purpose, but think it highly to be commended, as being very profitable for Physick, that he does illustrate the Physiological part; yet did I think that it would not be less profitable to the art of Physick, if I should set clearly before our eyes to be seen, not only the places, but likewise the diseases of those places, and rehearse them, after I had well viewed and observed them, and from my many dissections declare my experience.

But such things in that Book concerning the Circulation of the blood found out by me, which are translated, and seem to reflect only upon me, must first and chiefly be taken into consideration by me. For so great a mans judgment, concerning such a weighty business, is not to be set at nought (who is undoubtedly thought the chief, and ringleader of all Anatomists of this age) but the opinion of him alone, more to be weighed for commendation, then the verdicts of all others, which shall either applaud or contradict me, and his censure more to be weighed and looked upon. He then in *lib. 3. cap. 8. Enchir.* Acknowledges our

R

motion

motion of the blood in Animals, and ta
with us, and is of our opinion, as con
the circulation of the blood : yet not
ther, and openly ; for he says, *lib. 2. cap.*
That the blood in the port vein containe
mits no circulation, as the blood in the *vena ca*
va, and in *lib. 3. cap. 8*. That there is blood
which is circulated, and circulatory vessels, to
wit, the *aorta* and the *vena cava*, yet he denie
that the branches of them have any circulation
Because, says he, the blood running out into all th
parts of the second and third region, stays ther
for nutrition, nor does it flow back to the greater
vessels, but being plucked back by force, when th
greater vessels are in great want of blood, or when
it returns with a sudden force, or exstimulation
to the greater circulatory vessels. And so a little
after : Whether or no the blood of the veins, does
perpetually or naturally ascend ? or whether it re
turns to the Heart ? or whether the blood of th
Arteries do descend, or go from the Heart ? yet if
the lesser veins of the arms and legs be empty, the
blood of the veins in succession filling the empty pla
ces, may descend, which (says he) I have clearly
demonstrated against Harvey and Wallæus. And
because daily experience and the authority of
Galen does confirm the *Anastomosis* of the veins
and arteries, and the necessity of the Circulati
on of the blood ; You see, says he, how the cir
culation of the blood comes about, without the
confusion of humours, or the perturbation of anci
ent medicine.

By which words it is known, for what cause
the most famous man would partly acknowledg

partly

the Circulation of the Blood.

III

partly deny the Circulation of the blood, and why he endeavours to build a reeling and tottering opinion of Circulation. Lest, forsooth, he should destroy the ancient Physick, and not moved by truth, which he could not chuse but see, but rather for fear he should violate the ancient rules of Physick, or perchance, lest he should seem to resume or retract that Physiologie which in his *Anthropologia* he had published before. For the Circulation of the blood does not destroy the ancient Physick, but furthers it; rather it shews the Physiologie of Physicians, and the speculation of natural things, and disallows the Anatomical doctrine of the use and action of the *heart, lungs*, and the rest of the intrals; and that these things are so, will appear partly out of his own words, partly out of those things which I shall here set down; namely, that the whole blood, in whatsoever part of the body living it be, does move and shift place (as well that which is in the greater *veins*, and their *branches* and *fibers*, as that in the porosities of the parts in any region of the body) does flow to the *heart*, and flow from the *heart*, without interruption, incessantly, and never continues in one place without damage; though I do not say, but in some places it moves slower, in some faster.

First then, the most learned man denies only that the blood contained in the *Porta* does circulate, which he could neither have denied nor disapproved of, if he had not passed over the force of his own argument: for he says *lib. 3. cap. 8. If in every pulsation the heart receive one*

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drop

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drop of blood, which it expels into the aorta, and does make two thousand pulsations in an hour, there must needs a great deal of blood pass through.

He is likewise forced to affirm the same of the *mesenterie*, since through the *caliacal arterie*, there is thrust in more then one drop of blood at every pulsation, and is forced against the *mesenterie* and its *veins*: insomuch that it must either go out according to the just proportion of that which enters, otherwise the branches of the *Porta* would burst at last; nor can it (for the resolution of this doubt) be probably said, or possibly be, that the blood of the *mesenterie* should vainly, and to no purpose, ebb and flow through these *arteries*, like an *Euripus*; nor the relapse from the *mesenterie* by those passages and transplantation by which he would have the *mesenterie* disgorge it self into the *aorta*, likely to be true; nor can it prevail against that which is entring by contrary motion; nor can there be any vicissitude, where it is most certain that without interruption, and incessantly, there is an influx; but is compelled by the same necessity, by which it is certain, that the *heart* doth thrust forth the blood against the *mesenterium*. Which is most manifest; for otherwise, by the same argument, they would overthrow all Circulation of the blood, if thus he should, with the same likelihood of truth, affirm that two in the *ventricles* of the *heart*, namely in the *Systole* of the *heart* the blood is driven into the *aorta*, and in the *Diastole* returns, and the *aorta*, disburthens it self into the *ventricles* of the *heart*, as the *ventricles*

tricles again into the *aorta*, and so neither in the *heart* nor in the *mesenterie* should there be any circulation, but a flux and reflux, by turns, is turned up and down with needless labour: Therefore if of necessity in the *heart* is proved the circulation of the blood, for the reason aforesaid proved by himself, the same force of argument takes place likewise in the *mesenterie*; but if there be no circulation in the *mesenterie*, neither is there in the *heart*; for both these assertions, namely, this of the *heart*, that of the *mesenterie*, hangs upon the force of the same argument, only changing the words, and is established, and falls in like manner.

He says, that the Sigma-like *portals* do hinder the regress of the blood in the *heart*, but there are no *portals* in the *mesenterie*.

I answer, neither is this true; for in the *spleenick* branch, as likewise sometimes in others, there are found *portals*. Besides, *portals* are not all times requisite in the more profound *veins*, nor are they found in the deep *veins* of the joints, but rather in the skin *veins*; for where the blood flowing out of the less branches is prone naturally to come into the greater, by the compression of the *muscles* about it, it is sufficiently hindered from return, but where the passage being open, it is forced; What needs is there then of *portals*? But how much blood at every pulsation is forced into the *mesenterie*, is reckoned according to the same account, as if with an indifferent *ligature* you should in the *carpus* bind the *veins* coming out of the hand, and entering into the *arteries*; (for

the *arteries* of the *mesenterie* are greater then those of the *carpus*) if you tell at how many pulsations the vessel and your whole hand swell to their greatest bigness, dividing and making a subduction, you shall find much more then one drop of blood come in at every pulsation, notwithstanding the *ligature*; nor can it return, but rather that in filling the hand it forcibly distends and swells it, we may by calculation gather, that the blood enters the *mesenterie* in the same quantity, if not in a greater, by how much the *arteries* of the *mesenterie* are greater then those of the *carpus*. And if any should but see and think with himself, with what difficulty and pains, compressions, *ligatures*, and several means the blood is stayed, that leaps forcibly out of the least *arterie* which is cut or broken, with what strength (as if it were shot out of a spout) it throws off, and drives away, or passes through all the bindings, I think he would scarce believe that any part of blood which only enters, could against this impulsion and influx pass back again, being not able to drive it back with force. For which cause, considering these things with himself, I believe it would not ever enter his mind to imagin that the blood out of the *veins* of the *porta* could creep back by these same ways, and so disburthen it self into the *Mesenterie*, against so forcible and strong an influx into the *arteries*.

Moreover, if the most learned man believe not that the blood is moved and changed by circular motion but being still the same, it stands and mantles in the branches of the *mesenterie*; he

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he seems to suppose, that there is a two-fold blood, divers, and serving to divers uses and ends, and therefore it is of divers natures in the *vena porta* and *cava*, because one of them for its preservation needs circulation, the other needs not, which neither does it appear, nor does he demonstrate it to be true.

Besides, the most learned man adds in his *Enchirid.* lib. 2. cap. 18. *A fourth sort of vessels to the Mesenterie, which are called the Vena Lactæe (invented by Asselius) which being set down, he seems to infer that all the nutriment being drawn through them is carried to the liver, the forge of blood, which being there concocted and changed into blood, (he says in lib. 3. cap. 8.) it is carried in the left ventricle of the heart, which being granted, says he, all the scruples which were antiently motioned concerning the distribution of the Chylus, and of the blood through the same conduit, do cease, for the Vena Lactæe carry the Chylus to the Liver, and therefore these conduits are apart, and can be obstructed apart. But indeed I would fain know how this can be demonstrated to be true; If this milk be transfused and passed into the liver, how shall it get thence through the cava into the ventricle of the heart? (Since the most learned man denies that the blood contained in the numerous branches of the porta and the liver can pass, that so circulation may be made) but more especially since the blood seems to be a great deal fuller of spirit, and more penetrative then the milk or Chylus, which is contained in these vessels, and is hitherto impelled by the arteries that it*

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may find out some way for its self.

The most learned man makes mention of a certain Treatise of his concerning the Circulation of the blood, I wish I could see it, I might perchance recant.

But if the most learned man thought it more fit to place the circular motion of the blood in the *veins* of the *porta*, and branches of the *cava*, (as he says in his 3. Book Chap. 8.) *In the veins the blood does perpetually and naturally ascend or return to the heart, as likewise that which is in all the arteries descends and departs from the heart.* I say, I do not see, but upon this position, all difficulties which were objected of old of the distribution of the *Chylus*, and blood, through these same conduits, should likewise cease, that henceforward he should not need to enquire apart for, or to set down vessels for the *chylus*; seeing as the *Umbilical veins* do draw their nutritive juice from the liquors of the egg and carries it to the nourishing and augmentation of the Chick whilst it is yet an *Embryon*, so do the *meseraick veins* suck the *chylus* from the *intestines*, and carry it to the *liver*, and what hinders us to assert, that it does the like in those of riper age? for all difficulties cease, when there are not two contrary motions supposed in the same vessels; but that we do suppose that there is one continued motion in the *meseraicks* from the *intestines* to the *Liver*

I shall tell you in another place what is to be thought of the *venæ Lactææ*, when I shall speak of milk found in several parts of creatures new born,

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born, especially in mankind, for it is found in the *mesenterie* and all its *glandules*, as also in the *chymus*, likewise in the arm pits and paps of Children; the Midwives milk out the blood for their health as they believe.

But moreover it pleased the most learned *Riolan*, not only to deprive the blood contained in the *mesenterie* of circulation, but also he affirms, that neither the branches of the *vena cava*, or its *arterie*, or any part of the second or third region admits of circulation, so that only he calls the *vena cava* & the *aorta* circulatory vessels, for which in his 3 Book Chap. 8. he gives a very faint reason, *Because the blood, says he, flowing into all parts of the second and third region remains there for nourishment, nor does it flow back to the greater vessels, unless it be revulsed by the force and want of blood in the greater vessels, or flow back, being stirred with a sudden force, to the circulatory vessels.*

It is indeed of necessity, that the portion which passes into nourishment, should remain, for otherwise it should not nourish unless it be assimilated, and stay there, in lieu of that which is lost, and so become one: but it is not needful, that the whole influx of blood should remain there for the conversion of so little a portion; for every part does not use so much blood for its nourishment, as it contains in its *veins*, *arteries*, and *porosities*, nor is it necessary in his afflux and reflux that it should leave no nourishment within it; wherefore it is not necessary that for nutrition it should all stay, but likewise the most learned man himself, in the very
same

same book in which he affirms this, does seem every where almost to affirm the contrary, especially where he sets down the circulation in the brain, and by circulation (says he) the brain does send back blood to the *heart*, and so the *heart* is refrigerated. After which sort likewise, the remote parts may be said to refrigerate the *heart*, whence also in feavers, when the parts about the *heart* are grievously scorched and inflamed with feaverish heat, laying naked their joynts, and throwing off the cloaths, sick people endeavour to cool their *heart*, whilst (as the most learned man affirms of the brain) the blood being refrigerated and allayed of its heat, does then go to the *heart* through the *veins*, and does refrigerate it. Whence the most learned man seems to insinuate a kind of necessity, that as from the brains, so there is a circulation from all the parts, otherwise then before he had openly declared. But indeed he cautiously and ambiguously affirms, That the blood does not flow back from the parts of the second and third region, unless, says he, being revuls'd by the force and great want of blood in the bigger vessels, or that it does by a sudden forcible motion flow back to the greater circulatory vessels, which is most true, if these words be understood in a true sense; for by the greater vessels, in which, he says, want causes a reflux. I believe he understands the *vena cava*, or the circulatory *veins*, not the *arteries*; for the *arteries* are never emptied but into the *veins* or *pores* of the parts, but they are continuall stuffed full by the pulse of the *heart*. If all the parts did

did not incessantly refund blood in abundance into the *vena cava*, and the circulatory vessels, out of which the blood very suddenly passes, and hastens to the *heart*, there would quickly be a great want of blood. Besides that, the blood which is contained in all the parts of the second and third region, by the force of the blood directed and driven by every pulse, is forced out of the pores into the *veins*, out of the branches into the greater vessels, as likewise by the motion and compression of the parts adjacent; for that which is contained is thrust out by every thing containing it, when it is pressed and streightned: so by the motion of the *muscles* and the joynts, and the branches of the *veins* passing between being pressed and streightned, thrust the blood contained in the lesser vessels into the greater.

But it is not to be doubted, that the blood continually and incessantly driven, and comes with force from the *arteries*, and never flows back; if it be admitted, that in every pulse all the *arteries* together are distended by the propulsion of blood, and that the *Diastole* of the *arteries*, as the most learned man confesses, is from the *Systole* of the *heart*; nor does the blood once gone forth, return into the *ventricles* of the *heart*, by reason that the *portals* are shut, if I say the most learned man does believe these things, as it seems he does, it will easily be understood in every part of what region soever; by what stuffing or impulsion the blood in them contained is forcibly thrust down.

For so far as the *arteries* beat, so far reaches the

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the influx and the force, wherefore it is felt in all parts of every region, for there is a pulse every where in the tops of our fingers, and under the nailes, nor is there any part in our whole body, either sore with boyl or fellon, which does not feel the pricking motion of the beating of the *arterie*, and its endeavour to dissolve the *continuum*.

But further, it is manifest, that the blood does make a regress in the pores of the parts in the skin of the hands and feet, for sometime in great frost and cold seasons we see the hands and joints, especially of boys, so cold, that at the very touch they do almost resemble the coldness of Ice, and are so benumbed and stiff, that there is scarce any life in them, nor motion and yet in the mean time they are full of blood seeming red or blew, which parts can again by no means be warmed, unless by Circulation that refrigerate blood be thrust out, and in its place new, warm and spirituous blood flowing in do foment and re-warm the parts, and restore to them motion and sense; for they should never be renewed or restored by external heat, no more then the members of dead persons, unless some internal influent warmth did refresh them. This indeed is the chief use and end of the Circulation of the blood, for which cause, the blood by its continual course, and perpetual influence, is driven about; namely, that all the parts depending upon it by their first innate warm moisture might be retained in life, and in their own vital and vegetative essence, and perform all their functions, whilst (as the Naturalists say) they

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They are sustained and actuated by natural heat, and vital spirits; so by the heat of two extremities, heat and colds the temper of the bodies of creatures is kept in its mediocrity: for as the breathing in of air does temper the too much heat of the blood in the lungs, and in the centre of the body, and causes the eventilation of suffocating fumes; so also the blood being hot, and cast out through the arteries into the whole body, does foment and nourish the extremities in living creatures, and hinders them to be extinguished by the force of outward cold.

Therefore it were unjust and wonderful, if very little part of what region soever should not enjoy the benefit of the transmutation and circulation of the blood, for whose sake Circulation seems chiefly to be appointed by Nature. Therefore, that I may conclude, for you see how the Circulation of the blood is performed without perturbation or confusion of the humours in all the body, and in every part, both in the greater and in the lesser vessels, and that by necessity, and for the benefit of all the parts, without which, being cold and impotent, they could never be restored, or remain alive. It is enough, because its clear, that all influence of preservative heat does come through the arteries, and is done by circulation.

For which cause most learned *Riolan* seems to me, when he says, that in some parts there is no Circulation, to speak rather officiously, then truth; to wit, that he might please most men, and oppose no body, and that he rather wrote

wrote humanly, then gravely, in the behalf of the truth. As he likewise seems to do (*lib. 3. cap. 8.*) when he would rather have the blood to come into the *left ventricle* through the *septum* of the *heart*, through uncertain and hidden passages, then through the large and most open vessels of the *lungs*, being made with *Portals* artificially to hinder its return. I desire to see the reason of the impossibility and inconvenience which he says he propounded elsewhere. It is a wonder, since the *aorta* and *vena Arteriosa*, are of the same bigness, constitution, and frame, that their function should not be the same. But that is very improbable that the great River of the whole mass of blood should in so great abundance go into the *left ventricle* by so blind and small a winding of the *septum*, which should answer both to the entrance from the *vena cava* in the right side of the *heart*, and also its egress from the left, which do both require such wide orifices. But he has likewise produced these things staggeringly, for in *lib. 3. ca. 6.* he ordains the *lungs* as a sink or passage from the *heart*, and he says, *The lungs are affected by that blood which passes through, whilst its filth flows together with that blood*; so he says likewise, *That the lungs acquire corruption by distempered, and ill-conditioned intrals, which furnish that heart with impure blood, whose fault the heart cannot help, but by many circulations.* He likewise in the same place, concerning letting of blood, and shortness of breath, and communication of the *veins* with the vessels of the *lungs*, says against *Galen*, *If it be true that*

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the blood does naturally pass from the right ventricle of the heart to the lungs, that it may be carried to the left ventricle, and so to the aorta; and if the Circulation of the blood be admitted, who sees not in the diseases of the lungs, that the blood flows thither in greater abundance, and oppresses the lungs, unless they be first largely emptied, every part taking a share to ease them; which was Hippocrates advice from all parts of the body, head, nose, tongue, armes, feet, to take away the blood, that the quantity of it might be impaired, and that it might be revulsed from the lungs, and so draws out the blood till the body was quite without blood. He says likewise, The Circulation being supposed, the lungs are easily emptied by breathing a vein. If this counsel be rejected, I see not how it can be revulsed from thence; for if it flow back through the vena arteriosa into the right ventricle, the Sigmoidal portals hinder it, and the bree-pointed portals hinder the regrefs out of the right ventricle into the vena cava. Therefore by Circulation the blood will be exhausted, by cutting the veins of the armes and feet. And likewise Ferrius his opinion in the affections of the lungs destroyed, that blood is rather to be taken out of the right arm then out of the left, for the blood cannot return into the vena cava, unless it break through two gates and bars which are placed in the heart.

He addes moreover in the same place, (lib. 3. cap. 6.) If the Circulation of the blood be admitted, and that it doth pass often through the lungs, and not through the middle of the Septum of the heart, there is a two-fold Circulation of the

the blood to be assigned, one of which is perfected by the heart and the lungs, whilst the blood leaping out from the right ventricle of the heart is carried through the lungs, that it may come to the left ventricle of the heart; for leaping out from the same inward part, it returns to it, then by another larger circulation flowing out of the left ventricle of the heart, it goes about the whole body, and runs through the arteries and veins to the right ventricle of the heart.

The most learned man in this place might have added the third circulation, which is a very short one, out of the left ventricle into the right, drawing about a part of the blood through the coronal arteries and veins, by its branches, which are distributed about the bodie, walls, and septum of the heart.

He says, *He that admits of one circulation, cannot deny the other.* So might he have added, nor can he refuse the third. For to what purpose should the coronal arteries beat in the heart, if they did not drive blood thither? and why should the veins, (whose function and end it is to receive blood put into them by the arteries) but that they might draw blood from the heart? Moreover, in the orifice of the Coronal arterie' as the learned man himself confesses, in his third Book and his ninth Chapter, there is a portal which forbids all entrance, and is patent to egress: therefore truly he cannot but admit of the third Circulation, who likewise admits of another universal one, and that the blood does likewise pass through the lungs and the brain, (*lib. 4. cap. 2.*) For neither can there be

be an admittance of blood by pulsation, in all parts of every region, nor regrefs by the *veins* after the same manner, and therefore he cannot deny, but that the parts admit of Circulation.

Therefore it is clear from these very words of the most learned man, what his opinion is, both of the circulation of the blood through the whole body, as likewise through the *lungs*, and the rest of the parts; for he that admits of the first circulation, it is clear that he does not reject the other: For how can it be, that he who has admitted of another circulation through the whole Body so often, and through the greater circulatory vessels, should deny that universal Circulation in any of the branches or parts of the second or third region? As if all the *veins*, and those greater circulatory vessels, as he calls them, were not number'd by himself, and by all others, amongst the vessels of the second region. Is it possible that there should be circulation through the whole body, and not through all the parts? and therefore where he denies it, he does it very stammeringly, and only staggers and palliates in his negations: there where he affirms, he speaks understandingly, and as becomes a Philosopher, and as a skilful Physician and an honest man, gives his advice in this case, that in the dangerous diseases of the *lungs*, the letting of blood is the only remedy, against *Galen* and his beloved *Fernelius*: in which thing, if he had been doubtful, far be it from a Christian, and so learned a man, to recommend his experiments to posterity, to procure death, and the hazzard of mens lives; or that he should recede from *Fernelius* or *Galen*, men in high esteem with him. Therefore whatsoever he

has denied of the Circulation in the *mesenterie*, or any other part, in favor of the ancient Doctrine of Physick, or the *Vena Laëtea* or for any other regard, it is to be attributed to his civility and modesty, and to be pardoned.

I think it does already appear clearly enough, both from the words and the arguments of the most learned man himself, that there is a circulation every where, and that blood wheresoever it is, does change place, and pass through the *veins* to the *heart*; and the most learned man seems to be of the same opinion with me: Therefore it needs not, yea it were superfluous to bring hither my arguments which I have published in my Book concerning the motion of the blood, for the further confirmation of this truth, which are taken both from the frame of the vessels, placing of the *portals*, and other experiments and observations; especially since I have not as yet seen the most learned mans Treatise of the Circulation of the blood, nor as yet any of the most learned mans Arguments, but only a bare negation, by which being induced, he should reject the circulation in the regions and vessels, which he allows to be universal in most of the parts.

It is indeed true, that I did find out of the authority of *Galen*, and by dayly experience to be a *refugium* the *Anastomosis* of the vessels, yet so great a man as he is, so diligent, so curious, so expert an Anatomist, should first have laid open and shewn *Anastomoses*, and those visible and open ones and whirlpools proportionable to the impetuous stream of the whole blood, and the orifices of the branches, (from which he has taken away circulation) before he had rejected those which were

ere most probable and most open. He was ob-
d to demonstrate and declare where they are,
w they are fram'd, whether they are not only
for the intromission of blood (as we see the ar-
ies inserted in the bladder) and not for the re-
n of it, or what other way soever they have
en. But perchance I speak too boldly, for nei-
er the learned man, nor *Galen* himself, could
any experience ever behold the sensible *Ano-*
moses, or ever could demonstrate them to the
se.

did look after them with all possible diligence,
d was not at a little charge and pains in the
rch of the *Anastomoses*; yet could I never find
at any vessel, namely the *arteries*, together with
e *veins*, were joyn'd by their *artifices*: I should
llingly learn from others who ascribe so much
Galen, that they dare swear all that he says.
or is there any *Anastomosis* in the *liver*, *milt*,
igs, *reins*, or any other of the intrals, although
id boyl them till the whole *Parenchyme* was
ide mouldring, and like dust was shaken off,
d taken away with the point of a needle,
om all the *fibers* of the vessels, so that I could
e the *fibers*, and the last graines of every
vision. I dare therefore boldly affirm, that
ither the *vena porta* has any *Anastomoses* with
e *cava*, nor the *veins* with the *arteries*, or the
illar branches of the pore of the *choller-bagg*,
hich are dispers'd about all the flat of the *liver*
th the *veins*. Only this you may observe in a
sh *liver*, that all the branches of the *vena cava*
hich creep through the whole bunch of the
er, have *tunicles* pierc'd with many holes, like
ieve, as it is in a cinque, fram'd so for the re-

ceiving of the blood which falls down. The branches of the *Porta* are not so, but are divided into stems, and how that both the divisions of these vessels, the one in the flat, the other in the gibbous part, do run round to the very further rising of that intral without any *Anastomoses*.

Only in three places do I find that which is equivalent to an *Anastomosis*. There rises in the brain, from the soporal arteries creeping down into the *Basis*, many and unintangled fibers, which afterwards make up the *plexus chorois*, and passing through the *ventricles* do at last end in the third receptacle, which performs the office of vein. In the *spermatical* vessels, commonly call'd preparatory, little arteries drawn from the great artery do adhere to the veins preparatory aforesaid which they accompany, and at last are so received within their *Tunicle*, so that at the first they seem both to have one and the same; so that when they end at the upper part of the *testicles* where that part passeth forth into a point, which is called the varicous and vine-like body, we know not what to call them, *veins* or *arteries*, or the ends of both. As likewise the last appearance of the *arteries*, which go to the *Umbilical vein* are obliterated in the *Tunics* of that vein.

What doubt is to be made, if through such gulphes, the little branches of the *arteria magna* swollen with the impulsion and instuffing of blood could be eas'd of so great and so conspicuous stream? Nature at least would never have denied us visible and sensible passages, cinques and whirlpools, if she had had intention to have turned all the flux of the blood thither, and by that mean have deprived the lesser branches, and the solid part

parts of the benefit of the influx of blood.

Lastly, I will set down one experiment, which seems to be sufficient for the clearing of the Anomoses, and for the overthrowing of their use, and of the passage of the blood, and return of it out of the *veins* into the *arteries* by those ways.

Opening the breast of any creature, and tying the *vena cava* by the *heart*, so that nothing can pass that way into the *heart*, and presently cutting the *jugular arteries*, not touching the *veins* on neither side. If by giving vent you see the *arteries* emptied, and not the *veins* too, I hope it will be clear that the blood is carried out of the *veins* into the *arteries*, no where but through the *ventricles* of the *heart*: Otherwise (as *Galen* has observ'd) in a little space we should see the *veins* emptied, and destitute of blood by the efflux of the *arteries*.

In what remains, *Riolan*, I both congratulate my self and you; my self for your opinion with which you have adorn'd my Circulation; as likewise I return to you exceeding thanks for your learned, neat, succinct Piece which you sent to me, than which there is nothing more elegant; and I both owe and desire to return deserv'd commendation, but I confess I am not able for such a charge: For I know the name of *Riolan* will afford more praise to me in its subscription, than my praises, which I wish as great as may be, can do to his *Enchiridion*. The famous Book shall out-live all memory, and shall recommend your worth to Posterity, when all Monuments shall perish. To it you have very handsomly adjoyn'd the Anatomy of Diseases, and have very profitably enrich'd it with a new Treatise concerning

the Bones. May you, most worthy Man, continually increase in this your worth, and love me who wish that you may be both happy and long liv'd, and that your most famous writings may be an eternal Commendation to you.

William Harvey

ANOTHER
EXERCITATION
TO
JOHN RIOLAN;

In which many objections against the Circulation of the Blood are refuted.

MOST learned Riolan, by the help of the Press, many years ago, I published a part of my labour: But since the Birth-day of the Circulation of the Blood, almost no day has past, nor the least space of time, in which I have not heard both good and evil of the Circulation of the Blood which I found out: Others rail at it, as a tender baby unworthy to come to light; others say, that it is worthy to be foster'd, and favour my writings, and defend them; some with great disdain oppose them; some with mighty applause protect them; others say, that I have abundantly, by many experiments, observations, and ocular testimony, confirm'd the Circulation of the blood, against

against all strength and force of argument; others think it not yet sufficiently illustrated, and vindicated from objections: But there are who cry out, that I have affected a vain commendation in diffraction of living creatures, and do with childish slighting dispraise and deride at Frogs and Serpents, Gnats, and other more inconsiderable creatures brought upon the Stage, and refrain not from ill language. But I think it a thing unworthy of a Philosopher, and a searcher of the truth, to return bad words for bad words; and I think I shall do better and more advised, if with the light of true and evident observations, I shall wipe away those symptoms of incivility.

It cannot be eschewed but dogs will bark, and belch up their surfeits; nor can it be help'd, but that the Cynicks will be amongst the number of the Philosophers; but we must take a special care that they do not bite, nor infect us with their cruel madness, or lest they should with their dogs teeth gnaw the very bones or principles of truth.

Detractors, Momes, and Writers staid with railing, as I never intended to read any of them (from whom nothing of solidity, nor any thing extraordinary is to be hop'd for, but bad words) so did I much less think them worthy of an answer: Let them enjoy their own cursed nature, I believe they will find but a few favourable Readers; neither does God give wisdom to the wicked, which is the most excellent gift, and most to be sought for. Let them rail on still, till they be weary (if not asham'd) of it.

If you will enter with *Heraclitus* in *Aristotle* into a work-house (for so I call it) for inspection

of viler creatures, come hither, for the immortal gods are here likewise; and the great and Almighty Father is sometimes most conspicuous in the least and most inconsiderable creatures.

In my Book concerning the motion of the *heart* and blood in creatures, I only chose out those things out of my many other observations, by which I either thought that errors were confuted, or truth was confirm'd; I left out many things as unnecessary and unprofitable, which notwithstanding are discernable by dissection and sense; of which I shall now add some in few words, in favour of those that desire to learn. The great authority of *Galen* is of so much account with every body, that I see many make a difficulty, as concerning that experiment of *Galen* of the *ligature* of the *artery* above the pipe, thrust within the concavity of the *artery*; by which it is demonstrated, that the pulse of the *artery* comes from the faculty pulsifick, and that it is transmitted from the *heart* by the *tunics*, and not by the impulsion of the blood within the Concavities; and therefore that the *arteries* are stretch'd as bellows, not as bags.

This experiment is mentioned by *Vesalius*, a man very skilful in Anatomy; but neither *Galen* nor *Vesalius* says, that they tried this experiment, which I did; only *Vesalius* prescribes it, and *Galen* counsels it to those that are desirous to find out the truth, not thinking, nor knowing the difficulty of that business, nor the vanity of it when it is done, since although it be perform'd with all manner of diligence, it makes nothing to the confirmation of that opinion, which affirms, That the *tunics* are the cause of pulsation, but rather

rather shews, That it is set a-work by the impulsion of the blood. For so soon as above the reed, or pipe, you have with a band tied the *artery*, the *artery* above the *ligature* is presently dilated by the impulsion of the blood beyond the mouth of the pipe, from whence both the flux is stop'd, and the impulsion reverberated, so that the *artery* under the band does beat with very little appearance, because the force of the passage of the blood does no way assist it, because it is return'd above the *ligature*; but if the *artery* be cut off below the pipe, you shall see the contrary, from the leaping of the blood which is thrown out, and driven through the pipe, as in an Aneurism I have observ'd to come from the exesion of the *tunicles* of the *artery*, this (whilst the blood is contain'd within the membranes) hath a contentive vessel of its flux prænaturally made, not of the dilated *tunicles* of the *artery*, but of the circumposition of the membrane and flesh. You shall see the inferiour *arteries* beyond this Aneurism beat very weakly, whilst above, and especially in the Aneurism it self, the pulsations appear great and vehement, although we cannot there imagine, that the impulse or dilation is made by the *tunicles* of the *artery*, or by communication of the faculty of the *Cyst*, but mecrly by the impulsion of the blood.

But that the error of *Vesalius*, and the small experience of others, may the more clearly appear, who affirm (as they imagine) that the part under the pipe does not beat when the band is tied. I speak by experience, if you make the experiment rightly, that it will; and whereas they say, that upon the untying the band, the *arteries*
below

below do beat backwards; I say, that the part below beats less when you have untied it, then when it is tied.

But the effusion of blood which leaps out of the wound confuses all, and makes the experiment vain, and to no purpose, so that there can be no certainty demonstrated, as I said, by reason of the blood. But if (and this I know by experience) you lay open the *artery*, and hold with your finger close that part which you cut, you may at your pleasure try many things which will evidently make the truth appear to you. First, you shall feel the blood, being forc'd, coming down into the *artery*, by which you shall see the *artery* dilated; as likewise you may squeez out and let go the blood as you please: If you open a little part of the *orifice*, and look narrowly to it, you shall see the blood at every pulse to be thrown out with a leaping, and as we said in the opening of an *artery*, or in the *perforation* of the *heart*, you shall see the blood to be thrown out in every contraction of the *heart*, in the dilatation of the *artery*.

But if you suffer it to flow with a constant and continual flux, and give it leave to break out, either through the pipe, or by the open *orifice*, in the streaming of it, both by your sight and by your touch, you shall find all the strokes, order, vehemency, and intermission of the *heart*; just as you might feel in the pulse of your hand water squirted through a syringe at divers and several shootings, so you may perceive, both by your sight and by its motion, the blood leaping out with a varying and unequal force. I have seen it sometimes in the cutting of the *jugular artery*
break

break out with such force, that the blood being forc'd against the hand, did by its reverberation and refraction, fly back four or five foot.

But that this doubt may be more clear, that the pulsifick force does not flow through the *Tunicles* of the *arteries* from the *heart*, I have a little piece of the *artery* descendant, together with two crural branches of it, about the length of a span, taken out of the body of a very worthy Gentleman, which turn'd to be a bone like a pipe, by the hollow of which, whilst this worthy Gentleman was alive, the blood in its descent to the feet did agitate the *arteries* by its compulsion; in which case nevertheless, although the *artery* were in the same condition, as if it had been bound or tied above the little conduit-pipe, according to the experiment of *Galen*, that it could not be dilated in that place, or streightned like a pair of bellows, nor from the *heart* derive its pulsifick force to the inferiour or lesser *arteries*, nor yet carry through the solid substance of the bones that faculty which it had not receiv'd; yet I very well remember, that I often observ'd, whilst he was alive, that the pulse of the inferiour *artery* did move in his legs and feet: wherefore it must needs follow, that in that worthy Gentleman, the inferiour *arteries* were dilated by the impulsion of the blood, like bags, and not like bellows, by the stretching of the *tunicles*. For there must needs arrive the same inconvenience, and interception of the pulsifick faculty, the *tunicle* of the *artery* being wholly converted into a conduit, or pipe of bone, as might arrive from the reed or pipe which was tied, that the *artery* might not beat.

I knew likewise in another worthy and gallant Gentleman, the *aorta*, and a part of the great *artery* near the *heart*, turn'd into a round bone. So *Galen's* experiment, or at least one answerable to it, being not found out by industry, was found out by chance, and does manifestly evidence, that the interception of the pulsifick faculty is not intercepted by the construction or *ligature* of the *tunics*, so that by that means the *arteries* cannot beat; and if the experiment which *Galen* prescribes, were rightly perform'd by any, it would refute the opinion which *Vesalius* thought from thence to have confirm'd. Yet for this cause we do not deny all motion to the *tunics* of the *arteries*, but do attribute that to it, which we grant to the *heart*; namely, that there is a *coarctation*, and a *Systole* in the *tunics* themselves, and from their distension a regrefs to their natural constitution. But if this is to be observ'd, that they are not dilated and streightned for the same cause, nor by the same instrument, but by several, as you may observe in the motion of all the parts, and in the *heart*; it is distended by the *ear*, contracted by it self, so the *arteries* are dilated by the *heart*, and fall of themselves.

So you may make another experiment after the same manner: If you fill two sawcers of the same measure, one of them with *arterial blood*, which leaps out, the other with *venal blood*, drawn out of a *vein* of the same Animal, you may presently by your sense, and afterwards too, when both the bloods are grown cold, observe what is the difference betwixt both the bloods, against those who do fancy another sort of blood in the *arteries* than is in the *veins*; namely, they do

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do ascribe to the *veins* a fresher sort of blood, I do not know which way boyling, or blown up, swelling or bubbling, (like to honey or milk upon the fire) and so taking up more room.

For if the blood which is driven out of the *left ventricle* into the *arteries* should be leaven'd, so as to be blown up, and foam after that manner, so that a drop or two should fill all the concavity of the *aorta*, no doubt it would when it fell again, return to the quantity of some few drops (which cause some do alledg for the emptiness of the *arteries* in dead men) and the same would be seen in the *cotyla* full of *arterial* blood; for so we find that it comes to pass in the cooling of milk or honey. But if in either *cotyla* the blood be found of the same colour, and congealed, of a not much different consistence, and squeezing out the whey after the same manner, and if it take up the same room, both when it is hot and when it is cold, I think it will be a sufficient argument to gain any mans belief, and to confute the dreams of some, that there is neither in the *left ventricle* any sort of blood differing from that of the *right*, (as you may find out both by sense and reason) for you must needs likewise affirm, that the *vena arteriosa* should equally be distended with one drop of blood foaming up, and therefore that there is just such bubbling and leaven'd blood in the *right* as in the *left*, seeing the entry of the *vena arteriosa*, and the egress of the *aorta*, is equipollent and equal.

Three things are chiefly ready to breed this opinion of the diversity of blood. One is, that in the cutting of an *artery*, they see brighter blood drawn out: Another is, that in the dissection of dead

dead bodies, they find both the *left ventricle* of the *heart*, and all the *arteries* so empty: A third is, that they imagine that the *arterial blood* is more spirituous, and more replete with Spirits; and therefore they think that it takes up more room; the cause and reasons of all which things why they come to be so, by inspection is perceiv'd.

First, insomuch as concerns the colour, always and every where blood coming through a narrow hole, is as it were strained and becomes thinner; and the lighter part of it, and which swims above, and is more penetrable, is thrust out: So in *Phlebotomy*, the blood which springs out with greater flux or force, and out of a greater *orifice*, and flies further, is always thicker, fuller, and darker colour'd; but if it flow out of a little and narrow hole, and by drops, (as it does out of a *vein*, when the *ligature* is untied) it is brighter, for it is strain'd as it were, and only the thinner part comes out, as in the bleeding at nose, or that which is extracted by Leaches, or Cupping glasses, or any way issuing by *diapedesis*, is always seen more bright; because the thickness and hardness of the *tunics* becomes more impassible, nor yields so pliable, as to give an open way for the coming out of the blood: And it likewise happens in fat bodies, when by the fat under the skin the *orifice* of the *vein* is stop'd, then the blood appears thinner, brighter, and as if it did flow from an *artery*. On the contrary, if you receive in a sawcer the blood, when you have cut an *artery*, if it flow freely, it shall appear like *venal* blood; there is blood much brighter in the Lungs, and squeez'd out from thence, than any is found in the *arteries*. The

The emptiness of the *arteries* in dead bodies (which did perchance cozen *Erasistratus*, inso-much that he thought that the *arteries* contain'd only aerial spirits) proceeds from hence, because that when the *lungs* fall (their passages being stop't) the *lungs* do breathe no longer, so that the blood cannot freely pass through them, yet the *heart* continues a while in its expulsion, whence both the *left ventricle* of the *heart* is more contracted, and the *arteries* likewise empty, and not fill'd by succession of blood, appear empty: But if the *heart* cease both at one time, and the *lungs* to give passage by respiration, as it is in those who are drowned in cold water, or in those who are taken suddenly with unexpected death, you shall find both the *veins* and the *arteries* full.

As concerning the third, of the Spirits, what they are, and of what consistence, and how they are in the body, whether they be apart and distinct from the solid parts, or mix'd with them, there are so many and so diverse opinions, that it is no wonder if Spirits, whose nature is left so doubtful, do serve for a common escape to ignorance: for commonly ignorant persons when they cannot give a reason for any thing, they say presently, that it is done by Spirits, and bring in Spirits as performers in all cases; and like as bad Poets, to bring in the gods upon the Scene by head and ears, to make the *Exit* and *Catastrophe* of their play.

Fernelius and others do imagine aerial Spirits, and invisible substances; for he proves that there are animal Spirits (just as *Erasistratus* proves them in the *arteries*) because there are little cells in the brains which are empty, and since there is

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no *vacuum*, he concludes, that in living men they
are full of Spirits.

Yet all the School of Physicians agrees upon
three sorts of Spirits, that the natural Spirits flow
through the *veins*, the vital through the *arteries*,
and the animal through the *nerves*; whence the
Physicians say out of *Galen*, that the parts some-
times want the consent of the brain, because the
faculty, together with its essence, is sometimes
hinder'd, and sometimes without the essence. Over
and above besides these three sorts of influxive
spirits, they seem to assert so many more, which
are implanted. But none of all these have we
found by dissection, neither in the *veins*, *nerves*,
arteries, nor parts of living persons. Some make
corporeal Spirits, other some incorporeal Spirits;
and those who make corporeal Spirits, sometimes
say, that the blood, or thinnest part of the blood,
is the conjunction of the soul with the body;
sometimes they say, that the Spirits are contained
in the blood (as flame in smoke) and sustain'd by
the perpetual flux of it; sometimes they do di-
stinguish them from the blood. Those that affirm
that there are Spirits incorporeal know not how
to tread, but likewise do affirm that there are
potential Spirits, as Spirits concoctive, chilifica-
tive, procreative, and so many Spirits as there are
faculties or parts.

But the Schoolmen tell us also of a Spirit of
Fortitude, Prudence, Patience, and of all vertues,
and the most holy Spirit of wisdom, and all divine
gifts. They think too that bad and good Spirits
do assist, possess, leave, and wander abroad. They
think also, that diseases are caus'd by a Devil; as
by a *Cacochima*. But although there is nothing

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more uncertain and doubtful, then the doctrine which is assigned to us concerning the spirits: yet for the most part all Physicians seem with *Hippocrates* to conclude, that our bodies are made up of three parts, containing, contain'd, and enforcing, by the forcing he means Spirits. But if Spirits must be understood to be every thing which enforces in a mans body, whatsoever hath the power or force of action in living bodies must be called by the name of Spirits. Therefore all the spirits are not aerial substances, nor powers, nor habits, nor corporeal.

But omitting the tediousness of all other significations to our purpose. Those Spirits which pass out through the *veins* of the *arteries*, are not seperable from the blood, no more then flame from the flakes about it. But the blood and the Spirit signifie one and the same thing, though divers in essence, as good Wine and its Spirit. For as Wine is no more Wine after it has lost its spirit, but flat stuf or vinegar, so neither blood without spirit is blood, but equivocally goar; as a hand of stone or a dead hand is no more a hand, so blood without vital spirit is no more to be esteemed blood. So the Spirit which is chiefly in the *arteries*, and the *arterial blood* is as its act, as the Spirit of Wine in Wine, and the Spirit of *Aqua vite*, or as a little flame kindled in the Spirit of Wine, and living by nourishing of it self.

Therefore blood when it is most imbued with Spirits, it does require and look after more room, because it is swelled or leavened, and blown up by them (which you may certainly judge in my experiment which I brought concerning the measure of the sawcers) but like wine, because it hath

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Greater strength and force of action and performance, in which it excels, according to the mind of *Hippocrates*.

Therefore the same blood is in the *veins* which is in the *arteries*, though it be acknowledged to be more full of spirit, and more eminent in vital force: but it is not converted into something more aerial or vaporous, as if there were no spirits but aerial ones or none that had force but such as were flatuous and windy: But neither are the Animal Spirits natural, and vital, which are contained in the solid parts, to wit, the ligaments and nerves (especially if there be so many sorts of them) thought to be so many aerial formes, or divers sorts of vapours.

Those who acknowledge Spirits in the bodies of creatures, but such as are corporal, but of an aerial consistence, or vaporous or fierie, of them would I fain know, Whether I can pass hither and thither, backward and forward, as distinct bodies without the blood? Whether or no I say the Spirits follow the motion of the blood, as if they were either parts of the blood, or adhering to it by an indissoluble connexion, and an interrupted exhalation; so that they can neither leave the parts, nor pass without the influx, reflux, and passing of the blood.

For if, as the vapours attenuated by the heat of the water, the Spirits, by the continual flux and succession of the blood, become the nourishment of the parts, it will necessary follow, that they cannot remain apart from the nourishment, but do continually vanish, for that same reason that they neither flow back nor pass any way, nor abide, but according to the influxion, refluxion

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or passing of the blood, as being either their Subject, *vehiculum*, or nourishment.

Then I would know, how they show us that Spirits are made in the *heart*, and do make them up, either by the compounding of exhalations, or vapours of the blood (raised either by the heat or concussion of the *heart*.) Are not such Spirits to be thought much colder then the blood, since both the parts of which they are compounded, to wit, air, and vapour, are much colder? for the vapour of boyling water is much more tolerable then the water it self, and any flame burns less then the coal of a candle, and a wood-coal less then iron or brass red hot.

Whence it seems that such Spirits do owe their heat to the blood, rather then the blood is heated by the Spirits, and such Spirits are rather to be deemed fumes and excrements, flowing from the blood and body, (like smels) then workers in Nature; especially since they being so frail and vanishing, do so quickly lose that vertue, which in their original they receive from the blood.

From whence it were likewise probable that there should be an expiration of the *lungs*, by which these Spirits being blown out might be ayred and purified, and that there should be an inspiration into them, that the blood passing through betwixt the *two ventricles* of the *heart* might be tempered by the ambient cold, lest being heated, and rising and swelling with a kind of fermentation, like boyling honey or milk, it should so distend the *lungs* as to suffocate the creature, as in a dangerous *Athma* we have often seen: To which *Galen* likewise ascribes the reason, when he says, that this comes to pass by obstructi-

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on of the little *arteries*, namely the venous and arterious vessels. I have had experience of this, that by affixing of Cupping glasses, and pouring upon them good store of cold water, there has many been saved who have been in danger to be suffocated by an *Asthma*. I have here, perchance, spoken sufficiently concerning Spirits, which we ought to define, and show what and how they are in a Treatise of Physiologie only I will adjoyn.

Those that speak concerning innate warmth, as an ordinary instrument of Nature in performance of all things, and tell us of the necessity of influxive heat, to entertain all the parts, and keep them in life, and do acknowledge that it cannot exist without a subject, because they find a moveable bodie disproportionable, by reason of the swiftness of the flux and reflux, (especially in the passions of the mind) and because of the swift motion of this heat, they introduce Spirits, as bodies most subtle, penetrative and moveable; and just as they say, that from the ordinary instrument, to wit, the innate heat, proceeds the admirable divinity of Natural operations: so do they likewise affirm, that those Spirits of a sublime, bright, æthereal and celestial nature, are the bonds of the Soul; as the ignorant common-people when they do not conceive the reasons of things, think and say, that God is the immediate author of them.

Whence they resolve, that the influxive heat does come swiftly through all the parts, by the influx of Spirit, and that it comes through the *arteries*; as if the blood could not be so speedily moved, nor so fully nourish; and in the confidence of this opinion they are so far advanced, that

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that they deny that there is any blood contained in the *arteries*.

And with very slight arguments they endeavour to ground this, that the *arterial* blood differs from the blood of the *veins*, or that the *arteries* are filled with such Spirits, and not with blood, contrary to all that which *Galen* both from reason and experience brought against *Erasistratus*.

But it is manifest by our former experiment, and by sense that the *aerial* blood is not so different; the influx of the blood and Spirit with it being not separate from the blood, but that it flows in one body through the *arteries*, sense may likewise make evident.

You may observe when, and as often as the extremities of the hands, the feet, and the ears are stiff and cold, and are restored again by the influx of heat, that it happens that at the self-same time they are coloured, warmed, and filled, and that the *veins* which were unseen before, do swell to plain appearance, from whence sometimes when they are suddenly warmed again the parts are sensible of some pain; from which it appears, that the same which by its influx brings heat, the same is it that fills and colours them, but this can be nothing else but blood, as was demonstrated before.

Cutting off a long *arterie* or *vein* any body may see this evidently by sense, when he shall see the nearer part of the *vein* towards the *heart* let out no blood, but the further part pour it abundantly, and nothing but blood (as afterwards in my experiment which I set down, which I tryed in the inner *jugularie veins*.) On the other side, cutting an *arterie*, but a little blood flows from the fur-

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ther part, but the nearer part shoots with a violent force mere blood, as if it were out of a spout.

By which experiment it is known which way the passage is in them, either this way or that way. Besides, you'll know what swiftness there is in it, what sensible motion, not by little and by drops, and with what violence to boot.

But lest any would make an evasion, by pretending of invisible Spirits; Let the *orifice* of the vessel so dissected be let down into a vessel of water or oyl, for if any aerial thing came out, it would break out by visible bubbles; for after this manner Wasps, Hornets, and the like Insects, being drowned or suffocate in oyl, send out at last bubbles from their tail when they are dying: from whence it is not improbable that they do take breath too whilst they are alive.

For all creatures at last when they are drowned and stifled in the water, when they sail and sink, they use to send out bubbles out of their mouth and *lungs*, when they give up the ghost.

Lastly, it is assured by the same experiment, That the *portals* in the *veins* are so exactly shut, that air when it is blown in cannot pass; much less blood. I say that it appears to the sense, that neither sensibly nor insensibly, neither by little, nor by drops, the blood is removed from the *heart* by the *veins*.

And lest any should flye hither, and say thus, That this comes to pass when Nature is troubled, and does act besides Nature, not when she is left to her self, and acts at her own freedom; seeing the same things appear in a sickly and preternatural constitution, which appear in good estate
of

of bodie, it is not to be said, that cutting off a *vein*, since there flows so much blood from the further part, that this comes to pass beside Nature, because Nature is molested; for the dissection does not shut the further part, so that nothing can get out that way, nor can it be squeezed out whether Nature be troubled or no. Others do wrangle after the same manner, saying, That although when the *arterie* is cut near the *heart* the blood breaks out in so great abundance immediately, yet for that cause the *heart* being whole, and the *arterie* to, it does not always drive the blood by impulsion. Yet it is more likely, that all impulsion does drive something, nor can there be a pulse of the container without the impulsion of something contained: Yet some, that they might defend themselves, and decline the Circulation of the blood, are not afraid to affirm and maintain this; to wit, that the *arteries* in living creatures, and being according to Nature, are so full that they cannot receive a grain weight more of blood: and so likewise of the *ventricles* of the *heart*. But it is without doubt, whensoever, or how much soever the *arteries* and *ventricles* are dilated, and contracted, they ought to receive greater impulsion of blood, and that beyond many grains. For if the *ventricles* be so distended as we have seen in the Anatomie of living Creatures till they receive no more blood, the *heart* leaves beating, and continuing stiff and resisting, it occasions death by suffocation.

Whether the blood be moved or driven, or move it self by its own intrinsical nature, we have spoken sufficiently in our book of the motion of the *heart* and blood; as also concerning

the action, function, contraction, dilatation of the heart, how it is done, and together with the *Diastole* of the *arteries*, so that those which take arguments from thence for contradiction, seem either not to understand what is said there, or else they will not try the business by their own sight.

I believe there can not the attraction of any thing be demonstrated in the body but of the nutriment, which by succession of parts supplies by little and little that which is lost, as the oyl of a lamp by the flame.

Whence that is the first common organ of all sensible attraction and impulsion, which has the nature of a *nerve*, or of a *fiber*, or of a *muscle*, to wit, that it may be contracted and that by shortening of it self it may stretch out, draw in, or thrust forward: but these things are more fully and openly to be declared elsewhere, in the organs of motion in living creatures.

Insomuch as to those who do still reject the Circulation, because they neither see the efficient, nor final cause of it, there remains, because I have as yet joyned nothing to it, only to say thus much; First, you must confess that there is a Circulation, before you enquire for what it is, for from those things that do happen upon the circulation and allowance of it, the use and profits accruing are to be searched. In the mean time I shall say so much, that there are many things allowed and received in Physiologic, Pathologic, and Medicine, that no body knows the cause of; yet that there are such things no body is ignorant, namely, of rotten feavers, revulsion, purgation of excrement, yet all these things are known by the help of circulation.

Whosoever

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Whosoever therefore does oppose the Circulation of the blood, because so long as the Circulation stands, they cannot resolve Physical Problems, or because in curing of diseases, and using of medicaments, they cannot from thence assign any cause of the Symptoms, or see that those causes which from their Masters they have received, are false, or think it an unworthy thing to desert opinions approved heretofore, and think it unlawful to call in question the discipline which has been receiv'd through so many ages, together with the authority of the Ancients.

To all these I answer, that the deeds of nature, which are manifest to the sense, care not for any opinion or any antiquity, for there is nothing more ancient then nature, or of greater authority.

Besides, those Problems out of Medicinal observations not to be solved, as they imagine, to the Circulation they object, and do oppose to it the declaring of their own errours, to wit, that if the circulation be true there can be no revulsion, since the blood is driven upon the part affected as before, and so it is to be feared, that there will be a passage of the excrements and blood, through the most noble and principal of our entrails. They do admire at the efflux and excretion, when out of the same body at divers holes, yea sometimes at the same hole, foul and corrupt blood issues, whereas if the blood were driven with a continual flux, passing through the heart, it would be mixed and shaken together.

They do doubt how these, and many other things that they fetch from the School of Physicians can come to pass, for they seem to be repugnant

nant to the Circulation of the blood, nor do they think (as it is in Astronomie) that it is enough to make new Systemes, unless you solve all scruples.

I thought fit to return no other answer at this time, but that the Circulation is not the same every where, and at all times, but many things do happen from the swifter or slower motion of the blood, either through the strength or infirmity of the *heart*, which drives it, by the abundance, estate, or constitution of the blood, the thickness of the parts, obstruction, and the like; thicker blood hardly finds way through narrow passages; it is more strained when it passes the streyner of the *liver*, then when it passes the streyner of the *lungs*.

It does not with a like speed pass through the thin contexture of the flesh and *parenchyme*, as it does through the thick consistence of the nervous parts: For the thinner, more pure, and more spiritous part is sooner streyn'd through; the more earthy, cacochymick, and more tardy, staves longer, and is turn'd back. The nutritive part, and last aliment (be it the *Ros* or *Cambium*) is more penetrative; seeing it is to be applied to every part, whether it be to the horns, feathers, or nails, if being every where nourished they increase in all their dimensions; for this reason the excrements in some places are voided, thickned, or do burthen us, or are concocted: Nor do I think that there is any necessity that the excrements, of ill humors, being once set apart, nor the milk, flegm, nor sperm, or the last nutriment (the *Ros* or *Cambium*) should be return'd with the blood, but that it behoves that that which nourishes should adhere, that it may be agglutinated.

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ated. Of which, and a great many other things which are to be determined and declared in their proper places, to wit, to Physiology, and the rest of the parts of Physick, it is not fit to dispute, nor yet of the consequences of the Circulation of the blood, nor the conveniences, nor inconveniences of it, before the Circulation it self be established for granted.

The example of Astronomy is not here to be followed, where only from appearances, and such a thing that may be, the causes, and why such a thing should be, comes to be enquir'd after. But as one desiring to know the cause of the Eclipse, ought to be plac'd above the Moon, that by his sense he might find out the cause, not by reasoning of things sensible, in things which come under the notion of the sense, no surer demonstration can be to gain belief, than ocular testimony.

I desire that there may be one other remarkable experiment tried by all that are desirous of the knowledg of the truth, by which likewise the pulse of the *arteries* is both seen to be done by the blood, and evidenced to be so.

If the guts of a Dog, or a Wolf, or any Creature stuffed, and dried, such as you see at the Apothecaries, you cut away a part of it of any length, and fill it with water, and tie it at both ends, that it is like a pudding, hitting or shaking the one end of it, in the end over against it, by putting too of your fingers (as we use to feel the pulse of the *arteries* above the wrist) you may find every stroke and difference of the motion clearly. And after this manner in every swelling vein, either of living or dead, you may to raw students manifest all the differences of the pulses

to

to the sense, in greatness, frequency, vehemency, and time. For as it is in a long bladder, or in a long drum, all the strokes of one of the extrems is felt likewise in the other; therefore in the Hydroptic of the belly, as likewise in all abscessions which are fill'd with liquid matter, we use to distinguish an *Anasarca* from a *Tympanitis*; if all pulses and vibrations made in one side, be by touch clearly felt in the other, we think it a *Tympanitis*, and not as it is falsely believ'd, because it is like the sound of a drum, and is only by flatulosity, but because (as it is in a drum) every light stroke passes through it, and every shake goes through the whole; for it shews that there is a serous and wheyish substance within, and not a tough and slimy, as in the *Anasarca*, which being thrust, retains the marks of the stroke or impulsion, and transmits it not. Having opened this experiment, there rises a most powerful objection against the Circulation of the blood, neither observ'd, nor oppos'd against me by any that has hitherto written. Seeing in this experiment we see that there may be *Systoles* and *Diastrales*, without the egress of the liquor, who will believe but that it may be just so in the *arteries*, and that in them just so as it is in an *Euripus*, from hence thither, from thence hither, it may be driven by turns. But in another place we have sufficiently resolv'd this doubt, and now we also say, that this is not so in the *arteries* of living creatures, because continually and incessantly the right ear of the heart fills the *ventricles* with blood, the return of which the three-pointed *portals* hinder, and so the left ear fills the left *ventricle*, and both the *ventricles* in the *Systole* throw forth the blood which

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which the *Sigmoidal portals* hinder to return, and that it ought therefore either pass some way, and continually out of the *lungs* and *arteries*, or otherwise it would at last, by restagnation and intrusion, break the vessels which contain it, or suffocate the *heart* it self by distention, as we have observ'd to be plain to the sense in the dissection of a live Adder, in my Book concerning the motion of the blood.

To clear this doubt, I will recite to you two experiments, amongst many other (of which I told one before) by which it clearly appears, that the blood in the *veins*, with a continual and great flux runs continually through the *heart*.

In the internal *jugular vein* of a live Doe, which I laid open before a great part of the Nobility, and the King my Royal Master standing by, which was cut and broke off in the middle: from the lower part rising from the *Clavicle*, scarce a few drops did issue, whilst in the mean time the blood with great force, and breaking out of a round stream, ran out most plentifully downwards from the head through the other *orifice* of the *vein*. You may observe the same dayly in Phlebotomy in the flowing out of the blood, if you hold the *vein* fast with one finger, a little below the *orifice*, presently the flux is stopped, which after you let it go flows abundantly, as before.

In any visible long *vein* of your arm, stretching out your hand, and pressing out all the blood downwards as much as you can, you shall see the *vein* fall, leaving as it were a furrow in the place, but so soon as you thrust it back with one of your fingers, you shall presently see the part towards

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wards the hand, to be fill'd and swell, and to rise by the return of the blood from the hand. What is the reason, that by stopping of the breath, and by that means streightning the *lungs*, and a great deal of air being within, the pectoral vessels are streightned, whence the blood is driven into the face and eyes with so much redness?

Nay, that (as *Aristotle* says in his *Problemes*) all actions are perform'd with greater strength by keeping in of the breath, than by letting it free; so you get blood more abundantly out of the *veins* of the *brow*, or *tongue*, by compression of the throat, and retention of breath.

I have found sometimes in a mans body, newly hang'd, two hours after his execution, before the redness of his face was gone, opening up his *heart* and *Pericardium*, the *right ear* of his *heart*, and *lungs* much stuffed, and distended with blood, many witnesses standing by, especially I shewed them the *ear*, as big as a mans fist, so swell'd, that you would have thought it would have burst with greatness, which, the body being afterwards cold, and the blood having found other ways, was quite gone.

So from these, and other experiments, it is clear enough, that the blood runs through all the *veins* to the *basis* of the *heart*, and that unless it found passage it behooved to be streightned, or shut up in other ways, and that the *heart* would be overwhelmed with it, as on the other part, if it did not flow out of the *arteries*, but were regurgitated, the oppression by it would quickly appear.

I will add another observation: A noble Knight Baronet, Sir *Robert Darcie*, father to the Son-in-Law of the most learned man, and my

very

very great friend, and a famous Physician, Dr. *Argent*, about the middle of his age, did often complain of an oppressive pain in his breast, especially in the night time, so that sometimes being afraid of collapion of spirits, sometimes fearing suffocation by a Paroxisme, he led an unquiet and anxious life, using the Counsel of all Physicians, and taking many things in vain; at last the disease prevailing, he becomes cachectick, and Hydropick, and at last oppress'd in a signal Paroxism he dyed. In his Corps, in the presence of Dr. *Argent*, who at that time was President of the Colledge of Physicians, and Dr. *George*, a rare Divine, and a good Preacher, who was at that time Minister of that Parish, by the hindrance of the passage of the blood out of the *left ventricle* into the *arteries*, the wall of the *left ventricle* it self (which is seen to be thick and strong enough) was broken, and poured forth blood at a wide hole, for it was a hole so big, that it would easily receive one of my fingers.

I knew another stout man, who did so boyl with rage because he had suffered an injury, and received an affront by one that was more powerful then himself, that his anger and hatred being increased every day (by reason he could not be revenged) and discovering the passion of his mind to no body, which was so exulcerate within him, at last he fell into a strange sort of a disease, and was tortured, and miserably tormented with great oppression and pain in his *heart*, and breast, so that the most skilful Physicians prescriptions doing no good upon him, at last, after some years, he fell sick of the Scorbutick disease, pin'd away, and dyed.

This

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This man only found ease as oft as his brest was prest down by a strong man, and was thump'd and beaten down as they do when they mould bread: his friends thought he was bewitched, or possessed with the Devil.

He likewise had his *jugular arteries* distended about the greatness of ones thumbs, as if either of them had been the *Aorta* it self or the *Arteria magna* in its descent, and did beat vehemently, and were to the view like two long Aneurisms, which caused us try blood-letting in his *temples*, but that gave him no ease. In his corps I found the *heart* and the *aorta* so distended and full of blood, that the bigness of his *heart*, and the concavities of the *ventricles*, were equal in bigness to that of an Oxe; so great is the strength of the blood when it is shut up, and so vast its force.

Although then (by the experiment newly mentioned) there may be an impulsion without an exite (in the shaking of water up and down) in the pudding afore mentioned, yet cannot it be so in the blood which is in the vessels of living persons, without very great and heavy impediments and dangers.

Yet from thence it is manifest, that the blood in its Circulation does not pass every where with the same agility and swiftness, nor with the same vehemence in all places and parts, and at all times, but that it varies much according to the age, sex, temper, habit of the body, and other contingents, external, internal, natural, or preternatural:

For it does not pass through the crooked and obstructed passages, with the same swiftness as it does through those that are open, free, and patent; nor does it pass through bodies or dense parts, and
such

such as are stuff'd or constricted, as it does through those that are thin, open, and without obstruction; nor does it run out so swiftly and penetratively when the impulsion is slow and soft, as when it is driven with force and strength, and thrust forward with vehemency and abundance. Nor is the thick blood or solid masse, or when it is made earthy, so penetrative, as when it is more wheyish, made thin, and liquid.

And therefore with reason we may imagine, that the blood in its Circulation goes slower through the *veins*, then through the substance of the *heart*; swifter through the *liver*, then through the *veins*; swifter through the *spleen*, then through the *liver*; swifter through the *lungs*, then through the *flesh*, or any other viscera of thinner contexture.

We may likewise contemplate in the age, sex, temperature, habit of the body soft or hard, of the ambient cold, which condenses bodies, when the *veins* scarce appear in the members, or the sanguine colour is seen, or the heat appears, the blood being made more liquid by reception of nutriment. So likewise the *veins* do more conspicuously, and freely pour out the blood the body being heated before opening of a *vein*, then when it is cold. We see that the passion of the mind (in the administration of Phlebotomie) if any fearful person chance to sound, straight the flux of the blood is stopped, and a bloodless paleness seizes on all the surface of his body, his members are stiff, his ears tingling, his eyes grow dim, and are in convulsion. I find here a field where I might run out further, and expatiate at large in speculation: But from hence so great a light of truth appears, from which

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so many questions may be resolved, so many doubts answered, so many causes and cures of diseases found out, that they seem to require a particular treatise. Concerning all which in my medicinal observations, I'll set down things worthy your admiration.

For what is more admirable, then that in all affections, desires, hope, or fear, our bodies suffer several ways, our very countenances are changed, and our blood is seen to fly up and down? with anger our eyes are red, the black of the eye is lessened in shamefastness, and the cheeks are flushed with redness; by fear, infamie, and shame, the face is pale, the ears glow, as if they should hear some ill thing: Young men that are touched with lust, how quickly is their *nerve* fill'd with blood, erected and extended? But it is most worthy the observation of Physicians, why blood-letting and cupping glasses, and the stopping of the *arterie* which carries the flux (especially whilst they are doing) does as it were with a charm take away all pain and grief: I say, such things as these are to be referred to observations, where they are explained clearly.

Frivolous and unexperienced persons do scurvily strive to overthrow by logical, and far fetched arguments, or to establish such things as are meerly to be confirmed by Anatomical dissection, and ocular testimony. It behoves him, who ever is desirous to learn, to see any thing which is in question, if it be obvious to sense, and sight, whether it be so or no, or else be bound or believe those that have made tryal, for by no other clearer or more evident certainty can he learn to be taught. Who will perswade a man that has not
tasted

tasted them, that sweet or new wine is better then water? with what arguments shall one perswade a blind man that the Sun is clear, and out-shines all the Stars in the firmament? So concerning the Circulation of the blood, which all have had confirmed to them for so many years, by so many ocular experiments, there has been hitherto no man found, who by his observations could refute a thing so obvious to the sense (to wit the motion of flux and reflux) by observations alike obvious to the sense, or destroy the confirmed experience of it, nay by ocular testimony none ever offered to build up a contrary opinion.

Whilst in the mean time there are not wanting persons, who for their unskilfulness, and little experience in Anatomie, having nothing agreable to sense to oppose to it, they cavil at it with some vain assertions, and such as they adhere to from the authority of Teachers, with no solid supposition, but with idle and frivolous arguments, and bark at it besides with a great many other words, and those base ones too, with rayling, and base scurvy language, by which they do no more then shew their own vanity, and folly, and their baseness, and want of arguments, which are to be fetched from sense; so that they with their false Sophistical arguments do rage against sense: Just as when the raging winds advancing the waves in the *Sicilian* Sea dashes them in pieces against the rocks within *Charibdis*, they make a hideous noise, and being broken and reverberated hisse, and foam; so do these men rage against the reason of their own sense.

If nothing should be admitted by sense without the testimony of reason, or sometimes against

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the dictate of reason, there should be no question now to be controverted.

If our most certain Authors were not our senses and these things were to be established by reasoning, as the Geometricians do in their frames, we should truly admit of no Science, for it is the rational demonstration of Geometrie from things sensible to demonstrate things to the sense, according to which example, things abstruse, and hid from the sense, grow more manifest by things which are easier, and better known. Aristotle advises us much better *lib. 31 de Gen. Anim.* disputing of the generation of Bees, says he, *you must give credit to your senses; if those things which are demonstrated to you are agreeable to those things which are perceptible by sense, which, as they shall then be better known, so you may better trust your sense than your reason.* Whence we ought to approve or reject all things by examination leisurely made, but if you will examine or try whether they be said right or wrong, you must bring them to the test of sense, and confirm, and establish them by the judgment of sense, where, if there be any thing feign'd or not, sure it will appear. Whence *Plato* says in his *Critias*, That the explication of those things is not hard, of which we can come to the experiment, nor are those auditors fit for Science that have no experience,

How hard and difficult a thing is it for those that have no experience, to teach such things of which they have no experience, or sensible knowledge; and how unfit and indocile unexperienced Auditors are to true Science, the judgment of blind men in colours, and of deaf men in the distinction of sounds, does plainly shew. Who shall
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teach the flux and reflux of the Sea? or by a Geometrical Diagram teach the quantities of Angles, or the computation of the sides of a figure to a blind-man, or to those that never saw the Sea, nor a Diagram? A man that is not expert in Anatomie, in so far as he cannot conceive the business with his own eyes, and proper reach, in so far is thought to be blind to learning, and unfit; for he knows not truly any thing concerning which an Anatomist disputes, nor any thing from the implanted nature of which he should take his argument, but all things he is alike ignorant of, as well those things which are gathered and concluded, as the things from whence. But there is no possible knowledge, which arrives not from a pre-existent knowledge, and that very demonstrable. This one cause is the chief reason why the knowledge we have of the heavenly bodies is so uncertain and conjectural. Very fain would I know from those ignorant persons, that profess the causes and reasons of all things, why as both the eyes in beholding move together every way, nor particularly one moves this way, and the other that way, so neither both the *ears* of the *heart*?

Because they know not the causes of feavers, or of the plague, or the admirable properties of some medicaments, and the causes why they are so, must therefore these things be denyed?

Why is the Birth that breathes not till the tenth moneth not suffocated for want of ayr? since one that is born in the seventh or eighth, so soon as he has breathed in the air, is presently choaked if it have no air? How can it retain life whilst it is yet within the *Secundine*, or as yet not come forth, without breath? but so soon as he comes into the

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air unless he breath he cannot live?

Because I see many men doubtful in the Circulation, and some men oppose such things which understand them not aright, as I intended them, I shall briefly rehearse out of my Book of the motion of the *heart* and blood, what I did there intend. The blood which is contained in the *veins* (as in its own hold) where it is most abundant (to wit, in the *vena cava*) near to the *Basis* of the *heart* and the *right ear*, growing hot by little and little by its own internal heat, and made thin, it swells and rises (like leaven) whence the *ear* being first dilated, and afterwards contracting it self by its pulsfick faculty, streightways drives it out into the *right ventricle* of the *heart*, which being filled in its *Systole*, and consequently freeing it self from the blood which is driven into it (the three-pointed *portals* refusing passage to it) it drives the same blood into the *vena arteriosa* (where the passage is open) by which it does distend it. Now the blood in the *arterious vessel* being not able to return against the *Sigmoidal portals*, but because the *lungs* are extended, amplified, and restricted both by inspiration and expiration, and likewise their vessels, they give passage to this blood into the *arteria venosa*: of which the *left ear* keeping together equal motion, time and order, with the *right ear*, and performing its function, sends the same blood into the *left ventricle*, as the *right* sent into the *right*, whence the *left ventricle* together, and at the same time with the *right* (since it can gain no regrefs, by reason of the *portals* which hinder its return) drives it into the capaciousness of the *aorta*, and consequently into all the branches of the *arterie*; the *arteries* being filled with this

this sudden pulse, being not able so suddenly to disburthen themselves, are distended, suffer an impulsion and *Diastole*.

Whence I gather, seeing the same is reiterated continually and incessantly, that the *arteries*, both in the *lungs*, and in the whole body, by so many strokes, and impulsions of the *heart*, would be so distended and stuffed with blood, at least that either the impulsion would give over all together, or else the *arteries* would burst, or be so dilated, that they would contain the whole mass of blood which is in the *veins*, unless the efflux of blood were disburthened somewhere.

We may likewise reason after the same manner of the *ventricles* of the *heart*, being filled and stuffed with blood, unless the *arteries* did likewise disburthen, they would be at last distended and destitute of all motion. This consequence of mine is demonstrative and true, and follows of necessity, if the premises be true; but our senses ought to assure us whether such things be false or true, and not our reason, ocular testimony, and no contemplation.

I affirm likewise of the blood in the *veins*, that the blood does always, and every where, run out of the less into the greater, and hastens towards the *heart* from every part: whence I gather, that whatsoever quantity which is continually sent in, the *arteries* do receive by the *veins*, that the same does return and does at last flow back thither from whence it is first driven, and that by this means the blood moves circularly, being driven in its flux and reflux by the *heart*, by whose force it is driven into all the *fibers* of the *arteries*, and that it does afterwards successively, by a continual

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flux return through the *veins*, from all those parts which draw, and strein it through; sense it self teaches us that this is true, and collections from things obvious to sense takes away all occasion of doubt.

Lastly, this is that I did endeavour to relate and lay open by my observations and experiments, and not to demonstrate by causes and probable principles, but to confirm it by sense and experience, as by a powerful authority, according to the rule of Anatomists.

From these we may observe what force, & violence, and strong vehemency we perceive in the *heart*, and greater *arteries* by touch and sight. I do not say, that in all the vessels which contain the blood, the pulse of the *Systole* and *Diastole* is the same (in greater Creatures) nor in all creatures which have blood, but that there is such a one and so great in all, that by that means there is a flux of blood, and swifter course of it through the small *arteries*, the porosities of the parts and branches of all the *veins*, and from thence comes the Circulation: for neither the small *arteries*, nor the *veins* do beat, but only the *arteries* which are nighest to the *heart*, because they do not so soon send the blood out, as it is driven into them, for you may try, opening of an *arterie*, if the blood leap out in full stream, so that it come out as freely as it went in, that you scarce found any pulse in that *arterie* through which it passes, because the blood running through, and finding passage, does not distend it. In Fishes, Serpents, and colder creatures, the *heart* beats slowly and weaker, that you will hardly perceive any pulse in the *arteries*, because they pass their blood through very flowlie;

flowlie; whence it is that in these as also in the little *fibers* of the *arteries* of a man there is no distinction by blood; because they are not pierced with impulsion of blood.

As I said before, the blood that passes through an *arterie* which is cut and opened, makes no pulse there at all, whence it clearly appears, that the *arteries* suffer their *Diaſtole* neither by innate pulſifick faculty, nor by any granted them from the *heart*, but by the meer impulsion of the blood. For in the full flux, flowing out the length of its course, you may by touch perceive both the *Systole* and *Diaſtole*, as I said before, and all the differences of the pulse of the *heart*, their time, order, vehemency, intermiſſion in the emanation of the flux evidently, (as it were in a looking-glaſs.) Just as water, by the force and impulsion of a spout is driven aloft through pipes of lead, we may observe and distinguish all the forcings of the Engine, though you be a good way off, in the flux of the water when it passes out, the order, beginning, increase, end, and vehemency of every motion. Even so it is when you cut off the orifice of an *arterie*; where you must observe, that as in the water, the flux is continual; though it be sometimes higher, sometimes further: so in the *arteries*, besides the shaking, pulse, and concussion of the blood, (which is not equally to be perceived in all) from that time forward there is a continual motion and fluxion in the blood, till the blood be again returned to that place where it first began, that is to say, to the *right ear*.

These things you may try at your pleasure cutting up one of the longer *arteries*, (as the *jugular*) which if you take betwixt your fingers, you shall

shall clearly discern how it loses its pulse and recovers it again, beats less or more. And as these things may be tryed whilst the brest is whole; so opening the brest, and the *lungs* afterwards being collapsed and all motion of respiration gone, you may easily try it, to wit, that the *left ear* is contracted and emptied, that it becomes more whitish, and that it doth at last, together with the *left ventricle*, intermit in its pulse, beat leisurely, and at last leave off: And likewise by the hole which you may cut in the *arterie*, you may see the blood come forth less and less in a smaller thred, and that at last, (to wit, in the defect of blood, and the impulsion of the *left ventricle*) no more will flow.

You may likewise try this same in the tying of the *vena arteriosa*, and so take away the pulse of the *left ear*, and with untying it, restore the pulse at your pleasure. Whence the same thing is evidently tried by experiment, which is seen in dying persons, that as first the *left ventricle* desists from motion and pulse, and afterwards the *left ear*, then the *ventricle*, and pulse, lastly, the *right ear*; so where the vital faculty begins first, it ends last.

Which being tried by the sence, it is manifest that the blood passes only through the *septum* of the *heart* and not through the *lungs*, and only through them whilst they are mov'd, in respiration, and not when they are fallen or disquieted. For which cause in an *Embryon* (not as yet breathing) Nature instead of the passage in the *arteria venosa*, (that matter may be furnish'd to the *left ventricle*, and the *left ear*,) opens an oval hole which shee shuts in young men, and those that breath freely.

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likewise appears, why those that have the Vessels of their *lungs* oppress'd, and stuff'd, or those that have any loss of their breath, it is present token of death.

It is likewise clear, why the blood of the *lungs* is so in flame-colour'd; for it is thinnest that is gain'd through there. It is beside to be observ'd from our former conclusion, in order to those who enquire the causes of Circulation, and think the power of the *heart* to be the effecter of all things, & that it is the author of transmission by pulse, so with *Aristotle* they think it the author of attraction, & generation of blood, and that the Spirits are made by the *heart*, and the influxive heat (& that by the heat of the *heart*, as by the immediate instrument of the soul, or by a common bond and the first organ for perfecting of all the works of life. And so the motion of the blood and spirit, its perfection by heat, & every property thereof, to be borrow'd from the *heart*, as from its beginning (which *Arist.* says is in the blood, as in hot water, or boiling water) is in the *heart*, & that it is the first cause of pulsation & life. If I may speak freely, I do not think that these things are so (as they are commonly believed) for there are many things which perswade me to that opinion, which I will take notice of in the generation of creatures, which are not fit hear to be rehearsed, but it may be things more wonderful than these, and such as will give more light then natural Philosophie, shall be publish'd by me.

Yet in the mean time I shall say and propound without demonstration, (with the leave of most learned men, and reverence to antiquity) that the *heart*, as it is in the beginning of all things in the body,

body, the spring, fountain, and first causer of life is so to be taken, as being joyn'd, together with the *veins*, and all the *arteries*, and the blood which is contained in them. Like as the *brain* (together with all its sensible *nerves*, *organs*, and *spinal marrow*) is the adequate organ of the sense (as the phrase is.) But if you understand by the word *heart*, the body of the *heart*, with the *ventricles* and *ears*, I do not think it to be the frame of the blood, and that it has not force, virtue, motion, or heat, as the gift of the *heart*; and next that the same is not the cause of the *Diaστοle*, and distention, which is the cause of the *Συστοle*, and contraction, whether in the *ears* or *arteries*; but that part of the pulse which is call'd a *Diaστοle* comes of another cause, diverse from the *Συστοle*, and ought to go before every *Συστοle*. I think the first cause of distention is innate heat in the blood itself, which (like leaven) by little and little attenuated and swelling, is the last thing that is extinct in the creature. I agree to *Aristotle's* instance of pottage, or milk, in so far as he thinks that elevation, or depression of the blood, does not come of vapors, or exhalations, or Spirits rais'd into vaporous or aerial form, nor is not caus'd by an external agent, but by the regulating of Nature an internal principle.

Nor is the *heart* (as some think) like a charcoal-fire, (like a hot Kettle) the beginning of heat and blood, but rather the blood delivers that heat which it has receiv'd to the *heart*, as likewise to all the rest of the parts, as being the hottest of all. Therefore *arteries* and the *coronal veins*, are assign'd to the *heart*, for that use which they are assign'd to the rest of the parts, to wit, for influx

heat, for the entertaining and conservation of
therefore all the hotter parts, how much more
guine they are, and more abundant with blood,
are said convertibly so to be; and thus the
not having signal concavities, is to be thought
Ware-house, continual fire, and fountain of
blood, not because of the corpulency of it, but
cause of the blood which it contains like a hot
tyle; as in the same manner the *spleen, lungs,*
other parts are thought hot, because they
are many *veins* or vessels containing blood.

and after this manner do I believe that the na-
tural heat, call'd innate, to be the first efficient
cause of pulse, as likewise to be the common in-
strument of all operations. This as yet I do not
stantly averr, but propound it as a *Thesis*; I
would fain know what may be objected by good
learned men, without scurrility of words, re-
viches, or base language, and any body shall be
come to do it.

These things then are as it were the parts, and
footsteps of the passage, and Circulation of
blood; to wit, from the *right ear* into the
tricle, out of the *ventricle* through the *lungs*
into the *left ear*, then into the *left ventricle*, into
aorta, and into all the *arteries* from the *heart*,
by the porosities of the parts into the *veins*, and
by the *veins* into the *Basin* of the *heart*, the blood
turns most speedily.

By an experiment any man may try that plea-
sured by the *veins*, let the arm be tied, as the custom
is with a gentle ligature; and let it remain tied
long, still moving the arm up and down, till
the *veins* all of them swell exceedingly, and the
skin grow very red below the *ligature*, and then

let

let the hand be washed with Snow or cold water till the blood gathered below the *ligature* be coagulated enough, then presently untying the ligature, you shall find by the cold blood which returns hither, how swiftly it runs back to the *heart*, and what change it will make in its return thither; so that it is not to be wondred at, that in the untying of the ligature in blood-letting, some have found that the veins below the ligature do not swell with blood attenuated, and puffed up with spirit, but with blood only, and such blood which can be reverberated into the *arteries* through the *Anastomosis* of the parts, or the hidden *Meanders*.

It likewise shews how those that pass over snowy mountains, are often suddenly seized with death, and many such like.

Lest it should seem a difficult business, how blood should pass through the *pores* of the parts, and go hither and thither, I will add one experiment. It happens after the same manner to those that are strangled, and hang'd with a rope, as does in the tying of the arm, that beyond the cord, their face, eyes, lips, tongue, and all the upper parts of their head are stuffed with very much blood, grow extream red, and swell till they look black, in such a carcase untying the rope, whatsoever position you set it, within a very few hours you shall see all the blood leave the face and the head, and see it as it were fall down with its own weight, from the upper to the lower parts through the *pores* of the skin and flesh, and the rest of the parts, and that it fills all the parts below, and the skin chiefly, and colours it with black matter; how much more lively and sprightly the

blood is in a living body, and by how much more penetrating it is through the poresites than congealed blood, especially when it is condens'd through all the habit of the body, by the cold of death, the ways too being stop'd and hinder'd, so much the more easy and ready is the passage in those that are alive through all the parts.

Renatus de Cartes, a most acute and ingenious man, (to whom, for his honorable mentioning of my name, I am much indebted) and others with him, when they see the heart of a fish taken out, placed upon an even board, imitate a pulse (by collecting it self) in its erection, up-lifting, vigoration, they think that it is amplified, and dilated, and that the ventricles of it become more capacious, not according to my opinion. For when it is gathered, at that time the capacities of it are rather streightned, and it is certain that it is then in its *Systole*, and not in its *Diaſtole*, as neither when it falls weak and flagging, and is relax'd, it is then in its *Diaſtole*, or distention, and thence the ventricles become wider; so in a dead man, we do not say that his heart is in the *Diaſtole*, because it is flagging without any *Systole*, destitute of all manner of motion, and not distended at all, for it is distended properly, and is in the *Diaſtole* when it is fill'd by the impulsion of the blood, and contraction of the ear, as in the Anatomy of living things is evident enough.

Therefore they understand not how much the relaxation, and falling of the heart and arteries differ from their distention and *Diaſtole*; that distention, relaxation, and constriction, come not of the same causes, but from contrary causes, as making contrary effects, and diverse, as making divers motions, as all Anatomists know very well, that the opposite muscles in any part (called Antagonists) are the causes of several motions, to wit, of adduction, and extension, so there is necessarily by nature fram'd contrary, and divers active organs, for contrary and divers motions.

Nor does this efficient cause of pulse, which he sets down according to *Aristotle*, please me, to wit, that the ebullition of the blood shall be both the cause of the *Systole*, and of the *Diaſtole*. For these motions are sudden strokes, and swift hits. And there is nothing that swells so like leaven, or boyls up so suddenly, in the twinkling of an eye, and falls again; but that rises leisurely, and falls suddenly: besides, in dissection you may by your own eye sight discern, that the ventricles of the heart are distended, and fill'd by the constriction of the ears, and are encreas'd in bigness

according as they are fill'd, more or less, and that the distention of the *heart*, is a kind of violent motion, done by impulsion, not by an attraction.

There are some who think, as there is no need of impulsion for the aliment in the nourishing of Plants, but it is by little and little drawn into the place of that which is spent by the indigent parts; so the vegetive faculty performs its work alike in both, but there is a difference. Calid influxive is continually requir'd to the entertaining of the members of creatures, and preserving of vivifying heat in them, and for restoring of the parts which suffer by outward injury, and not for nutrition only.

So much of Circulation, which if it be not duly perform'd, or be hindred or perverted, or go too swiftly, there follows many dangerous sorts of diseases, and admirable symptoms, either in the *veins*, as swellings, abscessions, gries, hæmorrhoids, flux of blood, or in the *arteries*, as swellings, boyls, strong and pricking pains, aneurisins, tumors in the flesh, fluxions, sudden suffocations, *asthma's*, Rudidity, apoplexy, and others innumerable. Likewise it is not fit to tell in this place how, as it were with an Enchantment, many things are cur'd, and taken away, which were thought incurable.

I may set down such things in my medicinal observations, and discourses of Pathology, which I have hitherto known to be observ'd by none.

I will conclude (most learned *Rindan*) to give you more ample satisfaction; because you think that there is no Circulation in the *mesenterick*: Let the *vena porta* be tied near to the *cymæ* of the *liver* in a live dissection, which you may easily try, you shall see by the swelling of the *veins* beneath the *ligature*, that same come to pass which happens in blood-letting by tying of the arm, which will shew you the passage of the blood there.

And when you shall hear any man of that opinion, that by *Anastomosis* the blood can come out of the *veins* into the *arteries*, tie in a live dissection the great *vein*, near the division of the *cruralis*, and as soon as you cut the artery (because it finds passage) you shall see all the mass of blood emptied out of all the *veins* (nay out of the *ascendent cava* too) by the pulse of the heart, in a very short time, yet that below the *ligature* the *crural veins*, and parts below, are only full. Which if it could any way have returned to the arteries by an *anastomosis*, should never have come to pass.

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