EARLY SCIENCE IN OXFORD

IX

RICHARD LOWER. M.D.
Ætatis Suæ. 55.

EARLY SCIENCE IN OXFORD

BY

R. T. GUNTHER

VOL. IX

DE CORDE BY RICHARD LOWER

London 1669

WITH INTRODUCTION AND TRANSLATION

BY

K. J. FRANKLIN

OXFORD

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EDITORIAL NOTE

THE association of Dr. Richard Lower with Robert Hooke, both members of Christ Church in Oxford, and the early recognition of the great merit of his work by the latter genius, has been noticed so recently in the last volumes of *Early Science in Oxford*, that it is appropriate that the work of Hooke should be followed by that of Lower.

That Lower's epoch-making Treatise on the Heart should be so little known at first hand, even to physiologists, is due to the fact that no English translation has hitherto been printed. All historians of science will now be grateful to Dr. Franklin for having repaired this omission as a labour of love. He has also provided the copy of the London 1669 edition, once in the possession of a Josua Edisbury, from which the facsimile of the text has been made. The plates have been copied and slightly reduced from the copy belonging to the Royal Society of Medicine.

THE OLD ASHMOLEAN,
OXFORD. R. T. GUNTHER.
April 1932.

A facsimile edition of

TRACTATUS
DE
CORDE
ITEM
De Motu & Colore
SANGUINIS
ET
Chyli in eum Transitu

BY

Richard Lower, M.D.

LONDON: MDCLXIX

Prefaced by

AN INTRODUCTION AND TRANSLATION

BY

K. J. FRANKLIN, D.M.

TUTOR AND LECTURER IN PHYSIOLOGY OF ORIEL COLLEGE, AND UNIVERSITY DEMONSTRATOR OF PHARMACOLOGY, OXFORD

TO

E. A. F.

PREFACE

NO apology is really necessary for making Lower's *De Corde* more accessible by translation, but it will not be out of place if I explain briefly why I acceded to Professor J. F. Fulton's suggestion that I should do so. Medical history is not merely a fascinating hobby for one's leisure hours, or a means of keeping alive the memory of those who have done great things in the past; it is, also, essentially the right prelude to research in the present, and should accompany any such research. My own chief interest is the venous system and my more general one the circulation, and I think the problems which arise can, and should, be approached from the historical side, as well as through research in embryology, anatomy, physiology, pharmacology, and the like. The older medical books, however, are too rare and too expensive for many of us to have them on our shelves, and the language in which they are written makes them useless to most people. There is, therefore, a need of facsimile editions and translations. I have already made one such of *De venarum ostiolis*, 1603, of Hieronymus Fabricius of Aquapendente (in press: Charles C. Thomas, Springfield, Ill.), William Harvey's *De motu cordis* is available, and the next important work on the circulation, which needs similar treatment, is Richard Lower's *De Corde*, London, 1669. This translation I have therefore undertaken in my leisure time over a period of several months, and, if the result is not so perfect as I could wish, I trust that its defects will be ascribed, to some extent at least, to pressure of other work.

I have had generous assistance in my task from Professor J. F. Fulton, who lent me all his material and a copy of the rare French translation of *De Corde*, from Professor G. N. Clark, who supplied me with several new references, from Mr. H. E. Powell, Librarian of the Royal Society of Medicine, from Mr. T. Gambier-Parry and Mr. Strickland Gibson of the Bodleian Library, from Mr. W. J. Bishop, Assistant Librarian of the Royal College of Physicians, Mr. Le Fanu, Librarian of the Royal College of Surgeons of England, the authorities of the National Portrait Gallery, and last, but not by any means least, from the Rev. A. V. Schuster, Rector of St. Tudy, Cornwall, and Mrs. Schuster, and Major-General T. S. Baldock and his sister, the present occupants of Tremeer. I am most grateful to Dr. R. T. Gunther for undertaking the publication of the book, and to the Library Committee of the Royal Society of Medicine for the loan of their copy of *De Corde*, from which this translation has been made. This copy is unique, as far as my investigations go (see *18*), in not having a cancel page (Sig. A 6) in the Preface. The facsimile follows the Royal Society of Medicine copy in respect of this page. The size of the pages in the original is $9\frac{3}{16}$ inches by $4\frac{3}{16}$ inches; the margin in the facsimile is of necessity larger.

The frontispiece is the only known portrait of Richard Lower, and is taken from the first edition of

Dr. Lowers, and several other Eminent Physicians Receipts . . ., London, 1700. It seems, from Clark's *Life and Times of Ant. Wood,* that copies of this book were being distributed in Wood's lifetime, but he died in 1695 and this 1700 edition is the earliest one known. William Huddesford in 1772 (*31*, i. 298) noted that 'His name has been impudently affixed to many nostrums sold in the shops. The print of him is suspected to be a counterfeit.' I have discussed elsewhere other statements as to the authenticity of the portrait (*18*). It was, however, in the *Receipts* not long after Lower's death, and is, as stated above, the only one in existence, so it has been reproduced as the frontispiece. Its size in the original is $4\frac{7}{8}$ inches by $3\frac{1}{4}$ inches. It was copied, but poorly, in the 4th German edition of the *Receipts*, Leipzig, 1710; whether in other editions or not I cannot say, for this, in the possession of the Royal Society of Medicine, is the only one I have seen.

The signature is reproduced from *A Letter of Dr. Lower, prescribing for a nobleman* (*6*). There is another signature in the Tanner MS. (*3*), and I have stated elsewhere (*18*) where additional ones may be found.

De Corde was translated into French, with the omission of the preface; and the translation was first published at Paris, in 1679, under the title, *Traité du cœur, du mouvement et de la couleur du sang, et du passage du chyle dans le sang.* The translation is on the whole a good one, although certain difficulties are evaded. This work is, I believe, even more rare than the original 1669 edition. The Royal College of

Physicians has a manuscript English translation of *De Corde*, which was made by N. Peters in 1739, and which I have seen but have not used in any way. The translator was very probably Nic. Peters, Surgeon, who lived at Topsham, and published a paper in Phil. Trans., 1744, xliii. 151. The translation is entitled, *A treatise of the heart, of ye motion and colour of ye blood, and of ye passage of ye chyle, by Rd. Lower, M.D. 1669*. It is in an excellent hand, and has finely drawn copies of the seven plates at the end. Apart from these translations, only one other exists of even part of *De Corde*, namely, that of the chapter on Transfusion, which was published in the Annals of Medical History, 1928, x. 213–25. This contains some errors and omissions.

The rest of this preface will be concerned with biographical and bibliographical notices, then will follow the translation, with marginal numbers corresponding with the pagination of the original text, and finally will come the facsimile and the plates. As the translation will show the pagination of the original, it needs no other numbering, and none such, therefore, has been given to it.

In the biographical notice are included certain details about contemporary events in the lay and in the scientific worlds, and also notes about certain figures, such as Harvey, Thomas Willis, John Mayow, and others, with whom Lower had personal or scientific contact. The material, however, is insufficient to make the narrative run in a connected fashion throughout the account, and I must apologize in advance for its disjointedness. Free quotation has been made here and there from original sources, partly to add picturesqueness and to make the story more human, partly also to publish material which would not readily be accessible to the ordinary reader.

An evaluation of Lower's work, and of his position as an original contributor to anatomy, physiology, and medicine, is a task which needs much further study, and I have not therefore attempted it here, though I hope it may be possible for me to do so at some future date.[1]

[1] Franklin, K. J., *The Work of Richard Lower (1631–1691)*, Proc Roy. Soc. Med., 1931, xxv, 113–118.

TREMEER, THE BIRTHPLACE OF RICHARD LOWER, AS IT IS TO-DAY

Photographed by Mrs. A. V. Schuster, with the kind permission of the present tenants

ST. TUDY CHURCH, CORNWALL, IN WHICH LOWER WAS BAPTIZED AND BURIED

BIOGRAPHICAL NOTICE

RICHARD LOWER was born of a very good family at Tremeer, near Bodmin, in Cornwall in 1631. Tremeer apparently came to the Lower family as the marriage portion of Mary Nicholls, Richard's grandmother, to whom was related Anthony Nicholls (1611–1659), a member of the Long Parliament. Mary Nicholls married Edward Lower, who was really of St. Winnow's Parish. Their son, Humphry, inherited Tremeer, and married Margery, *née* Billing of Hengar (the biggest house in the district), and widow of Samuel Trelawney. Margery Lower died on 27 August 1686, and there are monuments both to her and to Anthony Nicholls in St. Tudy Church. Humphry and Margery had three sons, Edward, who inherited Tremeer and bequeathed it to his daughter, Richard, and Thomas. Edward was buried at St. Tudy on 13 February 1690/1, ten days after Richard. Thomas became a physician in London, and later was imprisoned with George Fox in Worcester Gaol on account of his Quaker beliefs. Tremeer was also the birthplace of Sir William Lower, the dramatic writer, who was a kinsman of Richard Lower.

Richard was baptized at St. Tudy on 29 January 1631/2. In 1636 Thomas Willis, whose assistant he afterwards became and with whose fortunes he was to be so intimately associated, was entered at Christ

Church, being then fifteen years of age. Three years later Willis proceeded B.A. About 1640 Francis Potter (*1*, iii. 1156) entertained the notion of curing diseases by transfusion of blood out of one man into another, thereby anticipating Lower, as he himself was, apparently, anticipated by Libavius. In 1642 Willis became M.A. and about that time bore arms for the King. He then devoted himself to the study of medicine (*23*). In May 1643 John Mayow was born in the parish of St. Dunstan-in-the-West. In 1645 Thomas Millington, to whom Lower dedicated his *De Corde* in 1669, was elected to Trinity College, Cambridge, from Westminster, where Lower also received his early education. In this same year William Harvey was, by the King's mandate, elected Warden of Merton College, but he left the University, in July 1646, on the surrender of Oxford to the Parliament, and returned to London. On 8 December 1646 Willis became B.M., and 'entering on the practice of his profession, he regularly attended the weekly market at Abingdon; he took a house opposite Merton College, and at once appropriated one of the rooms to the performance of divine service.' In January 1649 Charles I was tried and executed. This same year Lower was admitted a student of Christ Church from Westminster (*1*, opp. iv. 297), and he matriculated on 27 February 1650/1. On 17 February two years later he became B.A., and in June 1655 M.A. In 1656 Christopher Wren, assisted by Boyle and Wilkins, made the first successful intravenous injections, of opium and other drugs, into dogs. In 1657 Millington took his M.A. degree at Cambridge and removed to Oxford. William Harvey died on 3 June of this year. In 1658 John Mayow entered as commoner at Wadham College, being then fifteen years of age, and the next year was admitted Scholar. In 1659, also, Millington became M.D. and Fellow of All Souls, Willis published his *Diatribae duae Medico-philosophicae, quarum . . . agit . . . altera de Febribus*, &c., and Peter Sthael was brought to Oxford by Robert Boyle to give public teaching in chemistry, 'and by him settled in the same house wherein he lived, viz. in that house (owned then by an apothecary) next on the west side of University Coll. somtimes knowne by the name of Deep hall' (*31*, i. 290). Peter Sthael's later pupils included Christopher Wren and Lower. The next year saw the end of the Long Parliament and of the Commonwealth, and the return of Charles II as King; shortly after the Restoration, Willis was appointed Sedleian Professor of Natural Philosophy in place of Dr. Joshua Cross, and on 30 October was created Doctor of Medicine. John Mayow was elected a Fellow of All Souls in this, his second, year at Oxford, at the age of 17; he studied law and incidentally medicine. September 1661 shows the first of a series of entries in *Wood's Life and Times*, which give a picture of the friendship between Lower and Wood, whose physician Lower was for some years. Sir William Lower died at the beginning of 1662 and by his will, proved on 7 May, 'defeated his kindred of Tremere of his estate', which caused Richard Lower to describe him to Wood as 'an ill poet and a worse man'. In the same year Charles II bestowed the charter on the Royal Society, and Boyle enunciated his 'Law' in a separate tract, appended to the second edition of *The Spring and Weight of the Air* (19, 6). Peter Sthael had moved from Deep Hall to the house of Tylliard, an apothecary, when his class increased, and stayed there until the end of 1662, but early next year 'removed his school or elaboratory to a draper's house called John Bowell, afterwards mayor of the Citie of Oxon, situat and being in the parish of Allsaints, commonly called Allhallowes. He built his elaboratory in an old hall or refectory in the backside (for the house it self had been an antient hostle), wherein A. W. and his fellowes were instructed', Lower being of their number. 'In the yeare following Mr. Sthael was called away to London and became operator to the Royal Society.' In January 1663/4, Lower told Wood, 'as he was a cutting up a calf's head on a Sunday morning, about 8 of the clock in his study, his dore stood so much open as that he might thrust his fist throug: and hearing a russelling in his chamber, looked through that open space of his doore and saw the appearance of a beautifull yong man with long flaxen haire to his middle and a silke studying gowne on: and going to his study doore and oping it aske⟨d⟩ "Who is there, Sir John?" (meaning Sir John Hales who was his opposite neighbour): and going out into his chamber and seeing noe body, looked in his other study and none there neither. Then he went to his chamber doore, and that was shut and lached and could not be opened and shut without noise. And opeing the doore Sir J⟨ohn⟩ H⟨ales⟩ came out of his owne, who ⟨i.e. R. L.⟩ asked him whether he was in his chamber who ⟨i.e. J. H.⟩ answ⟨er⟩ed faithfully that he was not. Wherupon he took this to be an appearance.'

'This put mee in mind of Mr. J. C.,[1] who when he lay awake in his chamber at L⟨incoln⟩ C⟨ollege⟩ and his violl standing in a corner, something played over his strings, etc.'

In April 1664 Lower, while travelling with Dr. Willis to visit patients, made a discovery of the medicinal water at East Throp, commonly called Astrop, near Kings Sutton in Northamptonshire, 'the doctor being then, as usually, asleep or in a sleepy condition on horseback. Afterwards, our author Lower imparting his discovery to the doctor, they in their return, or when they went that way again, made experiments of it, and thereupon understanding the virtue thereof, the doctor commended the drinking of it to his patients. Soon after the water was contracted into a well, and upon the said commendations, 'twas yearly, as to this time it is, frequented by all sorts of people.' This discovery may have suggested the analogy on pp. 71–2 of *De Corde*. 1664 is the date of publication of Dr. Willis's *Cerebri Anatome Nervorumque descriptio et usus*, and in the preface the author makes handsome acknowledgement of Lower's contribution to the work. From other sources also we learn how much it owed to Lower's anatomical skill. Wood, for instance, says that Lower practised 'under Dr. Tho. Willis, whom he helped, or rather instructed in some parts of Anatomy, especially when he was meditating his book *De cerebro*'; while Henry Stubbe, an old schoolfellow of Lower, wrote 'I think my self

[1] John Curteyne, no doubt.

obliged to add one thing more where I speak as if Dr. *Willis* had had little to do in the discoveries of Dr. *Lower* about *Anatomy*: that although that great *Physician* had not leisure to attend the *Anatomical Inquiries*, yet did he propose *new matter* for *improving the discoveries*, and put Dr. *Lower* upon continual investigation, thereby to see if *Nature* and his *Suppositions* did accord: and although that *many things* did occur beyond his *apprehension*, yet was the *grand occasion* of that work, and in much the Author' (*28*, 178). In this year, too, Clarke and Henshaw, on pigeons, and Lower, on dogs, made preliminary experiments on transfusion from vein to vein, J. D. Major made the first successful intravenous injections in man (*16*, 3), Mayow became B.C.L., and Dr. Willis, in December, Hon. Fellow of the College of Physicians. In 1665, the year of the Great Plague,[1] Lower published his *Diatribae T. Willisii de Febribus Vindicatio* and crossed swords for the first time with the Irish doctor, O'Meara. On June 6 there was a chancellor's letter to accumulate—he 'being very well qualified for it, having given extraordinary testimony of his ability in that faculty', and on 28 June he became B. and D. Med. In *Wood's Life and Times* there are the following entries, 'July 18, T., Dr. Lower and I was at Gasington at . . .', 'Aug. 8, T., I was at Gasington to speake with Mrs. H. in relation to Dr. Lower his buisness, but she denied her selfe.', '29, T., at the Castle when we parted with Dr. Lower.' What the business was, I do not know, but it is referred to again

[1] The Plague began in the winter 1664–5, became more serious in spring, and reached its full virulence in summer 1665.

in letters from Lower to Wood and from Wood to Lower in the next year (3). In 1666, towards the end of February, Lower transfused dogs at Oxford (*De Corde*, 174), and Boyle wrote to him on June 26, asking him to communicate details to the Royal Society. This Lower did on July 6 (*De Corde*, 177, 180), and the account was published by the Society in their Philosophical Transactions in December 1666 (*De Corde*, 176). In the earlier part of this year Dr. Willis, on the invitation of Dr. Sheldon, Archbishop of Canterbury, removed to London, and took up his abode in St. Martin's Lane. The reputation he had acquired at Oxford preceded him to town, and at once introduced him to an extensive and lucrative practice: 'in a very short time', says Wood, 'he became so noted and so infinitely resorted to for his practice, that never any physician before went before him, or got more money yearly than he.' Lower followed him later in the year, and settled at first in Hatton Garden. In September[1] he was at Tremeer, as is shown by his letter to Antony Wood (3):—

4 Sept. 66.

Deare freind

I have rec^{d} but one lre. from you since I came away & yt was concerning Mr. H. but take no more notice of it, for I never intend to trouble my selfe any more in such matters: I hope to see you ag^{n} at Michaelmas or thereabout, in ye meane time remember mee to Honest J. C. etc. & if you have any newes worth yr sending twill bee very welcome, but nothing more then to heare yt you are well: I am sorrie J. C. is leaving Oxford, but if hee intend noe

[1] The Great Fire of London began on 2 Sept. 1666, and lasted for five days.

farther then London this winter, I hope I may have an opportunity to take my lea[ve] before hee travell

I am yr most
Affectionate fr^{d} & serv^{t}
R. Lower

[Tre]meere in
[Co]rnewall.

Wood replied (*ibid*):—

D^{r}

I have recd yrs dated 4 sept. for w^{ch} many thanks. I had sent oftner to y^{o} but y^{e} told me in y^{r} former letter y^{e} should be with us about y^{e} latter end or middle of aug: w^{ch} stayed my hand, I am very glad of y^{r} resolution against *those matters* y^{o} spoke off, I hope y^{o} will continue in it & not play y^{e} foole any further in them to y^{r} loss of money & time. I suppose by this time y^{o} have had soe great experience in them y^{t} I need not tell or advise y^{o} against them any further. Wee all here upon watch & ward day & night expecting y^{e} same doome y^{t} y^{e} Londoners have lately recd. & none can passe unless they bring sufficient testimonyes from whence they come; severall people have bin taken upon suspicion y^{t} come from London, & others againe y^{t} set houses on fire at Wolvercot, & Brightwell by Wallington, y^{e} plot as is generally reported was layd & acted by 8 papists french but how true I know not, time will discover all. by michaelmas, y^{e} time w^{n} you say youl come to us, y^{o} will find the scollers much changed in their habits for wee having a new vicecanc. (viz. Dr. Fell) all old laws & statutes are & will be revived & put in force nothing I have else to writ but

yrs now & ever
A. W.

if we could know y^{e} day of y^{r} coming to us
wee would take a walk & meet y^{o}.

Sept. 15. 66.

On 17 November 1666, Lower married Elizabeth, daughter of John Billing of Hengar, and widow of John Trelawney of Coldrinnick. By this marriage Hengar, parcel of the manor of Penrose-Burdon, apparently came into the Lower family. After Lower's death it passed to his eldest daughter, Loveday [?], who married, first the elder son of Sir William Morice, secretary of state, and secondly Major-General Trelawney. Hengar afterwards passed to Lower's second daughter, Philippe [?], who also married twice, and also had as second husband a Major-General, named Wheeler. Hengar was in Lyson's time the occasional residence of Philippe's daughter-in-law by her first marriage.

On 15 June 1667, Jean Denis made the first successful transfusion into man at Paris; on 17 October Lower was elected Fellow of the Royal Society; and on 23 November he and Edmond King, before that Society, made the first successful human transfusion in England. Arthur Coga, variously described as a 'harmless lunatic' and an 'eccentric scholar', was the subject, and was given nine or ten ounces of blood from the artery of a sheep. 'The man, after the operation, as well as in it,' is said to have 'found himself very well', but Stubbe (*28*, 179) has the following rather contradictory statement from the patient:—

To the Royal Society the VIRTUOSI, *and all the Honourable Members of it, the Humble Address of*

AGNUS COGA.

Your Creature (for he was his own man till your Experiment transform'd him into another *species*) amongst those many alterations he finds in his condition, which he thinks himself oblig'd to represent them, finds a decay in his purse as well as his body, and to recruit his spirits is forc'd to forfeit his nerves, for so is money as well in peace as warre. 'Tis very miserable, that the want of natural heat should rob him of his artificial too: But such is his case; to repair his own ruines, (yours, because made by you) he pawns his cloaths, and dearly purchases your sheeps blood with the loss of his own wooll. In this sheep-wrack't vessel of his, like that of *Argos*, he addresses himself to you for the Golden Fleece. For he thinks it requisite to your Honours, as perfect Metaplasts, to transform him without as well as within. If you oblige him in this, he hath more blood still at your service, provided it may be his own, that it may be the nobler sacrifice.

The meanest of your Flock,
AGNUS COGA.

Mayow's *Tractatus de Respiratione* appeared in 1668, and possibly also Lower's *De Corde* (*31*), despite the date 1669 on the title-page. In 1670 Mayow became D.C.L., and was also allowed to practise physic, though he had not the medical degree of the University (*20*, 8); in his *Tractatus Quinque* of 1674 he is described as Ll.D. and Medicus. Sthael returned to Oxford for a year in 1670 and then went back to the Royal Society. On 22 December 1671, Lower was a candidate of the Royal College of Physicians. In 1672 he published *Dissertatio de Origine Catarrhi et de Venaesectione* as a separate work; it had been attached to the 3rd edition of *De Corde*, Amst., 1671. In this year Thomas Willis also published *De Animâ Brutorum . . . Exercitationes duae* . . . In 1673 Lower's younger brother, Thomas, was arrested with George Fox, the Quaker, at Armscott, Worcestershire, and was carried to Worcester Gaol, where he remained for more than a year. Through Lower's interest, a letter was obtained which would have secured his brother's release, but, as it did not mention Fox, both of the prisoners continued in restraint. In 1675

Mayow left Oxford for Bath, Sthael died [?], and Lower, on 29 July, became Fellow of the Royal College of Physicians. On the 11 November Dr. Willis died at his house in St. Martin's Lane, and was later buried in Westminster Abbey. Lower, who had lived successively in Hatton Garden, Salisbury Court near Fleet Street, and Bow Street, now moved to his final London residence in King Street, near Covent Garden; 'where being much resorted to for his successful practice, especially after the death of Dr. Willis . . . he was esteemed the most noted physician in Westminster and London, and no man's name was more cried up at court than his' (*1*, iv. 297). Dr. Tenison,[1] Archbishop of Canterbury, was often heard by Wood to say 'that Dr. Lower was his special friend, and had the protestant interest very much at heart, and was for that reason a great lover of news and used to show that humour in every visit he made. He went very often to Nell Gwynne,[2] and would pick out of her all the intrigues of the court of King Charles II. He was heartily against a popish successor, and against the proceedings of the court of King James II, that the King himself was used often to complain of him and say, he did him more mischief than a troop of horse' (*1*, iv. 299). But this is anticipating. On the outbreak of the Titus Oates plot in 1678 '(about which time he left the royal society, and thereupon their experiments did in some manner decay)', Lower 'closed

[1] Dr. Tenison was Rector of St. Martin-in-the-Fields for eleven years from 8 Oct. 1680. He studied physic for a year or two at Cambridge after taking his B.A. in 1657. (Dict. Nat. Biog.)

[2] Nell Gwynne (1650–1687) was mistress to Charles II from 1668. (Dict. Nat. Biog. article *Charles II*.)

with the Whiggs, supposing that party would carry all before them: But being mistaken, he lost thereby much of his practice at and near the court, and so consequently his credit. At that time a certain physician named Tho. Short a R.C. struck in, and carried all before him there, and got riches as he pleased; but he dying in the latter end of Sept. 1685, most of his practice devolved on Dr. Joh. Radcliffe' (1653–1714). Mayow was elected a Fellow of the Royal Society on 30 November 1678, but died the next year, when still a young man, 'in an apothecaries house bearing the sign of the Anker in York Street, Covent Garden, London, having a little before been married not altogether to his content.' In 1681 Lower discredited Dugdale by his evidence at College's trial (*9* and *20*): he is described (*9*, *297*) as being 'then the most celebrated physician in London'. In 1683 took place the opening of the Ashmolean Museum at Oxford, perhaps the oldest museum in Europe; and Lower's father died in this year. Charles II died in 1685, and Evelyn wrote ten years later, 'Had much discourse' with Lord Normanby 'concerning Charles the Second being poisoned. Also concerning the Quinquina, which the physicians would not give the King at the time when, in a dangerous ague, it was the only thing that could cure him (out of envy because it had been brought into Vogue by Mr. Tudor, an apothecary) . . . Being asked why they would not prescribe it Dr. Lower said it would spoil their practice or some such expression.' On the accession of James II Lower was deprived of his court appointment, and fell into disrepute (*20*).

References to Lower about 1687, and in 1688, occur in *25*, i. 26, and in *26*, 33–5. In the latter year occurred the Glorious Protestant Revolution, William of Orange landed at Torbay on 5 November, and James II fled. In 1689 followed the Declaration of Rights, and the accession of William III and Mary as joint sovereigns.

Lower died at five o'clock on the morning of Saturday, 17 January 1690/1 (*26*, 97), in his house in King Street (*1*, iv. 298). A few days before, 'his chamber chimnie beinge on fier he got out of his bed, called for water, and a sheete to clap [on] the chimnie, and stayed so long about it that he caught cold, which put him into a feauour' (*4*, 364). On the 15th he was at the point of death, and his physicians had given him over (*31*, iii. 351). Wood D. 26, no. 14, is a leaf, 'Gualteri Charleton Scripta jam in lucem emissa'. It has this note (?by Aubrey), 'Jan. 15', corrected by Wood to 17, 'Dr. Lower died in Convent Garden, the bell now rings out for him. Dr. Charlton remembers him to you and tore this for you out of his book of anatomical lectures' (*ibid.*). Wood refers to him as 'the learned doctor', and 'the famous Dr.', and Luttrell as 'the famous physician'. His body was conveyed to St. Tudy (where some years before he had purchased an estate), and was buried in a vault under part of the south side of the church there (*1*, iv. 298). An entry, very faint, in St. Tudy's parish register reads, 'Dr. Richard Lower was buried 3 of Feb. 1690. No affidavit brought.' By his will Lower 'gave (as it was then said) 1000*l.* to S. Bartholomew's hospital in London, 500*l.* to the

French protestant refugees, 500*l.* to the Irish protestant refugees, 50*l.* to the poor of the parish of S. Paul in Cov. Garden, 40*l.* to the poor of two parishes in Cornwall where he had land etc.' (*1*, iv. 298–9). There are in existence two epitaphs on Lower, but they give very conflictng views. The first (*2*) reads:—

An
ELEGY
ON THE
Death of that Learned and Famous PHYSICIAN
DR. RICHARD LOWER

Unhappy Age! That must at last resign
A Soul so great, and so Adorn'd as thine:
Adorn'd with all that former Times could shew;
All that the Ancients taught, or Moderns knew.
When the learn'd WILLIS dy'd, he did impart
His utmost Skill to thy capacious Heart.
Full well he knew, there was no other Shrine
So fit to keep his Treasure in, as thine.
So the Old Seer did to his Son dispense,
A double Portion of Prophetick Sense,
When in his fiery Chair he mounted hence.
WILLIS Expiring, joy'd in Thee, to find
He'd such a Legacy for Human kind.
A Legacy more valuable far,
Than both the *Indies* and their Riches are.
They cannot to our Days one Minute give;
But thousands by thy powerful Art still live.
And live thou wilt in them, till Time shall be
Quite swallow'd up in vast Eternity.
How many Millions did thy Art restore?
Just to the Rich, and Tender to the Poor:
In Consults serious, in Debating sound;
Free in Advice, in Judgment most profound.
Thy Friendship Courted equal with thy Art,
Unenvy'd Greatness, and diffusive Heart;

None ever did with more Success embrace
The Peoples Wishes, and the Prince's Grace.
Oh had kind Heaven, e'er thou from hence wer't hurl'd,
Been pleas'd to lend Thee longer to the World!
What lasting Monuments had'st thou design'd,
Both to relieve and to support Mankind,
When our wise King thy Worth and Parts had try'd,
And found Thee fit for Armies to provide?
Then gave Thee leave his Bounties to dispense,
Best for thy Countries Honour, and thy Prince.
And Reader, now would'st thou his Equal know,
Go follow him, for there's none left below;
Go, follow to that Blessed Place Above,
Where all your Admiration will be LOVE.

LONDON; Printed for E. REYNER. 1691.

The second (7) is briefer:—

upon Dr. Lowers death being A man of a morose disposition. *By* Dr. Baynard:

Had not good nature o're ye ill prevail'd
Death in attempting Dr. Lower had fail'd
who might have lived with us many a yeare
prepared (in his owne pickle) vinigar.
But when ye Alkali had kill'd ye soure
His blood being sweetened off went dr. Lower.

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   The following should also be referred to:—

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[1] The Royal Society of Medicine copy has the following inscription:

Hic liber est meus
Testis est Deus
Si quis me quaerit
Hic nomen erit
Wm Stevens.

The British Museum copy has Walter Charleton's autograph, and his dating, 1668.

[2] A copy in the possession of Dr. R. T. Gunther is inscribed *Mic. Theobald, 1669.*

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A TREATISE ON THE HEART

ON THE

Movement & Colour

OF

THE BLOOD

AND ON THE

Passage of the Chyle into the Blood

BY

Richard Lower, M.D.

LONDON

Printed by *John Redmayne* for *James Allestry* at the Sign of the *Rose and Crown* in the Street commonly called *Duck-lane*. MDCLXIX

To the most distinguished

Thomas Millington
M.D.

SOme will be surprised—you yourself perhaps among them, honoured Sir—that I am making a further contribution to the literature on the heart and on the blood, after the apparently exhaustive treatises so many famous men have already produced on this subject. *Harvey*, for [ii] instance, in so far as it concerned his magnificent discovery of the circulation, described the structure of the heart and the movement of the blood in a way that left practically nothing to be added or desired by his successors. But, just as in the *Ptolemaic hypothesis* of the heavens smaller epicycles are allotted to the planets when the enormous revolutions of the worlds have been dealt with, and these epicycles are indispensable for the explanation of observed facts, so in the system of the human body, as also in that of other [iii] animals, there are points not mentioned in *Harvey's* circulation which need consideration. These points are, I grant you, of minor importance, but they do definitely help in the rational study of a number of symptoms. *Harvey* himself, indeed, seems to promise further contributions, had age and time allowed, where in his Book on the Circulation of the Blood, Chapter 9, he says:—'But how much is expelled in each by the separate beats, when more and when less, and why, I shall perhaps reveal later in more detail as a result of many observations.' Most [iv] unfortunately, however, he did not fulfil his promise and we were disappointed in our hope. So, as no one has yet undertaken to supplement his work, either by a complete account of the structure and movement of the heart itself, or by an accurate estimation of the velocity and quantity of the circulating blood, or by a clear picture of the difference in colour [v] of venous and arterial blood—has not, at all events, satisfactorily explained them—I have myself tried to fulfil the promises of that excellent man, and to bring them nearer to completion than they have hitherto been. I have attempted to descend into the very depths of the heart, to examine and reveal the fount of life itself. In doing this, I have not hoped or planned to give a complete account of the heart, nor an exposition of all its various states and conditions. Rather I have attempted a somewhat fuller and wider consideration and explanation of the abovementioned structure and movement of the heart: I have similarly treated its various anomalies, and [vi] their causes and symptoms, so far as I have been able to follow them by observation, and so far as such seemed to make for advance in medicine. If, however, this account is in any way imperfect, or gives too meagre a description, in view of the functional importance of the organ, I shall perhaps later produce a fuller account, when I have collected more observations on this subject.

Meanwhile, it is a shame and a disgrace that, while some in this age of ours engage in work so beneficial to mankind and so likely to produce a healthier [vii] knowledge of Nature, others are not lacking, whose ill-will towards all, or envy of particular persons, is such that they place every obstacle they can in the way of so worthy a project, although for ignorance they cannot do more. Among these an Irishman, Meara, takes first prize for sheer per- [viii] versity and stupidity. Himself unskilled, he is pained that others know anything, as is clearly seen in his writings, lately published under the pseudonym of Conlo Cassinius. But I pass over these personal passages because, if I had to contend with him in this matter, I should not have to go into the ring so much as into the cess-pit, and a victory in those regions would not compensate me for the filth I picked up in gaining it. On the other hand, the erroneous views [ix] he holds, especially about the function of the heart, the movement of the blood, the nature of the chyle and its passage into the blood (on these subjects he has written with so little skill that he might have been deep in sleep for the last forty years, and still be imperfectly aroused from it), should not, in the interest of others, be passed over in like silence. I have therefore written four consecutive chapters in this Treatise on these matters. All these I have written clearly, less with the idea of further exposing his ignorance—obvious, indeed, long before this— [x] than with that of promoting general scholarship and profit.

While engaged on these matters, I have interspersed here and there not a few original observations on *the Structure of Muscles*, which I have found far different from what has hitherto been accepted; on *the outflow of Serum from the brain*, now discovered for the first time; on *the Colour of arterial blood*, and on various symptoms. Finally, I have added a whole chapter on *Transfusion* for two reasons: first, that the [xi] subject is a kindred one, and, secondly, so that the credit for the discovery of this celebrated experiment may be given to the Author, to whom it is rightly due.

Your generous nature will, I hope, excuse anything in these chapters which fails to pass the test of your critical judgement, and you will not, I trust, disdain to accept this token and testimony of my feeling towards you—a testimony whose lasting powers among others I cannot forecast, but one which I surely owe you.

Yours most affectionately,

Richard Lower.

The Anatomy of the Heart

CHAPTER I

The Position & Structure of the Heart

IT is of very great importance for a true knowledge of the nature and qualities of the blood to have investigated not only its circular movement, but also to know and to compare its movements, its amounts, its elements, its various changes and their causes, as well as to estimate the quantity of the same fluid thrown out [p. 2] in individual beats. I have, therefore, thought it worth while to give a clear and concise account of the whole matter (which has been omitted hitherto by most authors, and desired, rather than explained, by others, including even *Harvey* himself), so far as I shall be able to achieve this object by conjecture and by experiment.

But as the movement of the Blood depends on the movement of the Heart, and in the absence of the latter can neither be understood nor exist, I must preface my account of it by some remarks on the Position and Structure of the heart. When these have been duly considered and collated, it will be easier to grasp how carefully both its Fabric and Position are adapted for movement, and how fittingly everything is arranged for the distribution of the blood to the organs of the body as a whole.

Thus in Man, and in almost all Carnivorous animals, the seat of the heart has been placed, not in the centre of the body, but in its upper part, so that it might thereby more easily send the necessary share of blood up to the head. For the output and distribution of blood is entirely dependent on [p. 3] the systole of the heart, and the fluid is by its nature not so readily propelled to parts above as to vessels on the same level, or downwards to vessels below; hence it would either be necessary, were the Position of the heart farther from the head, for that organ itself to be more strongly built to give a more powerful drive to the expelled blood, or else the head would often become unsteady through lack of blood. In those animals, however, which have a rather long neck, the better to equip them in their search for food, the position of the Heart is equidistant from the head and other parts; and this causes them no inconvenience, because they seek their food for the most part with their head hanging down, and to that extent the blood, while it has farther to go than in other animals to get to the head, yet travels thither along a more horizontal course, and more often, indeed, than not, along a downward one.

The part next the heart (about which I must preface a few remarks) is its membranous capsule, called the *Pericardium*, because it completely envelops the Heart itself (as the shell of a nut does the kernel). It is a strong and robust Membrane common and continuous everywhere with the Pleura, except where it is pierced by vessels; it has, in addition, the same [p. 4] shape and practically the same size as the Heart itself. For this organ it constitutes so necessary a support, that it is never found lacking in the smaller birds, serpents, frogs, and in all other animals, even the most minute, which I have hitherto been able to dissect. Its function is best conjectured from the fluid which it contains; for, besides the fact that the heart parenchyma, being protected by the pouch in question, is not affected by empyema, does not adhere to the lungs, and is less exposed to the ills of adjacent organs; there is always to be found in the clear space between the heart and the membrane some Serum, or watery fluid. By its means the external surface of the heart is constantly moistened, whereas, but for this action, it might shrivel and dry up through its continuous motion and heat, and so be rendered unfit for movement.

The origin of this fluid and its most probable source have not, however, been correctly stated hitherto. Several authors assert that the serous humours are raised into a cloud by the heat of the heart, and are kept in by the thickness of this membrane. They condense to form the fluid we are discussing, and this is, in consequence, according to the diversity of temperament, greater in amount in warm-blooded people, [p. 5] and less, on the other hand, in cold-blooded. But if we are to agree that such is the origin and cause of this fluid, there remains to be explained why, in particular, it does not often accumulate here in larger amount; for, as the humours must be raised into a cloud by the continuous heat of the heart and be kept inside by this membrane and turned into water, what is there to prevent its accumulating in unduly great amount, so that this capsule shall be unable to hold it? Further, since it will be continuously on the increase, unless it has at the same time some outlet, it may either be corrupted by excessive stagnation, or at least the heart itself may be overwhelmed by its over-production.

In seeking elsewhere, therefore, for the source of this fluid, we must notice that Nature uses much the same mechanisms and instruments in the various organs of the body, where the same or similar type of work or of functions exists; and, just as she sets lachrymal glands to collect fluid to anoint and moisten the eyes (and in its absence they would become dry [p. 6] and unfit for movement), so likewise has she placed various glands round the base of the heart. From these fluid trickles out inside the capsule, and, shaken hither and thither in the clear space we have already described, bathes the entire surface of the heart, and thereby renders its movement more ready and more easy of accomplishment.

Further, that this fluid is not entirely excretory in nature, or watery like the dropping dew, but rather part of the nutrient Serum oozing from the blood, is shown by the fact that it sets into a white jelly when heated only a very little at the fire, exactly as the serum swimming in the blood after venesection does, or the lymph secreted from glands. Such consistency is not acquired by sweat or by urine after any amount of boiling; they are either evaporated completely, or leave a sandy residue. One thing only must be noted, in passing, in this connexion, namely, that only that pericardial fluid is suitable for this experiment, which is found in a healthy animal suffering a violent death: the blood of such an [p. 7] animal contains nutrient serum. In animals dying of disease, or worn out by long-continued lack of appetite and ability to eat, the blood is completely devoid of chylous juice, and the result is as different as are the circumstances. But in healthier animals the fact is so clear that you find a large amount of mostly solid jelly in the opened pericardium of a slaughtered Bull. It only needs the heat of the organ to fail for it to set to that consistency: the effect is due to spontaneous action or to cold, and may be paralleled by the sudden setting into a jelly of a decoction of Hartshorn, when exposed to cold air.

Enough, however, has been said of the Fluid contained within the capsule: with regard to the membrane itself, there still remains the question, What is the final and efficient cause why the human pericardium is always attached to the diaphragm, when the same structure in the quadruped is free, and separated by a clear space from the diaphragm? As regards the *final* cause, the reason for the difference does not seem to lie in the fact that the human diaphragm has not to expand like that of other animals, for the similar functional necessity for respiration in man and other species makes such [p. 8] expansion necessary. Man, however, walks and stands upright, and the abdominal viscera therefore descend more easily through their own weight; hence there is less need in man for a strong diaphragmatic systole to help inspiration. Further, in expiration it is equally necessary for the same diaphragm to relax and to lessen its tension, so it had to be properly joined to the capsule of the heart in Man, lest, while he walked erect, it should be so depressed by the weight of the liver and other attached viscera, that the lung could neither collapse sufficiently nor expiration be properly effected. In quadrupeds the abdominal viscera rest on the diaphragm itself, and drive it up into the thoracic cavity by their weight, so in them a similar junction of pericardium and diaphragm would not have helped expiration, and would have been directly disadvantageous in inspiration, by interfering with the proper contraction of the diaphragm.

The Pericardium is, therefore, left free in lower animals so that it should not obstruct the systole of the diaphragm; in Man, on the other hand, it is attached to the diaphragm to help its diastole during expiration.

[p. 9] If, however, one asks what is the *efficient* cause of such a connexion in the human thorax, I would reply, as a suggestion only, that it is as follows. The Infant, shut up in its Mother's womb in the last months of pregnancy, lies for the most part with its head downwards (fitting the organ better so); thus the abdominal viscera rest all their weight on the diaphragm, which is as yet inactive and unoccupied with any movement, and so move it nearer the heart; they detain it in contact with this organ until it gradually adheres, and is finally so firmly attached as to be unable to free itself or to resume its old position.

From this same settling down of the lower viscera into the thoracic region of the foetus comes not only, I think, this adherence of the pericardium to the diaphragm, but it is also, I suspect, the reason for the greater deflection of the apex of the heart in the human being as compared with the rest of the animal kingdom. The diaphragm is applied to the whole side of the human heart and not to the apex only; this [p. 10] could scarcely have happened but for the downward pressure of the mass and weight of the viscera. If you ask me, however, why the apex of the human heart inclines to the left, I imagine it is because the trunk of the Vena cava, by passing through the diaphragm and travelling up along the right side of the heart, prevents this organ falling in that direction. On the other hand, a space lies free and unobstructed in the left half of the thoracic cavity, and so the apex of the heart is always deflected to the left by the mass of the superincumbent viscera, and comes to lie so close to this same left side (especially when the lung is collapsing during expiration, and the heart is turned to the left) that we can quite easily feel its vibrations with the hand.

Now that these points have been dealt with, it is necessary to show the supports on which the Heart itself rests, the stays with which it is fastened, and further how all these help, or at least are favourable to, its movement.

There are indeed many helping hands, so to speak, stretched out to assist the heart, but the chief support and [p. 11] stay of its parenchyma are the blood-vessels, which are like so many roots for its attachment. Also, since the base of the heart was designed to receive the blood into openings and wide apertures and to press it out again, it was absolutely necessary for it to be rendered specially fit and suitable for that office. But the peculiarly firm foundation that the blood-vessels provide for the performance of the heart's movements will be described at greater length later on, when I speak of the heart's movement.

The next remaining subject will therefore have to be discussed, namely, the parts of the heart. Among these, the nerves and blood-vessels which pass across its external surface are the first to meet one's eye, and should therefore be dealt with before the other parts.

It used to be a question of dispute whether the blood-vessels take their origin from the heart, or rather terminate in it. But since the *Illustrious Harvey* has shown that the first threads and beginnings of life are housed in a small scar-like mass, and that from the movement and pulsation of that very small sphere the arteries are moulded like so many pipes and channels for the carriage of the blood, there is no reason for us to delay long on that point. As regards [p. 12] the veins, however, the case is different. These vessels have come into being solely and exclusively to return the blood from the organs of the body, and hence they should undoubtedly be considered to arise everywhere in the peripheral regions of the body, and equally so to have their termination in the heart, into which they empty. No one will say that rivers arise from the sea into which they empty, but from their springs and rivulets. There are, however, other *vessels which* both arise from, and terminate in, the heart; for, while the Heart parenchyma provides heat and nourishment for the whole body, it also looks after itself in the same respects. It is warmed not only by the blood seething within its ventricles, and sated not only by the nutrient juice prepared within the ventricles, but in addition the chyle, which cannot adhere to the walls of the heart without danger to life (as will appear later) is distributed through the vessels together with the blood to the whole of the parenchyma. It there carries out the nutrition of the heart, and, as it is continuously used up, so an ever fresh supply of food-material comes to replace it.

It is true that the vessels which carry blood to the heart parenchyma are but two in number; they each divide, however, into two trunks soon after they are given off. The [p. 13] orifices of the vessels open off the aorta near its beginning, just outside the semilunar valves; they are called coronary vessels, because the trunks do not go off at once to the parenchyma, but first describe a circular course to ensure a better general distribution, and encircle and surround the base of the heart. From such an origin they are able to go off respectively to opposite regions of the heart, yet around the extremities they come together again, and here and there communicate by anastomoses. As a result fluid injected into one of them spreads at one and the same time through both. There is everywhere an equally great need of vital heat and nourishment, so deficiency of these is very fully guarded against by such anastomosis.

Moreover, just as there are two arteries carrying blood to supply the heart with food and heat, so are there two veins, also called coronary from their roundabout course, which serve to bring the blood back again. And, lest any one doubt later whether the capillary veins open into each other by anastomoses, let him look at the apex of the heart in a [p. 14] calf or any newly-born animal, in which these vessels are wider, and with the point of a small knife move and push the blood forward from this vein into that. He will then clearly see the fluid blood run from a vein on this side into a vein on the other side, and vice versa. I am sure that the same thing happens in the vessels of the bladder, intestines, stomach, and brain, so I have no doubt that capillary vessels (of the same kind) open freely into one another throughout all the organs of the body.

On the subject of the Nerves which are embedded in the heart earlier Authors, who were ignorant of the movement of the heart and the blood, were mostly silent, and not unnaturally. Next after them come those who recognize, it is true, a circulation, but believe it to proceed so slowly and in so tortoise-like a fashion that they say the blood is poured out drop by drop, and only leaves the heart when it bubbles over; little concerned, therefore, whether or not the heart's movement helps the circulation of the blood, they attach little or no importance to the muscular structure of the heart, and to the numerous nerves. If, however, one considers the tendi-[p. 15] nous and fibrous material of which the heart is made, and how it is interwoven everywhere with so many nerves, one must also conclude that all this endowment was not made without purpose, but that it was constructed and set up to fulfil the same function as do the remaining muscles. It receives many nerve-fibres and offshoots from the nerves of the eighth pair, all of which give off various branches to each auricle, as they pass along between the pulmonary artery and the aorta, and are then distributed widely to the heart-substance. These nerves are more clearly seen in the heart of a calf or of some new-born animal, where they are visible over the whole of the external surface of the organ. What service they perform for the heart will be related later.

Meanwhile it will not be out of place to turn one's attention to the different ways, in which the spirits flow through the nerves into the heart, according to the diversity in shape of animals. For the brain has no power or property of movement, to enable it to drive out the animal spirits (as the Heart drives out its blood), and the nerve fluid and spirits therein enclosed drop downwards only, owing to their nature, like water from its Retort; hence it comes about that the [p. 16] head, or the spinal cord, is placed above the rest of the body in every kind of animal, or else is able, at the will of the animal, to be lifted up to such a position. And, while one must admit that the inflow of blood into the brain drives the spirits out through the apertures and pores of that organ, as in the rest of the body, and that they are forced into the nerves and spinal cord in a continuous stream by this *vis a tergo*, yet, since this nerve fluid will be more difficult to drive and push upwards than downwards, the brain, or at least the spinal cord, is placed at a higher level than the rest of the animal, to allow the animal fluid to flow down with more ease into all the underlying organs. It was the difference in origin of the nerves from the spinal cord in Man and in quadrupeds which first led me to this interpretation. In Man, who has been fashioned with head and spine upright, all the nerves leave obliquely and are carried obliquely downwards; but in Brutes, the spinal cord of which is placed at a higher level than the body as a whole, all the nerves leave the cord in a vertical direction, and are also carried vertically downwards from it, once they have passed outside the verte- [p. 17] brae. In addition, while nerve-branches are inserted into the human Heart from the nerves of the eighth pair only, in the majority of the Brutes it is far otherwise; for, apart from the branches distributed from the nerve of the eighth pair, the parenchyma of the heart also receives very many nerve-offshoots from the intercostal nerve, as it crosses directly over the Heart. By these means the animal spirits flow into the Heart more easily to assist its movement, as one will see at once on first glance in calves, horses, and larger Animals. Clearly nature made this as an extra provision for Brutes, in case their heads, which are bent down in looking on the ground, should impart the animal spirits with insufficient ease or in insufficient amount to the rest of the body.

The Vessels of the Heart thus explained, we come at last to the Parenchyma or, rather, to the *Muscular Substance* of the organ. This, it is to be noted, is more carefully fashioned than all other Muscles of the Body. For its work is more necessary and continuous than that of all other muscles, and hence it was particularly appropriate that it should also far surpass them in the elegance of its structure. Yet, though it [p. 18] is obviously designed for a nobler purpose than are ordinary muscles, and surpasses them by reason of a certain special texture it possesses, it has this in common with them, that its fabric and movement are based on exactly the same kind of fibres and mechanical devices, even if these are differently arranged. To make this clearer, straight muscles must be compared with oblique muscles: but it is certain that any muscle you like in the whole body, whose fibres and whose movement are straight, is not provided with a single belly only (as Anatomists have stated hitherto—they admit only two double-bellied Muscles in the neck), nor with a head and a tail; it is equally certain that the fibres are not carried directly from one tendon to another (as they are usually pictured: see *Plate 3, Fig. 1*). But all have two bellies and their fleshy fibres are carried from a different origin to different and opposite terminations. This is shown in *Plate 3, Fig. 2*. In this figure

aa are the Tendons on the two sides.
bb are the two bellies of the double Muscle, with their fibres terminating respectively at opposite ends of the muscle.
[p. 19] *cc are the outer aspects of the two tendons into which all the fibres are inserted.*

This is the structure of all the Muscles throughout the body, whether in the upper or lower parts of the leg, the arm, or the neck of Man; further, the Muscles of the abdomen, the Maxillary muscles, the Temporal muscles, the Diaphragm, and the external and internal Intercostals, so called (of which each and all are twin bellies of one Muscle), are fashioned in the same regular manner. In order not to confine my examples to one single figure of a simple two-bellied muscle, I may perhaps put forward one or two diagrams of a more complex Muscle, such as is revealed in the different views of the dog's lumbar Muscle in *Plate 3, Figs. 3, 4, and 5. Fig. 3* shows the part of that Muscle which lies nearest the abdomen, with its perfectly parallel fibres ending in a long tendon at the end of their downward course. In this figure

a is the fleshy part of the muscle near the kidneys.
b is the lower part of the muscle where the tendon is inserted into the leg bone.
[p. 20] *cc are fibres going to end directly in one or the other tendon.*

The fourth Figure shows the lateral aspect of the same lumbar Muscle as it lies on the spinal vertebrae. This aspect is made up of a number of separate Muscles, and the tendon of each one of them is inserted into a separate vertebra. In this figure

a is the inner part of the muscle going away down to the tendon.
bbbbb are the small muscles on the opposite aspect. Their tendons
ccccc are inserted in each case into the nearest vertebra, and point upwards.

The structural arrangements of the two aspects of the muscle are shown simultaneously in Figure 5, so that one may see at a glance that it is one and the same Muscle, but with its fibres going in opposite directions.

In Figure 6 of the same Plate is depicted a certain Muscle which I call *Plumaris* on account of its shape. It occurs at [p. 21] the extremity of the Leg of the sheep, has its origin in the femur, and ends in a long tendon, which is inserted into the animal's tibia. While most other muscles give a picture closely resembling a feathered quill, this particular one is composed of a double feather; and, fashioned as it is on the pattern of a two-bellied muscle, it is also, apparently, designed for a corresponding movement. But the most complex of all muscles is that called the Deltoid; it has several bellies; these, by alternately facing in opposite directions, show clearly that, although nature is often apt to vary her manner of forming Muscles in different parts of the body, yet she always aims at the methodical arrangement of the two-bellied Muscle. This is clearly seen in *Plate 4, Fig. 1.* In this figure

aaa is the upper tendinous portion of the Deltoid Muscle, which is inserted into the scapula and the clavicle.
bbbb is the lower tendinous portion inserted into the middle of the arm.
ccc are the bellies of the muscle which point upwards.
ddddd are the bellies which point downwards.

[p. 22] The reason why the so-called two-bellied Muscles in the neck join in common central tendons, contrary to what one may see in all other Muscles of the body, lies, I imagine, in the following fact. They pass up over the jugular vein on each side of the neck, and hence, by compressing it, would interfere greatly with the descent of the blood from the brain, had it not been arranged that they should thin out at this point and be united by tendons. This is clearly seen in *Plate 4, Fig. 2.* In this figure

aa is the jugular vein.
bb is the two-bellied muscle.
cc are the two tendons.
d is the point of junction of the tendons from each of the two bellies.

I could have pictured several other straight Muscles without displeasure to the eye, but, as the texture of all is on a similar plan, the next thing which remains is for me to show the points of similarity between the Muscle, whose fibres and movements are obliquely circular, and the straight muscle.

[p. 23] According to Geometry's laws, the straight line is the guide to the oblique. Similarly, the common standard of the Structure of the straight Muscle is the best approach to the study of this circular Fabric of the Heart. For, just as the straight muscle is composed of a double series of fibres pointing towards different and opposite ends of the Muscle, and these, on contraction, draw their respective tendons nearer to one another, so exactly does it happen in the making of the Heart's Fabric and in the carrying-out of its movement. It is formed for the most part of a double set of fibres which go off from a common origin to opposite portions of the Heart. Nothing is clearer than this, whether we consider the termination of the Heart's fibres, or their course and sequence.

In a Heart, which has been well boiled and has had its auricles and larger vessels removed, there is seen a fairly strong tendon which passes right round and encircles the edge of the heart about its openings. In certain animals a part of this tendon at the top of the septum is ossified and hard. [p. 24] The fleshy fibres which enfold and make the external surface of the Heart pass upwards and to the right everywhere to be inserted into this tendon. The inner fleshy fibres, on the other hand, which lie next to the ventricular cavities, are inserted into the same tendon in exactly the opposite direction, as can be seen in *Plate 2, Fig. 1.* In this figure

a is the opening through which the Right ventricle receives blood from the vena cava.
b is the opening through which it expels it into the lung.
c is the opening through which the left ventricle receives the blood as it returns from the lung.
d is the opening through which it ejects the inflow of blood into the aorta.
eeee is the tendon set all round the openings of the Heart.
fffff are fibres returning on all sides from their passage round the outside of the Heart, and brought to an end in its tendon.
ggggg are inner fibres ending in the same tendon in a direction exactly opposite to that taken by the external ones.

Now that it is clear that the Heart's fibres end in two [p. 25] different ways, it is next necessary to show that they also encircle the whole circumference of each ventricle in a similar sequence, with the exception of a few rather delicate fibres, which are carried straight up over the external surface of the right ventricle to terminate in the base of the heart, as they are pictured doing in *Plate 2, Fig. 2.* In this figure

a is the base of the Heart.
b is the apex.
ccc are straight fibres pointing up towards the base.

All the other fibres common to each ventricle pursue an order and sequence which is double only, but diametrically opposite in its two parts. The fibres immediately underneath these straight external fibres in the right ventricle pass up obliquely to the right to terminate in the base of the Heart, and by their spiral course recall quite well *Helix* or the snail. As is to be seen in *Plate 2, Fig. 3*. In this figure

a is the base of the Heart.
b is the apex.
c are the fibres which enfold the left ventricle.
[p. 26] *d are the fibres which enfold the Right ventricle.*
e is the groove separating the two ventricles, which is hollowed out to receive the vessels of the Heart.

Under these external fibres are placed others directly opposite to their predecessors. Whereas the outer ones are carried across from the left side of the Heart to terminate in its base, these others pass in exactly the opposite direction. They arise all round the right side of the Heart, from there are carried obliquely across to the left side, and, encircling both ventricles of the Heart, pass up to the base of the left side, forming a second, inverted, *Helix*. As is clear in *Plate 2, Fig. 4*. In this figure

a is the base of the Heart.
b is the apex.
c is the right side.
d is the left side.
e are the fibres of the right ventricle.
f are the fibres of the left ventricle.

The orderly sequence and infolding of all these fibres will [p. 27] easily be grasped by any one who tries dissecting the Heart of an ox or of a sheep. Those in the first layer can easily be seen at first glance when the cuticle of the Heart has scarcely yet been removed, while the others, which are more deeply hidden, only come into sight when the first are taken away. In following them out, moreover, there is no need of any great caution, for their courses and convolutions are so obvious and distinct that they appear to be formed by a line of thread. Yet, although one may certainly liken them at first glance to rather thick threads wound into balls, they are not interwoven in the same way or, further, on the same plan as such balls; for, if one may pursue the metaphor, they do not encircle the Heart in a continuous thread, or in regular series of loops, and cannot, therefore, be unwound, like balls of thread, in a continuous sequence. For, though one might think, after separating off the external membrane of the heart, that, as far as one can judge from ocular inspection, all the fibres reach in one continuous course from the base of the apex of the Heart, yet, if one tries to measure out their courses from one end or the other, one will readily perceive that a very few fibres travel about half at least of that [p. 28] distance, but, having gone a little way from the aforesaid tendon, they soon twist under the preceding fibres, and are at once lost to view. Indeed, with regard to the external fibres, one has to confess that they do not all reach from the base to the apex; certain of them are shorter than the others, and, as soon as they have passed half way across the Heart, curve in at once like a bent bow and are inserted obliquely into the tendon of the other side and ventricle. The way in which they bend in and mutually support one another by the interdigitations of the fleshy fibres, is evident in *Plate 2, Fig. 5*. In this figure

a is the tendon round the opening of the right ventricle.
b is the tendon round the opening of the left ventricle.
c are fibres stretching from one tendon to the other with intermediary fibres passing hither and thither for mutual support.
[p. 29] *d is the place where, having enfolded the right ventricle, they curve to end obliquely in the tendon of the left ventricle.*

Now that we have seen clearly the course of the fibres common to both ventricles, it remains for us to dissect off the right ventricle, and to give equal consideration to the arrangement of the fibre-course in the left ventricle. As both sets, indeed, perform the same function, their structural scheme and form is similar; in other words, it is composed of a double set of fibres ending in opposite tendons. The external fibres pass upwards and to the right over the whole circumference of the left ventricle, and curve spirally upwards to end in the base of the Heart, as shown in Fig. 6.

In this figure the left ventricle is pictured lying on its side, to demonstrate the way in which the fibres converge at the apex of the Heart. In it

a is the base of the ventricle.
b is the apex.
ccc are fibres ascending obliquely upwards and to the right towards the base of the heart.
d is the side next the right ventricle.
e is the left side.

[p. 30] But in this ventricle also the whole of the fibres do not reach from the base to the apex, and, only after a number have been removed, can the others be separated that far; for several are deflected from the general course and path in the middle of their passage across the Heart, and disappear under the next preceding fibres to ascend obliquely to the tendon of the opposite side, and so describe by their passage a shorter circle. As was seen above in Fig. 5.

The inner fibres, on the other hand, all ascend obliquely upwards and to the left, in exactly the opposite direction to the outer fibres, to reach the base of the heart. They are inserted into the tendon at the base and form the inner wall of the ventricle.

The longer fibres of the opposite set run together to the apex of the Heart, and pass round it to form a whorl, in such a way, however, that the space which is left in the centre becomes the thinnest part of the Heart. The fashion of this whorl, and the meeting in it, at the apex of the Heart, of the fibres of the outer wall of the left ventricle with those [p. 31] of the inner wall, are quite well shown in Fig. 7. In this figure

a is the tendon of the right side.
b is the tendon of the left side.
c are some fibres of the outer wall.
d are fibres of the inner wall, together with the whorl formed by fibres of both sets near the apex.

From this it is obvious enough that the fibres of the outer and inner walls have contrary courses and also perform antagonistic movements, but that they do this in such a way that, while they cause the walls of the heart to shorten in opposite directions, they make both walls contract into a closer and more confined space. This will be shown more clearly later.

One point remains for me to mention, namely, that not all the fibres end at once in the tendon placed round the openings of the Heart; some of them protrude from the two sides of the left ventricle to end in the so-called fleshy columns. These columns, however, give off various tendons [p. 32] to the so-called mitral membranes, and these membranes are joined to the tendon at the base of the Heart. As regards the Heart's movement, therefore, the result is the same by whichever route they reach the base of the Heart.

Up to now we have seen the diverse way in which the fleshy fibres surround the sides and walls of the Heart. It remains only for us to explain how skilfully they are arranged round the apex of the Heart. This arrangement is more easily and neatly pictured than described, and it will therefore suffice to remark that, as the movement of the Heart and of the blood is circular, so also all the fibres and motor mechanisms of both here form more or less of a circle with its centre. This is shown by the apex of a boiled and dissected ox-Heart in *Plate 2, Fig. 8*. In this figure

> *aaaaa are outer fibres running in a spiral course to the apex as to the centre of a circle.*

And, while the inner fibres of the ventricle proceed in an opposite direction to the outer ones, if the inner part of the [p. 33] apex next to the ventricular cavity is considered, it will be seen that its fibres also form a sort of circle in the reverse direction to that formed by the outer fibres.

Finally, greater vibratory effort is necessary to drive the blood to the most distant organs of the body than to drive it only to the lungs, which are near by and spacious; hence it is to be noted that the left ventricle is stronger than the right, its fibres being individually thicker and more powerful than those in the other ventricle.

Up to now I have described the external structure of the Heart. It is only fitting that I should here say something about the auricles, for they are not less skilfully devised than is the Heart itself, even if they are smaller in size. The function and structural plan of both is the same. Each is a muscle and they are built up of a double arrangement of fibres. Nay more, as their movement precedes that of the Heart, they receive nerves from the branches of the eighth pair before these nerves reach the Heart itself. Their fibres are inserted into opposite tendons, for the tendon at the base of the Heart is common to the auricles also, and they rest on it as on a [p. 34] couch. The right auricle, however, on the opposite side, where it faces the vena cava, is strengthened by a harder, truly tendinous band. The fibres end, some in one, some in the other of these tendons, as is clearly seen in the everted and opened-out right auricle of the Human Heart in *Plate 5, Fig. 2.* In this figure

aaa is the base of the auricle where it joins the tendon of the Heart.
bbb is the tendinous band which separates it from the vena cava.
ccc are fleshy fibres passing hither and thither to the two tendons, and forming with their small intermediary fibres a feather-like pattern.
d is the large coronary vein.
ee are some smaller veins designed to return the blood from the Heart.
f is the upper part of the auricle.

I shall speak of their function below. Meanwhile, it should be noted that the comparative relations of the right and left auricles are not the same as occur in the case of the ventricles. [p. 35] The latter move simultaneously and with ever-equal paces; also, for a proper and regular lung circulation, more blood must not be poured out by the right ventricle than could be dispatched through the left; hence it was necessary that they should have practically the same capacity. For, with the exception of an extremely small portion of the blood (which is removed by the lymphatic vessels in the lung and serves to nourish and to moisten the lung) both chambers of the Heart hold and impart an equal quantity of this fluid.

Seeing that the features and conditions of the two ventricles are so regular and uniform in every respect, why is it that the auricles have no similar correspondence at all? I can only conceive that it is for the following reason. The auricles were apparently created and made to expel the blood into the ventricles, but the inflow of blood from the vena cava into the right ventricle proceeds slowly, and a larger and more capacious auricle is therefore needed on the right side, to receive within itself and to throw into the ventricle an amount of blood approximately sufficient to fill the cavity of the [p. 36] latter. On the other hand, owing to the collapse and subsidence of the lung in expiration, the blood is expelled and driven out at once in large amount from the pulmonary vein. Hence the only requisite is, apparently, that a more forcible movement shall be imparted to the blood as it flows past into the left ventricle, and that its passage shall be somewhat assisted. Thus there is no need of the help of so large an auricle on this side.

Now that we have in this way explained the external surface and texture of the Heart, the next thing that remains is for us to see the mechanism of its general internal structure. To facilitate the movement of the Heart, its external surface is smooth and even; for the same reason its inner walls are uneven in the extreme, and are irregular in their texture. Throughout its interior the Heart is hollowed out into various spaces and furrows, and is interlaced with fleshy fibres going in all directions. But this does not happen to an equal extent in the hearts of all animals, nor are the fibres similarly arranged or of the same size in the hearts of all animals in which they are present. Indeed, as the *most illustrious Harvey* noticed, they vary very much according to the kind of animal, [p. 37] and according to the size and strength of animals within a single species. In the larger animals, whose blood requires to be carried further afield and to be propelled with greater force, the ventricles of the Heart are strengthened internally by fleshy fibres and by small muscles, as it were, which stretch out hither and thither on many sides, and are variously divided into little trenches. The larger the Animals, the greater and fewer are these fleshy fibres, but in turn the deeper is the impress of the trenches. In the human Heart the fibres are smaller, but are arranged in a complex and inconstant order; they are also more numerous than in the hearts of all other animals I have hitherto been able to see. Their order and arrangement are shown in *Plate* 5, *Fig.* 1, in which the internal cavity of the left ventricle is opened out. In this figure

aa is the pulmonary vein opened out just before its entry into the Heart.
b is the left auricle of the Heart.
c is the foramen ovale, through which the blood flows in from the vena cava just in front of the opening of the left ventricle.
[p. 38] *dd are the two mitral membranes.*
ee are fleshy columns swelling up from both sides of the ventricle.
f is the base of the heart, where the blood flows into the ventricle from the pulmonary vein.
g is the place under the mitral membranes where it is discharged into the aorta.
h is the apex of the Heart.
iiii are fleshy fibres inwoven here and there throughout the whole of the inner surface of the ventricle.

Further, while the ventricles of the Heart in the larger Brutes are distinguished from the human by their larger internal fibres, the auricles, certainly in the horse and ox, are distinguished by wider fibres stretching here and there like fingers for varying distances. When these contract, the sides of the auricles close together to expel the blood. There should be no doubt in any one's mind that the other fibres in the ventricles help the movement of the Heart and the contraction of its sides.

While these fleshy fibres do indeed assist greatly in the [p. 39] contraction of the walls of the Heart, those fissures or grooves in the hearts of the larger animals are of the greatest service in ensuring that this contraction shall be tighter, and that the inner parts of the ventricles shall approach each other more closely, for a smooth and even internal surface would not permit this same action. For this reason such spaces or clefts occur chiefly in the left ventricle, inasmuch as they are necessary and useful to this ventricle only. The parenchyma of the left ventricle is composed chiefly of obliquely circular fibres, and they contract down on all sides towards the centre; such a closing down into so confined a space could not have occurred had these furrows and depressions not been hollowed out to fit the part for such movement. The wall of the right ventricle, on the other hand, is much thinner and is attached to the side of the left ventricle like some appendage; it contracts also through half a circle only; consequently it did not need deep pitting of its parenchyma to the same degree as did the left ventricle. But it might become unduly distended, either by the inrush of a torrent of blood against its thin walls, or by too great a quantity of [p. 40] blood collecting within it through heart-failure. This might go so far as to deprive the fibres of power to contract back to their normal (in the left ventricle such a misfortune is not to be dreaded at all on account of the strength and thickness of the ventricular wall). The better, therefore, to provide against such mishaps in the right ventricle, a certain round fleshy Muscle of reasonable strength stretches across the middle of the ventricle from the septum of the Heart to the opposite side. Such can be seen in the Heart of the sheep, ox, and other animals. In the Human Heart two or three such fleshy fibres are commonly found; these, if they do not help to draw the walls together, assist at all events in no small measure in preventing undue dilatation.

Now that we have described the inner surface of the Heart, we must next say a word about the papillae and fleshy columns, and about the valves situated at the various openings of the Heart, both where it receives blood from the veins, and also where it expels the same into the Arteries.

The papillae in the right ventricle are certain round, [p. 41] elongated, fleshy projections, which reach upwards from its sides and from their tips give off tendinous fibres to join the membranes called, from their shape, Tricuspid. These membranes rise from the edge of the ventricle, and completely encircle the entrance into it. Thus, when the apex of the Heart is drawn nearer the base in each Systole, the papillae also move upwards and slacken their fibres to very loose reins; the membranes to which they are attached follow suit, and, hanging loose, are driven upwards like bellying sails by the expulsion of blood at each Systole of the Heart. In consequence of this they close the opening of the Heart so exactly that not even the smallest drop can flow back into the auricle, but is expelled into the lungs, where no such hindrance bars its way. But, while the apex is drawn nearer the base at each Systole of the Heart, and the papillae slacken their fibres, in diastole the apex goes back again and draws down with it the papillae and their fibres. Hence the membranes are likewise withdrawn, and uncover at once the entrance into the heart, opening the doors, as it were, to the inflow of blood from the auricle.

[p. 42] It is sufficiently well established that the above does so happen, and that the valves do react and function thus at every systole and diastole of the Heart. It is not so easy, on the other hand, to grasp the method of their action and the manner of its performance, except from a study of the position and structure of the papillae to which they are attached. For, even if it is an undisputed fact that the tricuspid membranes belly out, sail-like, under the backrush of blood in Systole, until they completely close the entrance into the ventricle; it is, nevertheless, very well worth our while to see how and by what conformation of the parts in question this is effected. The method of it all, and the mechanical device which is used, depend on three facts. These are

1. That the papillae project and bulge out rather far on the inside surface.
2. That they are situated in different parts of it, and not all in one place.
3. That the papillae are situated on the side opposite to the membranes, to which they are attached.

This situation and structure of the papillae doubtless [p. 43] ensures that the membranes shall always be separated by some interval from the sides of the ventricle, and that they shall thus easily be raised by the first thrust of the blood which is driven upwards at each Systole. For, when the fibres of the papillae are relaxed, the membranes hang slackly across in the middle of the ventricle, and so it is inevitable that they should be pushed up by the blood flowing back into these pockets, as sails are blown out by the wind, and that they should unfurl just as far as the relaxation of their attachments permits. These attachments nature has allowed to move far enough for the membranes to stretch out on all sides and completely to close the entrance into the ventricle.

If, however, these membranes rose straight from the same sides of the ventricles, the membranes would lie too near the inner wall of the Heart and would be unable either to receive the blood behind them, or to be raised from the ventricle-wall; they would therefore let the blood go out again by its route of entry.

Any one will better understand the function and purpose of the papillae if he considers carefully the fleshy columns, which swell up on the sides of the left ventricle and are [p. 44] designed for exactly the same function. They are not made for movement, nor do they cause a contraction of their attached membranes (which would be more likely to keep open the entrance into the Heart); but they are placed there, and project to this extent from the rest of the inner surface of the ventricle, solely that they may keep the membranes sufficiently far away from the sides of the ventricle for them to be driven back by the blood flowing up from below, and completely to close that opening of the Heart, to which they are attached. This raising of the membranes from below, and the consequent closure of the opening, can be easily imitated and clearly seen by any one, who introduces a tube through the opening or the apex of the Heart and injects water through it, provided the auricle and pulmonary vein at the base of the Heart are first dissected off. Precisely the same thing will occur if the Heart is almost filled with water and pressure is applied at the apex.

Not all the membranes in the right ventricle receive their fibres directly from the papillae: but by their means they are equally able to check the back-flow of blood. The membranes are everywhere contiguous, and hence it must happen that directly those, whose fibres are inserted into papillae are [p. 45] lifted by the blood, the others which are joined to them are simultaneously raised, and fully distended by the upward flow of blood. That this shall more readily happen, one must believe that the blood thrown into the chambers of the Heart at each diastole penetrates back between those membranes and the walls of the ventricle, and that the membranes themselves rise upwards and puff out more as the ventricular cavity becomes fuller. This can be demonstrated by pouring water into the ventricle until it is full, or by injecting it through a tube placed in the opening. What helps a great deal towards this is that the fibres, which stretch from the fleshy columns and papillae, allow free passage along their interspaces to the blood flowing in behind those membranes. For, apart from the possibility of their sifting and mixing the blood, they seem to be specially designed for the following function, namely, to keep the stretching of the membranes within due bounds, and to allow freer ingress to the blood, so that it may penetrate more readily into the deepest windings and recesses of the ventricles, and so these fibres may help to quicken the dilatation of [p. 46] the Heart and the raising of the membranes. For the blood which is thrown into the Heart and received among the fibres soon fills the ventricle, and simultaneously, by its raising of the membranes, prevents its own escape through them. Hence, when the Heart contracts, it must of necessity expel the blood through the open channel into the aorta.

Further, the left ventricle, designed as it was for heavier work and greater effort than the right ventricle, had necessarily to excel it far in the strength and thickness of its wall. Hence its fleshy columns, fibres, and membranes far surpass in size and denseness the similar mechanisms in the right ventricle. The Systole of the left ventricle is a much more powerful contraction than that of the right ventricle, and so needed stronger instruments of this sort to withstand the pressure and to direct the blood into the aorta. To prevent regurgitation of the blood back into the chambers of the heart after it has rushed out through the arteries, three membranes, called from their shape semilunar, are placed [p. 47] at each exit from the Heart, the first set where the blood leaves for the lung, the second where it enters the aorta. These membranes unfold whenever the blood is forced back, and fit so tightly together that they close completely the arterial channel. This is clearly seen if the arterial trunk is divided close to its origin, and water or spirit is poured into it. *Plate 4, Fig. 3* shows the membranes relaxed to allow the outflow of blood. In this figure

aa is part of the left ventricle opened up.
bbb are the three semilunar valves collapsing to allow egress to the blood.
c is the trunk of the aorta opened up.
dd are the two coronary arteries leaving the trunk of the aorta just beyond the semilunar valves.

eee is the root of the aorta at its junction with the tendon of the Heart.
ff are the mitral membranes divided and turned back to either side to allow a sight of the semilunar valves.

The situation of the valves shows clearly how they facilitate [p. 48] the passage of the expelled blood. The extent to which they help to check any backflow of the same will appear equally well from *Plate 4, Fig. 4.* In this figure

aaa is the trunk of the aorta cut off at its root.
bbb are the three semilunar valves closing on each other, and blocking the passage against any back-rush of blood.
cc are the two coronary arteries.

Now that we have examined the usual arrangement of every part and corner of the Heart's abode, it will also be pertinent to see the means adopted to provide a pathway to and from the Heart itself.

Just before the threshold of the right auricle, that is to say, where the ascending vena cava joins the descending and prepares to discharge into the auricle of the Heart, a certain small swelling is formed by underlying fatty tissue. This swelling is well worth attention. Its interposition at this point causes the blood, which falls down the descending vein, to be diverted into the auricle, when it would otherwise [p. 49] have continued on down into the ascending vein, and would have caused great hindrance and slowing to the blood-flow up through that vein into the Heart. The danger from this was greater in the upright position and form, and hence the swelling in the vena cava of man was made larger and much more prominent, so that, if you put a finger into either of the two trunks, you will only with difficulty reach the other. As is shown in *Plate 1, Fig. 1.* In this figure

a is the trunk of the vena cava descending on the right side.
b is the trunk of the vena cava ascending on the right.
c is the swelling interposed right between the two veins.
d is the opening of the auricle.
e is the foramen ovale.
f is the Heart lying over to the left in its natural position.
g is the coronary vein.

On the other hand, in quadrupeds, such as the Sheep, Dog, Horse, and Ox, the passage of the blood from either end of the body is more level and horizontal, and, owing to [p. 50] the mass and weight of the dependent Heart, the trunks of the venae cavae slope down a little from above to the Heart; one may assume, therefore, that so large a barrier was not needed in their case, though it is not completely absent. As is seen in *Plate 1, Fig. 2.* In this figure

a is the trunk of the ascending vena cava.
b is the trunk of the descending vena cava.
c is the swelling separating the two veins.
d is the right auricle.
e is the foramen ovale.
f is the opening of the Heart.
g is the coronary vein.
h is the Heart itself hanging down from its vessels, but supported underneath in this position by the lungs.

Further, in order that the blood shall not seethe and swell in this meeting-place while the auricular contraction denies it free ingress, the whole circumference of the vena cava is muscular at this point in the larger Animals, both Man and Brutes; the object of this is twofold, to keep the vein trunk within due limits of extension, and to drive the blood it contains into the auricle without intermission and with more [p. 51] force than were otherwise possible. That the auricle may seize this blood more firmly and drive it into the ventricle of the Heart, its internal fibres stretch right out from the root of the auricle, where it joins the base of the Heart, towards the vena cava, and seizing within themselves the blood collected therein, grasp it, so to speak, in their fingers, and soon, in their turn, pass it on to the Heart. These fibres, indeed, in the auricle of one of the larger Animals, such as the Horse or Ox, are as large as monkey's fingers, and doubtless have the same function.

While the above-mentioned swelling at the threshold of the right ventricle, where the ascending vena cava meets the descending vena cava, prevents blood flowing down the latter vein and pressing down on that which is coming up the former vein; equal ingenuity has been employed outside the opening of the left ventricle, to prevent the blood, which is ejected with such force, from being unequally distributed to the various organs. For this opening of the Heart faces directly upwards, and hence, if the channel, which receives [p. 52] directly the first shock of the blood, led it likewise to the cranial region, too much blood would inevitably be sent to the brain; it would also of necessity gradually increase owing to the force of vibration, with the result that the lower parts of the body would be cheated of their appetite and food. To avoid such a disaster, the divine Artificer constructed the trunk of the aorta (next the Heart) with such skill in Animals, whose Hearts move rather forcibly, that the blood does not run straight into the axillary and cervical arteries, but first turns through part of a circle. Midway between the ventricle and these arteries, the aorta (to a varying degree in different animals) is strongly arched. Consequently it is the curved angle which bears the shock and the full force of the ejected blood, and directs the greatest part of the rushing stream into the descending trunk of the aorta. But for this too much of it would be distributed to the higher branches of the aorta; these it would distend unduly, and would soon by its impetus put an end to the head. All this is fully shown in *Plate 1, Fig. 4*. In this figure

[p. 53] *a is the root of the Human aorta.*
b is its descending trunk.
c is the angle where it curves on itself.
d is the right axillary artery.
e is the right cervical artery.
f is the left cervical.
g is the left axillary.
h are the two coronary arteries.

In the Figure, the curving of the aorta at [*c*] deflects a very large part of the rushing stream of blood ejected from the Heart into the descending trunk, but, to prevent it all from going in that direction, the intervening axillary and cervical arteries are so made that they must receive their requisite share of the blood as it flows past. The right side of any one of these arteries is much higher than the left, and hence some part of the fluid in the larger trunk must be intercepted by them. This will be more readily grasped from *Plate 1, Fig. 5*. In this figure

aaa is the right-hand and higher part of each successive artery.
b is the angle of the aorta curving on itself.
[p. 54] *ccc are the lower sides of the arteries which intercept the blood as it flows past, and against which the blood dashes.*
d is the descending channel of the aorta.

If these arteries, on the other hand, left the aorta perpendicularly, practically the whole of the blood would pass by their orifices without any diminution, as *Plate 1, Fig. 6* shows. This figure, though it represents a condition which never actually exists, is put side by side with *Fig. 5* to allow a better understanding of the arrangement therein depicted.

Before we pass from the subject of the Heart-muscle, one further point claims our attention. In the Foetus still enclosed in the womb respiration cannot take place, and there is therefore no need for the whole of the blood to pass through the lungs. An alternative channel has in consequence wisely been provided for the greater part of it. In the as yet unborn foetus, just below the swelling we have recently described, a foramen (called the foramen Ovale) opens into the neighbouring pulmonary vein just before the entrance into the left ventricle. Through this foramen the greater part of the [p. 55] blood returning in the vena cava passes, from just in front of the entry into the right ventricle, across into the pulmonary vein, and is sent down into the left ventricle together with the rest of the blood returning from the nutrition of the lung. To prevent its return by the same route, a membrane is attached all round the edge of the foramen, except at its lowest part, and, overlapping, sail-wise, the lowest part of the orifice, hangs down loosely in the pulmonary vein. Hence it yields readily to the blood-flow from the vena cava, and throws open the door. On the other hand, if strong pressure is exerted on the blood to flow back from the pulmonary vein into the vena cava, the membrane is closely applied to the pulmonary vein at the first approach of the blood, and so effectively prevents any inflow. In just such a way the duct of the ureter, passing through the double coat of the bladder, allows the urine a free and unrestricted inflow, but absolutely prevents any backflow. And, since there is no need for all the remaining blood, which flows into the right ventricle of the Heart and is ejected by it into the pulmonary artery, to make the circuit of the lungs, an [p. 56] arterial channel opens in addition between the pulmonary artery and the aorta proper. Hence the blood expelled from the right ventricle is in large measure passed on through this channel into the aorta, and is dispersed throughout the body with the rest of the blood. But, when the foetus is born and begins to breathe, this foramen and channel have no longer any function, and narrow little by little from day to day, until the foramen at length closes completely, and the channel slowly turns into a ligament, through which nothing can any longer pass. The shape of this foramen and membrane is shown in *Plate 1, Fig. 3.* In this figure

aaaa is the edge of the foramen ovale, to which the membrane is attached.
bb is the same membrane, hanging down below the circumference of the foramen.
c is the blood flowing along in the vena cava.
d is where it flows into the pulmonary vein.
eee is where it drives back the membrane, and rushes on through an open door.

[p. 57] I have now given a description of the Heart. It remains for me to detail the various differences it shows in animals of diverse kind, birds, fish, serpents, frogs, and other still smaller creatures, and to give reasons for these differences. But the compass of them is so great that weariness, rather than profit, would attend their enumeration. It will suffice if I make mention here of their more important characteristics, and of those which help most to elucidate the Heart's story in the more perfect animals. Thus in Birds, such as the dove, hen, chicken, goose, and others, the Heart is built up of a complex of fibres, which correspond exactly with those found in larger animals and which are, relatively, equally as large. For, though the outer side of the transverse septum nearest to the right ventricle shows a smooth, even surface, the inner part, comprising what is left of this side, is entirely fibrous. Both ventricles, too, are provided with semilunar valves at their respective openings into the lung and into the aorta. At the orifice or entry into the right ventricle there is a complete absence of tricuspid [p. 58] valves, but in their place, just above the entry from the auricle into the ventricle, there hangs down a fleshy valve, exactly semilunar in shape; this valve always opens towards the apex, and receives eagerly and greedily the blood which flows up from below at each contraction; the more it is filled out, the closer it lies against the ventricular orifice, and prevents there any outflow of the rest of the blood. Though the right ventricle, moreover, is flat and smooth on one side, the left is fibrous all over in every kind of Bird, however small; it is also provided with fleshy columns rising clear of the other fibres, and with mitral valves so skilfully made that no blood is allowed to pass back to the lungs. If the apex of the Heart is cut off and water is injected into the ventricle through a tube, a very pleasant demonstration results. The membranes in question soon swell up under the pressure, and, approximating very closely to one another, completely shut off this opening into the Heart, so that, however strongly and forcibly the water is injected, none is [p. 59] allowed to pass, and it all goes out through the aorta.

This organ, it is clear, is as perfectly formed in these smaller animals as it is in the larger for the distribution of the blood to the rest of the body. It is equally beyond doubt that it is never entirely absent even in the smallest of all Nature's creatures; they may not rejoice in a heart with two chambers, but can at least boast a heart with one. As, however, its structure cannot be seen sufficiently well with the naked eye, I will not speak further of it.

CHAPTER II

The Movement of the Heart

In the previous Chapter, we dealt at sufficient length with the Position and Structure of the Heart. In it we realized the extreme perfection of the Heart's fabric, formed with diverse means and with a skill beyond all comprehension [p. 60] of the spirit of man. We must now show next what, and of what kind, are the movement and function of this wonderful mechanism.

This noble structure, the Heart, received the name of muscle from Hippocrates and the earlier physicians because of its intricacy of fibres: that its movement was equally Muscular, the very illustrious *Harvey* rightly observed from his dissection of Living Animals. It seemed to him *to become tense all over, and to contract throughout its whole fibrous structure, to rise up, and get smaller and harder at each movement,* so it was natural for him to say that its action was one which it shared with the remaining muscles. This, indeed, we see him state formally in Chapter 2, 'de Motu Cordis'. *When the muscles are in active motion, they become stronger, are tensed, become hard where before they were soft, rise up and get thicker, and in similar fashion does the heart.* After *Harvey*, then, has so carefully and painstakingly observed the movement of the Heart, and has taught that it vibrates extremely strongly and forcibly, one may perhaps be surprised at the fact that the distinguished Descartes, Hooghelande, and other famous men (because they did not pay close enough attention either to the strength of the Heart's structure and [p. 61] its great efforts at every Systole, or to the rapidity of the blood's movement) have been in doubt if the Heart causes its own movement, or if it is not rather put into motion by the blood. They observed that various fluids prepared by chemical methods, and mixed together, interacted violently and frothed up to such an extent as to break their containing vessels, unless freely exposed to the air. Scarcely deigning to change the name, they have given the same story about the blood. Moreover, that this view may more readily find acceptance, they have taught that there lodges in the left ventricle of the Heart in particular a nitro-sulphureous ferment: that the blood is full of heterogeneous particles very ready to ferment, and that, as soon as it reaches this active material, it instantly becomes lighter and swells up. Seeking more room in consequence, it is forced to escape into the aorta more by its own action than by that of the Heart.

But it will be easy to show that no such ebullition is provoked within the blood, and that no such ferment is present [p. 62] in the Heart; for, although great effervescence and interaction result from the mixture of bodies of totally different saline nature, and a great deal escapes, the blood fluid is quite different in character and is too inert to effervesce so violently and suddenly in the Heart or in its vessels. We know how innocuous this fluid is, how gentle the spirit which usually imbues it, how smooth and peaceful its return along the veins to the Heart; and, when an opening is made for it and it is caught in suitable receptacles, how quickly it clots like milk, without any sign of effervescence or upset.

Those, moreover, who claim the existence of such a ferment in the Heart, should have shown the source from which it is continuously replenished. For, if they say that the coronary arteries distributed throughout the Heart pour a certain juice into its ventricles, they should notice that the inner membrane of the ventricle is so impervious that it allows [p. 63] nothing to penetrate into its cavity; as is clear if one forcibly injects the arteries with some dye. If, on the other hand, they state that this ferment is derived and replaced from the particles of blood hidden in the hollows and cracks of the ventricles, it is certain that these furrows and hollows were made for the closer contraction of the ventricle, as stated above; and that they close and adhere so tightly that none are any longer visible, nor do they leave any place or space for hiding the remnants of blood.

Indeed, ebullition of blood within the Heart, if it exists, is so far from helping at all in its movement, that it appears to be directly opposed and antagonistic to such movement; for Diastole does not occur as a result of the expansion of the ventricular walls by the increase of blood, but partly through the weight and amount of the same which is injected by the auricles, and partly through the movement of restitution. Thus the Heart's diastole alternates continually with its and the Auricle's Systole. That ebullition is not of use in the execution of the Heart's Systole is shown by the following [p. 64] fact, namely, that its movement is one of expansion, and would therefore serve rather to draw apart the walls of the heart than to bring them together.

Further, what ebullition is so regular, or has phases of swelling of such equal duration, or is powerful enough to be able to eject fluid with such force from the Heart to the most distant organs of the body (and much further if it is provided with egress)? If the blood moves through its own power, why does the Heart need to be so fibrous and so well supplied with Nerves? It could be formed of much simpler ventricles with flat inner surfaces, if it had been made solely to receive blood, and not to expel it.

Moreover, if we consider the amount of blood sent into the ventricles of the Heart at any diastole, we shall find no place in the Heart suitable, or large enough, for ebullition such as described. For the blood does not fall down from the auricles drop by drop, as Descartes and others have imagined, but is sent out by the auricles in such amount as to fill the whole internal cavity of the Heart; further, the Ventricle expels at any Systole the whole of the blood it has received during the previous diastole, as will be seen more clearly [p. 65] later. In addition, I do not clearly see, and I imagine no reasonable argument can be put forward, why the ferment is said to be lodged chiefly in the left ventricle and the ebullition rising therein to be attended by so much more effervescence; why it is not equally so in the right ventricle, since the action of each ventricle is the same, and they are distinguished only by the thickness and strength of their fibres for the reason given above; finally, why it is not chiefly found in the auricles, for they are the first to move, and provide incessantly not only the first impulses for the Heart's motion, but the spark which sets off the whole.

Besides this, the blood stays too short a time in the Heart for the production of such ebullition. It passes through the ventricles faster than the winking of an eye, and gunpowder, on being lighted, does not burst into flame any more quickly. In addition, blood expelled from an artery is not light or foamy in any way, if it is received into a vessel placed near by, but is of a venous consistency and weight, and like venous blood in all except its colour.

[p. 66] Finally, the movement of the Heart is shown to be independent of any ebullition of blood by the fact that a Heart taken from a living animal and entirely emptied of blood does not cease to move, even if it is cut into small pieces. It is a matter of common knowledge that the Hearts of fairly young animals, long after they have been cut out of the thorax, pick up their pulsations at once, and continue them for a long time, if they are gently stimulated with a small pin. Eels' Hearts, similarly stimulated with a needle several hours after they have been taken out, are seen to pulsate once more, since their spirits are entrapped and entangled in the rather viscous matter and are unable to escape so quickly.

But, to decide experimentally whether or not any ebullition of blood helped the blood's movement at all, it occurred to me to see if the Heart would continue its movement undiminished, after I had drawn off the blood, and had replaced it intravenously by an equal quantity of other fluids, less liable to become lighter or to froth up. With this object in mind I drew off through the jugular vein of a Dog almost half of its total blood volume, injecting instead through [p. 67] the crural vein an equal amount of beer mixed with a little wine. This procedure I repeated several times in succession until, instead of blood, the fluid coming from the vein was merely a solution with less colour than the washings of meat, or than claret several times diluted. The Heart-beat, meanwhile, became only slowly more feeble, so that practically the whole of the blood was replaced by beer before life was replaced by death.

It is easier, however, to produce an experiment than to produce conviction, and I may therefore, perhaps, be allowed to add this one story, which was told me by a doctor of impeccable veracity. A youth of sixteen was troubled (for some unstated reason) by a large flux of blood, which lasted without cessation for two days, and no treatment or skill availed to check it. Friends and neighbours tried to restore him to fitness with broths: these he desired so much and consumed so greedily that the flux became progressively greater, and at last things came to such a stage that he had lost practically all his blood, and such as did still flow out [p. 68] was watery and pale, and had neither the character nor the appearance of blood; it was more like the broth he had so often swallowed than blood. For two days this watery flux lasted without change, the Heart meanwhile going on beating as usual; then the flux at length came to an end, the Youth slowly convalesced, and thereafter developed into a strong, well set-up man.

Before, however, the door is finally closed on this subject, one must note that two observations of Harvey can be, and usually are, brought forward at this point by the opposition. These are, that the Blood has motion both before the Heart is formed, and also after it is dead, which easily shows that its movement is independent of the Heart. But the answers to these objections will be obvious.

1. Although it must be admitted that that little vital drop lodged in the little scar is stimulated by the brooding-warmth and expands, we shall, nevertheless, have to attribute the credit for this to the membrane which encloses it, for this membrane both checks and restrains it. When that productive fluid enclosed within the scar is warmed for a [p. 69] long time by the external heat, the spirits concealed within it expand in various directions. Some strike the enclosing membrane, and are entrapped; others distend the membrane to make room for their expansion. The membrane is unable to provide sufficient room to free itself from such tension, and contracts down on itself. As a result the fluid is put under pressure, and, seeking an outlet, makes a way for itself and forges out a channel. In such manner the very first beginnings of our life and threads of our body appear to arise. In addition, muscular movement depends entirely on contraction, and so we must consider the origin of this movement as beginning from the Systole of that vesicle, rather than from the ebullition or expansion of the spirits in that little drop of fluid. For the vesicle was in existence before the actual blood, and when, later, the fluid changes to

blood and becomes activated, the vesicle is simultaneously seen to begin its movements. Pulsating from the very beginning, it is not only the receptacle for the fluid so [p. 70] converted into blood, but also its propulsive mechanism. By its effort and assistance the blood proceeds beyond the bounds of the little scar, and hammers out arteries to provide room for itself, and veins to bring back nourishment.

2. As regards the blood-waves in the vena cava after the death of the auricle, I think they occur through no intrinsic movement of the blood, but by local contractions of the vessels, caused by the passage of spirits in all directions down the nerves, and analogous to the long-continued tremulous movement of muscles after death, when the spirits are wandering at random within them. So much for this ferment pictured by some authors within the ventricle, particularly the left ventricle, of the Heart, a ferment which causes ebullition of the inflowing blood. We must now consider the next theory, put forward by other writers, who state that the Heart contains a sort of vestal Fire, which so heats the inflowing blood that it must immediately pass on out into the arteries. It is almost as if they think that every inflow of blood is warmed by the fire of the Heart and straightway [p. 71] rushes out, as though the ventricles were alight and glowing with heat, and the blood ready to burst into flames at the first touch of fire, like gunpowder. How far this is from reality we shall quickly consider.

Apart from the fact that it is hard to imagine that the Blood becomes so rarefied that, on falling into the ventricles of the Heart at each diastole, it is broken up at once into its constituent particles, and shoots into the vessels, like lighted gunpowder (a property given to no fluid), there is also the fact that the Heart-rate is immediately increased by food and by moderately large draughts of fluid, while the chyle, which passes with the rest of the blood through the ventricles of the Heart, is as yet imperfect and therefore less liable to rarefaction.

I am so far from believing the movement of the blood to be dependent on any heating of it within the Heart, that I do not think it owes any of its heat to this organ. Although the Heart should, rightly enough, be acknowledged as the source of heat (and heat is carried from it to all parts of the body), it will not perhaps be any truer to say that heat is produced only in this organ, or that the blood is warmed only [p. 72] by it, than that the waters of hot springs receive their heat from the bath into which they discharge, and not from the intrinsic fire of the parts which they bathe and wash against in their passage in the bowels of the earth. For there is nothing in the Heart which is sufficient to produce so much heat. It is certain, in any case, that the Heart does not produce its own heat, but needs to be warmed just as it is nourished entirely by the blood flowing into it from the arteries. *It is improbable*, as Velthusius says, *that there exists in the Heart a heat of sufficient intensity for this organ to produce by its activity and by its own heat so sudden and so powerful an ebullition of the blood which enters it: and the structure of the Heart is not so strong and lasting as to bear for so many years a heat of this strength. If we insert the fingers into the Heart of an animal during a vivisection experiment, we do not feel a heat of this intensity, and the pericardial fat could not solidify, as it does, under such circumstances.*

The great heat of the blood must therefore be attributed to the Heart no more than to the vessels and viscera as a whole, and especially to those which are enclosed within the [p. 73] thorax and the abdomen. For, while the blood is cooled in the extremities, where it is exposed, practically without covering, to the external air during its passage, it is equally certain that it warms up as soon as it enters the enclosed cavities of the thorax and the abdomen. It is thus that fat, well-covered men, whose blood-vessels lie more deeply and are buried in flesh, are better able to withstand cold than thin men, although the Hearts of such excessively fat men are not so active and strong as are those of men, who are more slender and thinner.

The blood is, therefore, entirely responsible both for the heat of the Heart itself, and for the activity and life of our bodies, which its heat produces. Nevertheless we admit that, though nature has not given the Heart greater heat than other Muscles, yet, in so far as it is ceaselessly and continuously in movement in so confined a place, it is endowed with more constant and active a heat than the other members of the body. Hence, perhaps, on this account, by contact with [p. 74] itself, it does warm and heat up to a somewhat greater extent the blood which it receives.

Now that these matters have received due consideration, I think it is clear that the movement of the Heart does not in any way depend on ebullition of the blood, nor the heat of the blood on any fire within the Heart.

But we are certainly warmed by a fire that is more than fictitious or metaphorical, and so it would be worth while in the next place to explain at somewhat greater length how the blood itself becomes heated and in its turn provides warmth for the whole of the body. However, since this would be outside the plan of the present work, and I also understand that the learned Dr. Willis is giving the matter some thought in his book on 'The Spirit, and also the heating of the Blood', I should not like to depart so far from professional courtesy as to forestall him in this matter.

The foregoing passages have established to our satisfaction that the movement of the Heart is independent of the blood; it remains to state next the instruments and devices by which it is accomplished.

These are of two kinds, the *immediate*, which are directly responsible for the movement, and the *remote*, which assist it.

[p. 75] Those which accomplish the movement are to be sought for on the spot within the Heart itself; for in that organ are all the parts ready and fitted for the production of movement within it, as is shown by the fact that no Muscle is better arranged than these parts. That it receives Spirits from the abundance of nerves which are inserted into it and which form a dense network all over its Surface, that it is strengthened by all kinds of fibres which make an intricate pattern with their ramifications, and that its base is surrounded by a tendinous border, is clearly seen; and in the Heart of even a very small animal, where the structure of this organ can still be made out, there seems to be no one of these structures absent or missing.

This mechanical provision shows clearly that the Heart is definitely a Muscle, and has a movement exactly similar to that of the other Muscles. To explain more clearly, however, the movement of the Heart, we will begin with the more simple movement of a straight Muscle, and use this as a standard.

The straight Muscle is composed of two bellies with a tendon attached to each, and, corresponding with this [p. 76] double structure, its movement is also double. The fibres of the two bellies end in opposite tendons, so that, while the parts to which the bellies are joined by the tendons seem to draw nearer to one another by one and the same action, this is, nevertheless, not accomplished by a single movement of the two bellies. For, even if they contract from opposite ends to the same centre, the two opposite bones or members to which they are attached only respond simultaneously to opposite contractions of the two bellies, and approach one another as a necessary consequence of this response. All muscular movement seems, therefore, to resemble in its execution the handshake of two men, which leads to their subsequent close embrace. Also, there exists no muscle with only one belly, or with fibres stretching in one continuous line from tendon to tendon, but each muscle is two-fold with fibres running to opposite ends, and so one might wonder in passing if the movement of any muscle may not more rightly be attributed to the opposed contractions of the two bellies, rather than to a simple swelling-up of the [p. 77] muscle. Nay further, if the movement of a muscle occurred through such swelling, what is there to prevent the fibres of any muscle (seeing they are straight and attached to one another only by the slenderest of membranous fibrils) from being parted from one another and torn asunder, at any rate until the separation leads to pain? In addition, a Muscle distended outwards by such swelling should be extremely noticeable, whereas the opposite is actually the case, namely, that a Muscle constricts down on itself at each movement, and gets smaller and harder. In other words, the character of its movement is exactly opposite to a process of swelling-up.

Further, if movement occurs through the conflict of spirits of different nature meeting in the Muscle, or through a mixture of air with animal spirit, why are all parts of the muscle not in a state of perpetual movement, as both components are continuously flowing into it? And what command has the Spirit over us, if it is responsible only for the impulse to movement, serves only to fire the tinder, and arouses a tumult which it will be unable to quell at will?

[p. 78] It is surely scarcely credible that things so antagonistic can exist, at all events in a well-ordered body, or can be united, without the spirit being able to control them.

We are not to imagine within ourselves the presence of a spirit so ridiculous that it is able, so to speak, to brandish a sword, to turn it hither and thither, to advance it and withdraw it, and is yet unable to sheath it at its pleasure. We are able to control our movements, and keep them within such bounds as we please; Muscles also seem to be designed so that they may accomplish their movements by the effort, and with the help, of fibres pulling from opposite ends. I do not see, then, why we should seek in so violent a source for the manner and cause of this movement. Let all this, however, be a passing reference.

It has previously been shown that the Structure of the Heart is analogous and similar to that of the other Muscles in the body in plan, if not in shape, and so it remains for me to prove that its movement also is similar, and is carried out in conformity with the general arrangement of its fibres.

The movement of any two-bellied muscle is effected in general by the fleshy fibres drawing the opposed tendons [p. 79] together towards a central point, and the Heart is also essentially composed, on the plan of the other muscles, of a double row of fibres facing in opposite directions—the outer ones stretching across from left to right and encircling the whole of the parenchyma in their folds, and the deeper ones being carried in the directly opposite direction—and so, since they draw the walls of the Heart more closely together on all sides, the intraventricular spaces must necessarily be greatly diminished and constricted. The process can, therefore, not unfittingly be compared with the wringing of a linen cloth to squeeze out the water, or with the closing of a purse by the traction of a double string in opposite directions. The fibres act in exactly the same way in constricting the Heart, and it is they principally which effect its movement.

Moreover, some of the fibres of the Heart are straight, but all the others twist round the apex and the whole of its surface in an oblique and contrary direction to end in spiral lines in its base. Hence these fibres not only compress and [p. 80] diminish the intraventricular cavity, whenever they contract on both sides, but they also bring the apex nearer the base. For, however great is the effort of the fibres to pull the base of the Heart downwards, this latter rests on a support which is so steady and so strong that it cannot respond at all to their pull. Hence the only thing that can happen is for the movable part to give way to the stationary one, with the double result that the Heart-structure as a whole becomes more constricted, and its apex comes nearer to the base. This is very similar to what takes place, when in the popular sport a man hanging on a rope contracts his arms strongly and carries himself up aloft.

Moreover (to mention this in passing), every movement is effected by a contraction, and the fibres of the Heart are made solely for such a purpose, so it is also clear that the whole movement of the Heart is located in Systole; and, as the fibres are overtensed at every contraction of the Heart, therefore, when that effort abates, the Heart relaxes again by a sort of movement of restitution, and is once more [p. 81] distended by the inflow of blood from the veins. By no movement of the Heart, save one of tension-diminution, and the inrush of blood, its diastole follows regularly on its systole.

As a result of the examination of the heart's movement, that of the auricles is more easily understood, since the fibres which are common to both auricles and which stretch from one to the other are perhaps the mechanism which ensures that they both commence their movements together; but some fleshy fibres are attached to the common tendon of the heart, while others are inserted into the fibrous ring next to the vena cava, and therefore, since their contractions are from opposite ends, they cause a shortening of the intervening space, and so in similar fashion expel the contained blood into the chambers of the heart.

That the movement of the heart, however, is accomplished by its own fibres needs no other evidence or proof than the fact that its ventricles differ from one another in their fibrous structure, as much as in their function and in the degree of movement necessary for each. A short and a long journey require different degrees of strength for their performance. [p. 82] So, according as the distance the blood is projected and propelled is shorter or greater, the ventricles are endowed with thinner or with thicker fibres, and the left ventricle greatly excels the right in the strength of its fibres, as it does in its work and importance. Yet, though the fibres of the right ventricle are much more slender and thinner than those of the left ventricle, it is not lacking in any set of these fibres; and it is not to be regarded as non-pulsatile because it beats less forcibly, nor is one to think of it as moving much less solely because of the nearness of the left ventricle. For, though the right ventricle is attached to the left, and contracts as a whole towards that ventricle at each Systole, thereby describing only half a circle in its movement, it accomplishes this by its own fibres, and not by the aid of the other ventricle. So far, indeed, is the left ventricle from helping in any way the movement of the right ventricle, that the side of the transverse septum which is next the cavity of the right ventricle is almost always (especially in smaller animals) flat and smooth; while the same septum, on the side facing the cavity of the left ventricle, is completely [p. 83] fibrous and hollowed out by deep trenches; a clear proof that the septum helps the contraction of the left ventricle only, as I have shown above.

It is abundantly evident from this fibrous structure of the internal septum that it is of great assistance in the movement of the left ventricle; and, indeed, it could not be otherwise, since this septum is part of the left ventricle, and its fibres are continuous everywhere with the general surface of the left ventricle and merge into it.

Further, it has been shown that those furrows and spaces hollowed out in the septum help the ventricle to contract down to a smaller size than would otherwise be possible, and hence it is obvious how inept is the statement that they help the passage of blood from one ventricle to the other. They are in fact completely impervious, and are designed solely for the function above described.

We have seen up to now how strong is the structure of the heart, how reinforced everywhere by fibres. It is our duty to see next what is the force by which it carries out its movements. No one, who denies that it vibrates extremely powerfully and forcibly, seems to understand really well its wonderful structure or to consider it with sufficient care. It [p. 84] is quite clear, not only from the great force with which the blood is ejected, but also if one takes the heart itself in one's hand, or inserts a finger after cutting off the apex, that its movement and contraction are extremely strong and forcible; so much so that its Systole not only causes a narrowing of the intraventricular space, and expulsion of blood to a corresponding extent, but the heart vibrates strongly and violently, and the blood is driven out and expelled by the vigorous and powerful upward leap and activity of its walls. Indeed, while I may at least note here that *Fernel, Forest,* and *C. Piso* have described how a heart was once attacked by a spasm of such violence as to fracture the ribs, and each Systole could be heard in the street far away from the bed: further, how the patient's garments were agitated by the continuous pulsation of the thorax and heart as though by a fan, and the very thorax and sternum were displaced by the movement from their natural position and forcibly protruded; there is also the fact that one can hear from afar the individual heart-beats in horses returning from a long ride. The blood is at this time being sent through the vessels [p. 85] with such force and violence that you can count the individual beats from far off, and can proclaim them as surely as if you had your finger on the artery. Indeed I have often noticed that, even with men who were not really strong, the curtains of the beds in which they lay were thrown upwards at each movement of the heart, and followed closely the rhythm of its beat.

This being the case, it will be fitting to inquire what impulse causes the heart's movement, and whence it is given such power or strength, that it can perform this movement without intermission throughout the course of life.

I should here speak of the ultimate way in which the heart's movement is effected, but, as it is over-difficult to obtain any due conception of this, and it is the privilege of God alone, who comprehends the heart's secrets, to understand its movement also, I will not waste effort in examining it further.

It will suffice, therefore, if I merely observe that the force and strength, by which the heart expels with regular, even [p. 86] beat the blood that falls continuously into its chambers, do not arise from anything within the heart, but come down into it from the head above, as if from heaven. The heart is, functionally, extremely important and necessary, and nature therefore exerts such care and solicitude in the execution of its movement, that, in addition to the important nerve-branches distributed thickly all over it, she has also prepared the cerebellum as a perpetual storeroom of animal spirits, so that there may be a continuous inflow of them into the heart. This organ is so dependent on their liberal and continuous inflow that, if this is cut off for even the smallest period of time, the heart's movement ceases there and then. If the nerves of the eighth pair are tightly ligatured in the neck, or are divided (which is much the same thing as far as the animal is concerned) it is remarkable how great a change suddenly occurs! The heart, which before beat quickly and regularly, begins to palpitate and quiver as soon as the ligature is applied; the wretched animal prolongs a weary life for a day or two to the accompaniment of heart-tremor and excessive dyspnoea, and finally dies without warning.

[p. 87] The degree of cardiac distress which the animal soon feels as a result of such section or ligature is well shown by the rapid onset of convulsive movements, which are so pronounced and violent that it is difficult, without using strong cords, to keep the animal in the same place or position of the body.

The reason the animal does not die at once from the application of such a ligature is as follows. Besides the help afforded by the recurrent nerve, various nerve-branches are implanted, below the ligature, into the nerves of the eighth pair, before they send their offshoots to the heart. These branches come from the intercostal plexus below the entry into the thorax, and by their means spirits are supplied, albeit in smaller amount, to sustain the weakened movement, as long as the blood remains fluid and thin. The blood-fluid, however, commences to stagnate and to clot on account of the sluggish action of the exhausted heart, and so these reserves of spirits are not long equal to continuing the pulsation, and in consequence life finally becomes extinct through failure of this movement. These facts are so definite [p. 88] that I have no doubt the animal would at once faint and the heart cease to beat, if the nerves in question were ligatured a little below that communication with the intercostals. It is not easy to put this to the test, because the junction of the nerves occurs just below the clavicle, and near the larger blood-vessels, so that it can neither be seen by the eyes nor explored by the fingers.

It has been shown that the heart's movement is caused solely by the inflow into the nerves, with which it is abundantly supplied. I ought next to state the number of ways in which this movement undergoes variation and the causes of the same. The heart's movement, however, is greatly increased or decreased according to the general state of agreement and co-operation among the organs, and so I think it will be pertinent if I first show which are these organs, and what kind of assistance they give.

The nearest connexion of the heart is with the thorax and the lungs, and by that natural relationship their functions are mutually united, so that neither can move easily without [p. 89] the other, or long survive it; the lungs, however, function through no effort of their own, but only through outside assistance; hence the fact that they offer the air a free passage into the blood must rather be placed to the credit of the diaphragm and of the intercostal muscles.

Any internal obstruction in the pulmonary passage, or excessive external compression of the same, any prevention of, or hindrance to, the free contraction and relaxation of the diaphragm and intercostal muscles, therefore, affects in similar fashion also the movement of the heart. Affections of these organs, into which category fall such things as quinsy, lung abscess, internal swelling, pleural effusion, empyema, convulsive fits, immoderate and prolonged laughing, cause difficulty either by occlusion of the trachea or the pulmonary blood-vessels, or by pressure on the heart and lungs through their weight and size, or by opposition to the free expansion of the thorax in inspiration. They therefore alter the heart's movement in varying ways.

[p. 90] It would take too long, though, to explain the nature of each of these several maladies, or its secondary action on the heart. In so far, however, as the movement of the heart and blood is often seriously upset by distorted movement of the chest, especially of the diaphragm, it will be worth while to show what are the chief affections of this organ, and how they make their mark upon the heart.

Respiration is hindered by two things in particular, namely, laughing and hiccough.

1. In laughing the diaphragm seems to be driven up into the thoracic cavity by the abdominal muscles forcing the viscera against it, and to give way to this force in jerks, as if with the object of driving air through the parts and so producing a laugh within the larynx. Hence, as the diaphragm is attached to the pericardium, it pushes and forces the heart and its base close to its own vessels, both in the region of blood-inflow and in that of blood-outflow. The doors of the heart being closed, there is, therefore, a [p. 91] temporary intermission of the circulation. This is clear from the generalized venous swelling which occurs in the neck, face, and forehead. As soon, however, as the laugh finishes, and the return of the diaphragm to its proper level pulls the heart down, so that it can recommence its systole and diastole, the circulation is restored, and the venous swelling, which was previously visible while the laugh was in progress, disappears completely with the re-emptying of the vessels. It is quite certain that this is the case, because during too prolonged a laugh, especially in children (whom their nurses often incite to laugh far too long), not only does the face begin to get livid through superabundance of blood, which is prevented from returning, but in addition death itself sometimes follows these unwise practices, as the literature shows from time to time.

2. In hiccough (this is properly speaking an affection of the diaphragm—though it very often owes its pernicious effect and its origin to the stomach—and we can therefore at will imitate its convulsive movement, or prevent it for a time by holding the breath), as the pericardium is attached on all sides to the fibrous ring of the diaphragm, the latter must [p. 92] necessarily pull on the former when it contracts, and so disturb the heart's movement. And, although a brief upset like this does not annoy the heart very much, yet in malignant fevers, when it persists overlong, perhaps over many hours and days, it excites and tires the heart-muscle to such an extent that, after a wearisome bout of such disturbance, patients complain chiefly of cardiac pain and unrest. In addition the heart-beat is very weak: indeed, it is inevitable, with the connexion between the diaphragm and the heart, that spasm of the former should hinder their mutual functions. The diaphragm cannot be contracted so

often and so violently, without at the same time dragging the heart down with it, and so upsetting the heart's movement by its antagonistic action throughout the course of the paroxysm.

But while it is true that the movement of the blood and of the heart depends entirely on the brain, as seen above, yet, so that such great advantages should not be thought to be freely conferred on one of them only, it will not be amiss to note in passing that, although the brain is master over all [p. 93] the organs of the body below it, as a king over his subjects, and rules and governs all at its will and command, it is not so placed above them that it can survive or have any power in the absence of their help and service. On the contrary, the animal spirits, and life itself, are so dependent on the continuous supply of blood to the brain, that every kind of suppression of this supply soon leads to syncope and unconsciousness, and, further, if such processes persist unduly long, the life of the animal ceases completely. The reason for this is simply that the animal spirits, through the constant inflow of blood, trickle down the nerves from the brain to provide for the continuation of the movement of the chest and of the heart, and must therefore be replenished by a constant supply of blood. So the brain, if deprived of its right and continuous contribution of this fluid, suffers a sort of eclipse, and the animal, robbed of sensation and movement, falls of its own weight; as one can see in those attacked by syncope.

On the mutual service rendered by brain to heart and heart to brain sensation and movement essentially depend. By the heart's movement blood is continuously sent to the [p. 94] brain and cerebellum for the production of the spirits. The spirits, in turn, flow into the heart through the nerves, and ensure it a perpetual and constant movement. The heart is responsible for the unfailing supply of spirits in the brain: the brain for the perpetual movement of the heart.

While, however, these two organs help and serve each other, so that neither can exist without the other, both are dependent in equal degree on the action of the stomach. The cause of our life consists essentially in the manufacture of chyle from food in the stomach, in the production of blood from chyle in the heart and its attached vessels, and, finally, in the passage of the purer and most delicate part of the blood into the brain. Many fluids are always leaving our blood, and there is a constant loss of blood-mass and of animal spirits. The vital heat must, therefore, be revived by continuous fresh blood, and nature has thus provided for the manufacture of chyle in proportionate amount within the [p. 95] stomach. This chyle replenishes the diminishing blood-fluid in corresponding measure. But this is insufficient in itself for the supply of chyle in due amount and measure to the blood. It is in addition of the greatest importance for the chyle first to be properly prepared; for, if the chyle mixes with the blood in an unprepared and unpurified condition as a result of bad digestion, with the spirituous, active constituents not yet set free by fermentation, it will never afterwards become volatile or spirituous (just as, if you distill fresh beer or unfermented wine, you will only extract a crude, bitter fluid with a minimum of spirit). So, as it will be suitable neither for the manufacture of good blood, nor for the proper separation of spirits, the animal's economy suffers in turn from these faults of the stomach, and they redound next on the heart itself. Thus, when the stomach rejects food, or receives it but does not properly digest it, the heart-beat at once departs noticeably from its usual regularity. This one can see in persons of feeble constitution, or in those weakened by frequent intoxication.

[p. 96] These are the nearest-removed mechanisms and causes, by which the heart's movement is aided or altered. There remain others which are more local, and so to speak intrinsic causes, which alter or destroy the movement. This occurs in four ways in particular: I. By the fault of the heart itself; II. By the fault of the containing vessels; III. By the fault of the blood; IV. By the fault of the inflowing spirits.

I. I must first speak of the factors resulting from the heart itself, and from its Pericardium.

1. It is not only requisite for the furtherance of the blood's movement that the two ventricles of the heart should correspond, both as regards the size of their chambers and as regards the number of their beats. It is also necessary, from the nature of the case, that the sides of the heart should be endowed with like strength to carry out this function of preserving a constant circulation of blood, and of driving

this fluid everywhere in regular sequence and in due quantity through the vessels. From this it follows that, when any of these postulates is lacking, the blood's movement also must [p. 97] be considerably altered. But, as such an error of nature, through which the exact proportion between the ventricles of the heart is lacking, rarely or never occurs, there is no reason for us to speak further of it. On the other hand, the parenchyma of the heart is subject to various illnesses and disorders, and so its movement also must be considerably affected. If the parenchyma of the heart, for instance, is too heavily laden with fat, or suffers from inflammation, ulcer, abscess, or a wound, so that it is unable to pulsate and contract without great difficulty and hardship, or without serious inconvenience, its movement is greatly reduced, and it gives out what blood it can, though not as much as the rest of the body needs. The blood's movement also is, therefore, correspondingly feeble and slow.

2. Moreover, while the heart is sometimes troubled by its own internal condition, it is also occasionally oppressed from outside through some defect of its own or of its capsule. The fluid enclosed in the pericardium renders great service in lubricating the surface of the heart and in facilitating its [p. 98] movement; it likewise occasionally oppresses and floods the heart when it is in excess. For instance, when that envelope is full in hydrops Cordis, and the walls of the organ are compressed on all sides by the surrounding fluid to such an extent, that they are unable to dilate sufficiently to receive the blood, the heart-beat diminishes greatly, until at length it is completely suppressed by too great an outflow of fluid, and syncope and death result. A similar process can be seen in hydrops pectoris, where the lung is unable to distend sufficiently. The thoracic cavity is filled with water, and no room is left for dilatation of the lungs. Respiration becomes difficult and finally impossible for those thus afflicted, although they make the greatest effort to inspire, as I have often observed in such patients.

I may mention here in passing that, as an excessive amount of that fluid contained in the pericardium so hinders its movement, that it finally abolishes and suppresses the same, it is more likely that it follows on palpitation of the heart than that this movement, arising in the heart, is provoked by the fluid. What renders this more probable is the fact that this complaint attacks the healthy and often gives no [p. 99] warning, that it arises also from other causes, and announces its coming by no sign or token. This will be referred to when the complaint is further analysed below.

3. While the heart's capsule is stated to be of service to it on more than one count, serving, indeed, both for its moistening and for its protection from outside harms, it is also often injurious to the heart in more than one way. For, just as it injures the heart by accumulation of fluid within it, so, when this is completely absent, it approaches so close to the heart, that at length it adheres everywhere to this organ. Hence, as it is also joined to the diaphragm, it must combine and unite the heart's movement with that of the diaphragm. How great a hindrance and disadvantage this must be for both organs, I have shown above, and it will be still clearer from the following story.

The wife of a certain citizen of London, aged 30, healthy and active enough previously, became very dejected and melancholy during the last three years of her life, suffered from breathlessness on the least exertion, had a small and often an intermittent pulse, and complained almost continuously of attacks of pain and of great physical discomfort [p. 100] in the precordium. She had at last become subject to frequent fainting-fits, and to loss of consciousness and chilling of the extremities on the gentlest movement of the body. No treatment was of any avail to her in this condition, and, her strength at length slowly exhausted, she died. When the body was opened, no abnormalities at all were visible among the abdominal viscera. While examining the other organs, however, we discovered a pathological condition of the heart, to which we may rightly attribute the cause of all her troubles. The thorax was opened and the lungs were healthy enough; the pericardium, however, had become closely attached all over to the whole surface of the heart, so that it could only with difficulty be separated from it. Further, this membrane had become thick, opaque, and hard, instead of being thin and transparent, as it should naturally have been. Hence, as there was no space for the free movement of the heart, and no fluid for moistening its surface, it is little wonder that she complained all the time of these ills. Further, as the diaphragm is always attached to the pericardium in man, when the heart itself was also united to [p. 101] the pericardium, the diaphragm must of necessity have carried the heart down with it at every inspiration, and during that time must have held up and suppressed its movement. So the observed intermission of the pulse succeeded regularly at every inspiration.

4. But just as the heart's movement (as was stated just now) is liable to be suppressed altogether by increase of this fluid, so it is liable to be violently excited and disordered by other inhabitants of this capsule. Very often worms, born inside the capsule, cause great trouble to the heart by their gnawing, and reveal their presence by the quivering of the heart, distress, frequent intermission of the pulse, stinging pain, and syncope. This crowd of symptoms and animals I have often seen completely dispersed by two applications to the region of the heart of a plaster made of the *leaves of artichoke, tansy, and common wormwood, cooked in a very little vinegar of white wine, and mixed with a little mithridate.* So far I have spoken of the alterations which [p. 102] result from the fault of the heart itself, together with its pericardium.

II. While it has been shown that both ventricles of the heart must necessarily correspond, both in the volume of their chambers and in the rhythm of their beat, for the proper distribution of the blood to all the organs; the agreement between the vessels and ventricles must also be exact and their symmetry mutual. The heart, however, is the actual agent which, in driving the blood from itself, simultaneously fashions the vessels for its carriage; hence we cannot believe it possible that there is any organ where vessels were not simultaneously present. Therefore, as the blood-vessels are double and designed for diverse function, and assist the alternate movement of the heart and of the blood, it will be worth while to note how they are endowed for the purpose of helping both objects, or later how they can sometimes be a hindrance.

It is a matter of general knowledge that arteries were made to take blood from the heart, and to carry it to the whole of the body, while the veins, on the other hand, were designed to carry it back and return it to the heart: that the former vessels were provided with a thicker coat to [p. 103] withstand the force and rush of the blood, while the latter, in which the blood runs more slowly, were given a much thinner one.

But, while the blood-vessels were formed, from their very beginning, either by the blood thrown out by the heart, or by that returning within it, they can afterwards be changed by the blood in various ways, so as profoundly to alter the movement of the heart and of the blood. And, as the arteries are the functional unit nearest to the heart, it is right to discuss their failings first.

The trunks of the arteries, then, are endowed with a thicker and stronger coat, and so they are kept everywhere within their proper limit, when there is equally open access for the blood to all organs. When, however, their lumen is blocked and closed by some impacted matter, or they are obliterated and dried up by the wasting of the parts, or the channel of any particular one is compressed and constricted by any external body or circumstance, then, as the amount [p. 104] of blood is proportioned to the body as a whole, and the force imparted to it by the heart is constant, whenever the blood's passage is hindered in any one artery, those arteries nearest to it and in association with it must sustain the rush of the expelled blood, and themselves take up the whole amount destined for this other artery. Hence it sometimes happens that, when the lumen of some artery has been too long obstructed or ligated, the blood busies itself in opening a wider channel for its passage in the neighbouring artery; and, until this happens, the movement of the blood in all the arteries around must of necessity be greatly accelerated and conducted with greater haste. The blood, impeded in its passage in this vessel, must drive and buffet all the more into the next ones, until it has considerably dilated them to give itself room.

Arterial obstruction anywhere produces in the remaining vessels the same effect as does arterial wasting and thinning. The ventricles of the heart and the blood are proportioned to the vessels as a whole; hence, if some organ or member of [p. 105] the body begins to waste away, the blood previously allotted to it must be applied to the other organs of the body; so its vessels dilate more, and carry a fairly large increment of blood. The learned *Glisson* very rightly attributes the large size of the liver and the head in spinal patients to the wasting of the other organs, and observes that the intelligence, as well as the brain, increases on account of the greater blood-supply. For, when some part of the body wastes away and gets thinner, the blood which is usually allotted to that part must be sent to the other parts of the body; and, as no part of the body is less resistant, and more fitted to yield to the force of the blood, than the liver and the brain, these organs are easily distended by the inrush of a larger amount of blood, and become more massive and greater in size.

In just the same way also, when an artery is constricted or compressed, the course of the blood in neighbouring organs is accelerated as a result of the greater driving power. If, for instance, one cervical artery is ligatured, the pulsation in [p. 106] the opposite cervical artery, and also in both axillary arteries, immediately undergoes a great increase on account of the greater blood-supply. The extent to which constriction of even the smaller arteries is able to hasten the movement of blood in others, is obvious from the tight binding of the lumbar region which we employ to keep off cold. The reason for this is not only that it keeps the clothes closer to the body, but that, by preventing the blood from moving in the smaller, external vessels, it renders it more rapid in its flow and more abundant in the internal ones. Thus, those, who are naturally warm in the kidneys, will not suffer their clothes to be at all closely bound to the lumbar region, for fear they become too warm inside, through the diversion of the blood from its external course. Moreover, while constriction of smaller arteries is often beneficial or the reverse to the rest of the body, hindrance to the blood's descent through the trunk of the aorta a little below the heart [p. 107] can only be effected with very great disturbance and danger to the heart, since there is exact agreement between the vessels and the ventricles of the heart, and the amount of blood ejected at each systole is proportioned to the branches of the aorta as a whole. The blood due to the whole of the body, and proportioned to it in correct measure, cannot all be taken up by half of it, and must therefore flood the brain and heart; and, as it cannot be expelled from the heart for lack of space, the ventricles of this organ must of necessity be overfilled and choked up. This I have indeed often found in various dogs. I have opened the left side of the thorax, and, inserting a finger a little below the region of the heart, I have pressed the descending trunk of the aorta back against the spine. The dogs would resist with such struggling and howling, that they would almost tolerate more quietly excision of the very heart itself from the chest. But when I tried the same experiment in other dogs, after previous withdrawal of a large amount of blood, so that the organs above the point of compression were equal to taking the rest of the blood and had room enough for it, they suffered the application of my finger with scarcely any sign of annoyance.

While the blood, when impeded anywhere, dilates the [p. 108] nearest vessels to provide for its passage, sometimes, either because of the weakness of the vessels, or because the blood is being diverted and drawn to some organ in greater amount than it requires, it so stretches and distends the vessels, which are giving it passage, by its additional amount and speed, that its inflow into the organs next this one is less in amount than is due. It is thus that the spine of those suffering overmuch from simple gonorrhoea, or from excessive uterine discharge, is so weakened that they are scarcely able to walk erect or to bend themselves in any way. This is not because the spinal medulla, or the nerves arising from it, by expending too much of their fluid (if such exists) on the testes or uterus, deprive themselves of that which is essential to them—they are not, nor can they be, so generous as some have foolishly suggested, for the nerve-fibres which are distributed to the testes are very few and scarcely visible —the reason lies rather in the fact that the expanded spermatic and uterine arteries deposit the nutrient juice of the blood in too great and unusual an amount in the testes and uterus. Hence they deprive the vertebral arteries, which are situated opposite them, of their blood, and the spinal [p. 109] medulla also, which should be supplied by these arteries, of its nourishment. This is shown more clearly by the treatment; for anything that compresses and constricts the spermatic vessels restores simultaneously and in equal measure the even distribution of the blood and the due tone of the parts.

Any obstruction or constriction of an artery renders the movement of the blood more rapid in the neighbouring parts; when, on the other hand, any blood-channel is opened or completely severed, so as to allow free exit to the rushing stream of blood, because it could flow out more freely and rapidly through such an open door than it could be driven through the pores of the body, it flows in great amount to the part where resistance is less, and gushes forth by the freer way which is offered to it, with the result that the pulse is much diminished in the neighbouring parts in correspondence with the diminished inflow. From this one can best explain why section of arteries helps so much in alleviating pains, inflammations, and many such symptoms, that it [p. 110] always seems to afford immediate relief. This is so because the blood, which is expelled from the heart through the arteries, circulates with some trouble and difficulty through the pores and body-structure. Hence, when it has got a free and unimpeded pathway, it all rushes out and overflows at once in a torrent, and in consequence its rapidity and pulsation is much diminished in the neighbouring vessels, emptied and deprived as they are of their accustomed fluid. This process is akin to that which occurs in a river, which is divided into two streams or rivulets and runs peacefully and steadily along in a flat country. If the bank which previously held in one stream, breaks down and this stream bursts headlong from its channel, it not only causes an outflow from the stream opposite the breach, but in addition the level of the neighbouring stream to which it is joined by various ditches and brooks (like so many anastomoses), sinks at once, and its current is slowed. Each stream has found an easier outflow, and runs out through the freer channel. A process exactly similar to this occurs in the vessels of the body. At any rate I have found that, if the cervical artery of one side be opened, the pulse in its fellow of the opposite side is at once greatly diminished; similarly, [p. 111] if one crural artery is perforated, the pulsation of the artery in the opposite leg instantly becomes very much less.

We have seen up to now how potent are the dilatation, constriction, and amputation of an artery in altering the movement of the blood; it remains for us to demonstrate that the same can occur on the venous side.

While it is of less importance for me to explain the causes of venous dilatation than the alteration of the blood's movement effected by such dilatation; I must remark that veins are chiefly enlarged either through the compression of some organ, or through abundance of blood, or (whether it be due to the weight of the blood itself, or to a relaxed tone of the veins, or to the heart propelling the blood with insufficient force) through difficulty in its return. Therefore, in pregnant women, through the pressure of the uterine mass on the vena cava and both iliacs in the pelvis, and through the increase of blood and fluids and the difficulty of their upward movement from the lower organs; and, in those of a sad and melancholy disposition, through the slowness of the heart's [p. 112] movement; the veins of the tibiae are often distended to form large varices. The blood, through obstruction to its return, or through insufficient propulsion from behind, is delayed overlong in the lower veins, and distends them finally by its weight and mass, to provide more room for itself. So, when the patients go back to bed, or, in the case of the pregnant women, when they are delivered, these veins immediately empty because of the easier return of blood to the heart. When, however, they have been too long accustomed to this increase in size, they cannot easily recover their former tone or contract, so as to prevent the diversion of blood from the heart and vena cava, and not seriously disturb the regular, orderly circulation of the blood. A defective pulse and languor of spirit are thus the sequel to over-dilatation of these veins. I made careful observations of this condition not so long ago in a countryman about forty years of age, and almost worn out by long-continued melancholy. He was troubled with a varix or venous dilatation on the anterior surface of the left tibia, which was so large that the swelling stretched like a large sausage from the malleolus [p. 113] to the knee, and was a very considerable impediment to him in walking. As far as I could estimate from the size of the swelling, it contained almost two pounds of blood. Yet, when he lay down on the ground and raised his tibia, or when he exerted pressure with his hand on this bag of blood from below upwards, the swelling slowly subsided through the transference of blood to the crural vein and to the vena cava. When, on the other hand, he stood upright again on his feet, the bag soon rose to its former size, and this must have been due to inflow of fresh blood. As, however, he complained of weakness in addition to the annoyance of this heavy weight, and of marked listlessness when the swelling lasted a little overlong (which I think must be attributed to the retention of blood and undernourishment of the heart), I advised him, as a preventive of both evils, to keep the tibia always compressed with a pretty tight half-boot or bandage, and to apply an astringent plaster. By these means he was definitely relieved for the future.

But, while venous dilatation anywhere diminishes the movement of the heart very appreciably, by diverting the [p. 114] due supply and inflow of blood, just the same trouble affects this organ, where veins are confined in so narrow a space, that they do not allow a sufficiently free passage to the blood. In very fat animals compression of the veins by the excessive mass of adipose tissue prevents the blood from being supplied in proper amount for the continuance of the heart's movement; hence it is apt to stagnate and clot in its vessels and in the heart, and so renders the animals liable to sudden death (especially such as are not endowed by nature with a strong, robust heart). Moreover, while compression of any vein, albeit rather a small one, makes a certain difference by preventing the blood's movement, the more and the larger their vessels which are blocked and constricted, the more immediate is the danger threatening the heart. Compression of the aorta a little above the diaphragm causes an accumulation, in the upper organs only, of the blood due to the whole body and accurately apportioned to the vessels as a whole; it therefore brings [p. 115] ruin and calamity to the head and to the heart. If, on the other hand, the vena cava is tightly ligatured a little above the diaphragm—where it passes towards the heart in a trunk which is free and unconnected with any other organs—so that the passage of blood through it is instantly suppressed, the amount of harm this means for the animal can scarcely be told. For, though it reveals no feeling of pain or torment by struggling or howling as a result of the application of the ligature to the vein, it nevertheless soon begins to weaken, and to become exhausted to such a degree, that it can scarcely stand on its feet. Indeed, I once saw a rather fierce mastiff not so much prostrate himself as tumble and fall on the ground, as if he had been altogether deprived of life. The reason they bore so differently and so quietly ligature of the vena cava, while they were extremely upset by compression of the aorta, seems to be nothing but this. When the vein is ligatured in that spot, the blood due to the body as a whole is chiefly expended on the lower part of the body only. Hence the head is deprived in great measure of its life-giving inflow, and is so unable to impart [p. 116] spirits to sustain the heart's movement, that both organs necessarily become much feebler and weaker in their actions, and this happens painlessly to both. On the other hand, when the aorta is compressed above the diaphragm, the blood, which is in large measure destined for the lower portion of the body and for the abdominal viscera, is all poured into the upper and smaller portion of the body. This portion is quite incapable of receiving it, and so must necessarily be oppressed and choked by the excessive amount of blood. As this quickly causes great disturbance to the brain and to the heart itself, the animal is annoyed in the way described, as soon as pressure is exerted, and makes every effort to get away. The experiment is noteworthy in more than one respect, and hence I think it will not be amiss, if I describe at this point the operative technique. The right side of the thorax must be pierced between the seventh and eighth rib, a little below the level of the heart. Then a finger must be inserted to feel the position of the vena cava, the right side of the chest pushed as near to the vein as possible, so that a string may be more easily passed round the vein, and the ligature must be drawn tight at this point within [p. 117] the chest. The chest must then be relaxed and the wound sewn up. When the experiment has been completed, the dog soon becomes very weak, and dies within a few hours. Further, when the abdomen is opened, one sees a large quantity of serum within it, as if the animal had suffered long from ascites. I had previously found that this fluid was secreted as the result of an interrupted circulation of blood from arteries to veins; for not long before I had passed a string under the jugular veins in a dog and ligatured them tightly; after some hours all the parts above the ligature were remarkably swollen, and within two days the dog died with all the appearances of suffocation by a quinsy. All this time not only did its tears flow rather plentifully, but a large amount of saliva also dribbled from its mouth, as if the flow were being stimulated by a dose of mercury. When the animal was dead, I separated its skin from the swollen parts, and thought myself to find the swollen parts distended by extravasated blood. What had happened was quite otherwise, since I was able to see practically no trace or [p. 118] colour of blood. On the contrary, all the muscles and glands were obviously very greatly distended and rendered highly transparent by a clear serum. This definitely proves that serum is secreted whenever the blood is unable to pass from arteries into veins, because it has, as in a filter, paths which are more open to it, and pores adapted to its form and more suitable for it to flow into. The thicker part of the blood, however, is unable to pass through at all, as it is too gross for these paths, and it is therefore forced to stagnate within its vessels. I leave it to others to judge how far these findings help in the investigation of Ascites and of anasarca; one point only I must note, namely, that ascites does not always, if ever, result from rupture of lymphatics. I have dissected very many sheep, which had died of hydrops pectoris and abdominis, and I have nowhere seen lymphatic vessels more swollen and full than they were everywhere in these animals. So, if any one intends to write a complete account of the lymphatic veins, no bodies will afford him better material for the scheme he has in view.

[p. 119] Up to now I have shown how the movement of the heart is affected through the fault of that organ itself and of its vessels.

III. We have next to explain how far the blood may be regarded as responsible, and by what defect in it the heart's movement is impaired.

It disturbs the heart's movement in three ways in particular:

1. By solidification and coagulation.
2. By being present in excess.
3. By being present in subnormal amount.

1. The movement of the heart is changed by the blood when it is coagulated and congealed, either by mixture with a foreign substance, or by withdrawal of its own constituents,

so that it completely closes its own path and passage. This sometimes happens in plague and in poisoning, and as a result there follow those very serious symptoms, namely, heart-trouble, tremor, palpitation, intermittent pulse, and finally syncope and sudden death. All these I once saw—not without great compassion—in a fair-sized mastiff, after injecting into the crural vein half a pound of moderately warmed fresh milk (for the sake of a test). I had previously withdrawn an equal quantity of blood to make room for the [p. 120] milk. Scarcely half an hour elapsed before the animal was affected by very great internal unrest, cardiac oppression, and convulsive movement of the diaphragm (to accelerate the circulation of blood). Soon after there followed rapid palpitation, tremor, and very deep sighs, and finally it died of syncope amid pitiful cries and wailings. In the post-mortem examination I soon saw that the vena cava, both ventricles of the heart, the pulmonary vessels, and the aorta, were filled with a solid mass of milk and blood; and so closely was the blood united throughout with the milk, that it could not easily be torn apart or separated by the fingers. I have no reason to doubt that the coagulation occurring in plague is similar, as it manifests itself by exactly the same signs and symptoms.

2. The setting and congealing of the blood-mass causes cessation and suppression of the heart's movement by blocking its own paths in the vessels and in the heart. At the same time, if the blood is present in too great an amount, or is swollen by an undue quantity of serum or of chyle, it [p. 121] sometimes so fills and overburdens its vessels and the ventricles of the heart, that they must necessarily be over-distended, and cannot, moreover, contract adequately. They are, therefore, completely overwhelmed by their excessive content of blood. Thus constant choking is common in men who always feed luxuriously and fully, and especially in drunkards, unless the blood-vessels are emptied by a copious and timely venesection, and some part of the intoxication is removed by clysters, so that the circulation may once more be unimpeded.

3. A plethora of blood, then, causes choking and oppression of the heart's movement by overfilling the ventricles of the heart and its own vessels. On the other hand, when there has

been so great a loss of blood and emptying of the vessels, that the blood only excites the ventricles of the heart without adequately filling them, the heart often works in vain and at length ceases to move. Such often happens in profuse haemorrhages, and in long-continued fasting.

IV. Let it suffice to have shown hitherto how much the heart's movement is changed by the heart itself, or by its vessels, or by the blood. It remains for me lastly to explain [p. 122] how its movement is changed by variation in the inflow of spirits.

The orderly movement of the heart depends on the due inflow of spirits through the nerves, and so the movement of the heart will be very greatly changed by variation in their inflow.

1. The movement of the heart is accelerated in violent exercise in proportion as the blood is driven and poured into its ventricles in greater abundance as a result of the movement of the muscles. The heart must pass on the blood as fast as it receives it, and so it distributes it in larger amount to the brain as well as to the other organs. To discharge a mutual obligation, the spirits are likewise sent out in larger amount to hasten the movement of the heart. In fevers, also, the movement of the heart is remarkably accelerated, not because the blood boils out fiercely into the aorta, but because its heat and feeling of warmth is inimical to the ventricles of the heart, and, transmitted to the cerebellum, excites the spirits to quicken the heart's movement for its [p. 123] expulsion; partly, too, because some very fierce, uncurbed portions of the blood are deposited in the brain, and stir up the spirits dwelling there to a state of excitement: just as the movement of the heart is surprisingly increased through drinking good wine or any highly spirituous beverage, because the spirituous portions are distilled in large amount from such liquids into the brain, and excite the spirits dwelling in the brain to similar disorders.

2. The movement of the heart is diminished in large haemorrhages, fastings, long-continued illness or grief of any kind, prolonged lassitude, fainting disorders, and malign fevers: inasmuch as the blood, through deficiency in total amount, or through lack of fresh food, or through the ravages of long-continued fever, or its constitutional weakness, is

so far degenerate and impoverished that its exhausted, effete, or aged mass is quite unequal to the distillation of spirits for the brain. Hence, through the incorrect nature of the spirits, or diminution in their due inflow, or deficiency, the heart must necessarily reduce its movement, until the [p. 124] blood increases in amount, or is renewed by fresh food, or is more perfectly compounded.

These effects are only indirectly due to the brain and to the spirits. I must next show how the movement of the heart is changed through the fault of the spirits themselves.

3. It is perverted in emotional states, such as anger, joy, and sudden fright, when the spirits fly to the heart in excessive and unwonted amount or with a greater rush than usual, accelerate its movement very greatly, and excite and convulse it with bounding movements that are sometimes terrific. This condition writers have from time to time called by the diminutive term *palpitation*, not perhaps giving it adequate consideration; but actually the heart-muscle is subject to the same ills as other muscles, just as it performs work identical with theirs. It is equally liable to spasm and to convulsive movement, and is much more often attacked by such conditions. In so-called palpitation (which is really a convulsive movement) the heart is often seized by a systole so violent that it has been known to move the very ribs from [p. 125] their place, and to fracture them. Further, like other spasms, it is excited by the same causes, and recurs periodically; and, while those so seized usually advance the plea of sudden fright or anger, they fall once more into the same plights for any cause similar to that which first excited them. For, when the spirits have once been driven into tumult and confusion, and have been carried too hurriedly to the heart, they will thereafter adopt the same path and movement, and will cause a similar spasm to attack the heart, when they are equally excited by any cause, however trivial. This can be seen in those subject to so-called palpitation.

4. The spirits, then, in the brain and cerebellum sometimes overstimulate the heart-muscle, when they are driven to disordered activities. When, on the other hand, they are carried off and drawn away in another direction, this muscle is often contracted so tightly and firmly that it has no diastole for a long time. Hence nothing is more usual than

for women who are affected by hysterical emotion or by epilepsy to complain very much, as the paroxysm gets worse, of spasm and constriction of the heart (as if it were being [p. 126] compressed by the hand). If at this time you apply a finger to the artery, you will not feel the least trace of a pulse. Similarly, when the paroxysm is over, they complain of great cardiac trouble and oppression, because, owing to the impeded movement of the heart, the blood, which collects and piles up within it, oppresses it with its weight and overburdens it. For this reason most epileptics strike and beat upon their breasts repeatedly while the paroxysm lasts, in order to stimulate the heart to movement, and to prevent the blood from clotting. Because, if the paroxysm lasts too long, there is danger of the blood clotting to such an extent that the heart will never again be able to loosen it or to shake it free. Hence too long continued epileptic paroxysms often end in death.

5. While the heart's movement ceases awhile when the spirits are drawn off elsewhere, it fails completely when their inflow is altogether cut off: as in Apoplexy. In this complaint the whole of the medulla oblongata is apparently obstructed at one and the same moment, and in like manner the whole [p. 127] nervous network arising from it suffers eclipse. The heart, together with the rest of the body, is completely deprived of sensation and of movement, and rests from its labour, until perhaps the paroxysm ceases, a very rare happening in this complaint.

As it is evident, from what has been said above, that the heart's movement depends on external influences, and undergoes various alterations in sympathy with the other organs of the body, I must next show what affections and symptoms follow on the various disorders of its movement.

The changes which occur in its movement are manifold and various, and so the other organs most in sympathy with the heart share its injury in various ways. And, as nothing is so nearly related to the heart itself as is the blood, and there is nothing on which the brain depends more closely, so there is nothing which causes disorder or failure of the heart more rapidly than the blood or the brain.

The troubles and symptoms which are induced in the blood-fluid are two in particular.

1. If the heart's systole, which shakes up the blood-fluid and dashes it against the sides of the ventricle and the walls [p. 128] of the vessels, delays a little too long, the nutrient juice of the blood begins to separate into parts, to pile up and thicken like jelly, and finally to be caught up among the cardiac fibres hanging here and there, to adhere to the very walls of the ventricles, and to harden by the heat of the heart; and oftentimes to increase to such an extent as almost to fill both chambers of the heart, and greatly diminish its movement. Thus it is usual and customary in patients suffering from wasting diseases, poor constitution, or scurvy (as their pulse is weak and intermittent), for the ventricles of the heart and all the blood-vessels to be stuffed almost full of clotted chyle. This I have often seen in many such after death, and in those exhausted by long illness, especially if they have become bed-ridden by such weakness. It has, indeed, been cause for wonder that the heart contracted at all, or that the remaining blood, which was still fluid, was able to penetrate within those vessels to preserve life and warmth in the organs of the body. I once, for instance, saw [p. 129] in a patient, who died of wasting at Oxford, and who was often subject to fainting a little before his death, that the entry into the right ventricle was so closed up by such a fleshy clot, and the clot had become so tightly fixed among the tricuspid fibres, that a passage scarcely large enough to introduce a goose-quill remained for the blood-inflow. The left ventricle, moreover, was closed up in almost identical fashion, so that the entry into the heart could with difficulty be disclosed by the fingers. Such clots I have seen so changed to flesh that I have noticed large numbers of veins and fibres within them; when I dissected these into small pieces, they poured out blood as if some organ of the body were being incised; showing clearly that the nutrient juice within the blood provides food for the organs, since it was thus fitted, not only to change within its vessels into tissues as such, but also to assume the very colour and structure of flesh. The cause of this coagulation seems to be as follows: the heart's movement is feeble for a long time, and the patient is simultaneously bed-ridden; as a result of this horizontal posture of the body the blood is carried along at a slow rate, and [p. 130] because of such slowness and delay in its movement

(especially as the nutrient juice in the blood is highly viscous) it gradually solidifies, and assumes a shape which varies with that of the heart and containing vessels. Hence it has occasionally been taken for a polyp of the heart, a worm, or a serpent. From these facts it is obvious how useful exercises and movements of the body are as an aid to health; for the more often the blood is shaken up within the heart and thrown against the walls of the vessels, and is moved and activated in the body by contraction of the muscles, and finally driven through the pores of the body; the more must it be thinned and freed from those stagnations, to which the nutrient portion of the blood is otherwise over-subject.

2. While stagnation and clotting of the blood are induced by a small, weak movement of the heart, the mixture of the blood is best maintained, on the other hand, when the heart's movement is vigorous and strong. But, if the movement becomes violent, the blood-fluid is very greatly thinned as a result of the extreme shaking it receives, and hence sweating occurs on exercise, bathing, and dry or steam [p. 131] sweating-baths. If this excessive activity is occasioned for too long a time and to an undue extent, the blood is deprived of its means of transport through loss of serum, and is rendered unfit for circulation; and the heart itself becomes tired in its work through the loss of spirits. As a result fainting and syncope occur.

These are the symptoms and effects which redound most directly on the blood itself through alteration in this way or that of the heart's movement. There are, however, other things which affect equally the organs containing the blood.

1. When the movement of the heart is weak and intermittent, it predisposes to such head affections as vertigo, scotoma, blindness, and fainting. The reason for these symptoms lies in the fact that the animal spirits and life itself depend on a continuous supply of blood to the brain. Hence, if the circulation is stopped for a little while, or the supply is insufficient in amount, then, because of the failure of blood, the head immediately becomes unsteady, the eyes are shrouded in darkness, and the whole fabric of the body [p. 132] is liable to fall flat on the ground. For this reason we lay those affected by syncope on their backs on the ground, so that they may the more quickly be restored to

life; because, though the heart is weak, it will nevertheless be able, in that posture, to propel the blood to the head along a fairly horizontal course, although it was unable to send the blood thither in the erect position of the body. Through the inflow of blood, sensation and life are restored, and that likeness of night at once disappears.

2. On the other hand, when the heart's movement is accelerated, and blood is supplied too rapidly to the head, it causes headache by twitching and shaking the membranes, and it induces wakefulness by exciting and driving from their place the animal spirits, which have collected through sleep within the brain, and are resting, so to speak, from their labours. Perhaps in similar fashion to the way in which sleep soon attacks us beside a slow and gently-murmuring stream, but we are excited rather by fear and kept awake beside eddies and cataracts.

These are the chief effects which follow changes in the heart's movement as one's shadow does one's body. It remains next for me to show how the blood-flow is changed [p. 133] according to variation in the position and shape of the body, and the result of such change.

The inflow of spirits into the heart (as stated above) varies according to the variety of animals; and similarly the blood-flow undergoes a difference according to the diversity in position and shape of the body. It is an undisputed fact that the return of the venous blood is the result of the impulse given to the arterial blood, and not of any attraction by the heart. Hence it is easy to imagine how much the position of organs helps in facilitating or retarding this movement. In man, standing upright on his feet, the blood from the jugular veins and the descending vena cava falls down into the heart chambers comparatively quickly and easily by its own weight (just as the veins in the hand are soon seen to be empty when it is raised, but swollen and full when it hangs down); but the blood which is in the lower parts and in the ascending vena cava is only driven and forcibly moved on towards the heart by the arterial blood, and this with greater difficulty and against its own [p. 134] inclination; in the body lying flat on the ground, however, the blood returns with equal ease from both extremities. It will therefore be worth while to consider what is the position of a member in which the blood-flow is faster through that organ, and what is the effect of a quicker or of a slower circulation.

While night and day, then, and sleep and waking hours, follow each other in mutual succession, the position of the body is erect or recumbent according to the needs of nature.

1. Thus in Man, standing upright, the blood flows down into the heart from the upper part of the body with practically no external assistance; and the blood is only driven upwards from the lowest part of the body with difficulty through the impulse of the arterial blood, and at times by the contraction of the muscles in exercise; and so the circulation of the blood in the upper parts must also be more rapidly effected than in the lower. This will be more clearly seen later.

2. In the recumbent position of the body, however, when it is at rest from movement, the circulation of the blood through the extremities is carried out more rapidly or more slowly, according to their degree of elevation above the rest of the body.

[p. 135] The effects and disadvantages which a quicker or slower passage of blood leaves behind it in the organs are two in particular.

1. An accumulation of serous fluid.
2. A diminution of vital heat.

These affect chiefly the extremities of the body (the feet and the head).

1. In the feet, especially of sick persons and of those who are unable to indulge in proper exercise, the blood ascends with some difficulty (in the erect position) towards the heart, and through its stagnation and delay in passage it distends the smaller capillary vessels by its bulk, and accumulates in this position of the body. Hence come oedematous, dropsical swellings of the feet. The proof of this view is that when these persons go to bed, and lie down with their feet at the same level as the rest of their body, this serum is reabsorbed into the venous blood in its circuits, and so the parts are again emptied and before the next day the swelling completely disappears.

2. In addition to the collection of fluids and the slower [p. 136] circulation in the lower organs, there ensues also

a diminution of heat; though we feel less cold in the daytime, because the blood is well propelled as a result of exercise and of walking, and hence the way is open for fresh blood, newly forged on the heart's anvil. If, however, we go to bed and put ourselves at rest with the feet lower than the rest of the body, they will not begin to grow warm, until the bed is so arranged that they are at a higher level. The reason for this seems to be that the venous blood leaves the feet more rapidly in consequence of such raising, and the arterial blood therefore flows in more freely and in greater abundance; with the latter heat is restored to the part.

This is so usual in the majority of comparatively cold-blooded men, whose blood is over-rich in serous fluid, that sleep only creeps over them, owing to the feeling of cold, when the bed has been remade to raise the feet higher.

The feet, then, swell and grow cold owing to the over-slow return of venous blood. At the same time, if the head is too low during sleep, the brain reveals the presence of an exces-
[p. 137] sive amount of blood because, though this organ feels the cold less for its inclusion within the covering of the skull, the blood returns with greater difficulty from this position. Every one of those who sleep thus complains next morning of mental sluggishness, sleepiness, cold in the head, ringing in the ears, and swelling of the face. All of which troubles disappear by degrees after he has arisen, and the blood, reabsorbing those serous fluids in its passage, has carried them back with it to the heart.

As mention of sleep has occurred here in passing, it will be appropriate to show here in a few words the position of the head which is most conducive to healthy sleep. Inasmuch, then, as the human brain is completely destitute of a rete mirabile (to receive part of the serous overflow from the blood and to keep it from the brain), and the blood-vessels, although formed with a tortuous pathway to break the rush of blood, set it down unimpaired in the brain—as shown in *Plate 5, Fig. 3.* In which

[p. 138] *aa are the two carotid arteries at their entry into the skull.*
bb is where they pass through it in a twisting course.
cc is where they discharge blood at the base of the brain, their mouths opening directly upwards.

dd are the vertebral arteries at their entry into the skull.
ee is the point where the two vertebral trunks join in one and go in a straight channel towards the carotid arteries to join with them by anastomosis.

—a comparatively serous and watery blood must of necessity flow into the brain, especially when the body is lying flat and the head is likewise bent backwards; as, further, the blood poured into the head in such a position does not flow back from the brain so rapidly and promptly as it does when we are erect, the brain itself, and in addition the whole nervous system, must inevitably be inundated by too much serum. This is proved to their cost by such as are subject to [p. 139] spasmodic complaints, hydrops cerebri, vertigo, paralysis, sluggish perception, and brain disease. For, if they go to sleep with the head lowered and on a level with the rest of the body, next morning, owing to the excessive flooding of the brain and nerves with serum, they complain at random and exhibit signs of vertigo, dimness of vision, cold in the head, tremor of the limbs, lisping speech, and swelling of the whole face. Moreover, they are often attacked during sleep by troublesome dreams or by nightmare, and the whole of the next morning seem to themselves to be sluggish, sleepy, and heavy; and they are scarcely able, if at all, to shake off their sleepiness for a long time afterwards. On the other hand, those who go to bed with the head at a higher level have a pleasant and restful, though shorter, sleep, because in that position the blood and its serum flow down from the brain comparatively easily through their own weight; and next morning they awake much more active and vigorous, and are more alert and ready for every kind of work and occupation.

It will not be amiss to remark here in passing on that very bad habit common to some people, who indulge in heavy drinking late at night (a time at which, especially in large [p. 140] cities and in universities, they are most free from studies and business). Nothing can be more pernicious and harmful to the brain than such procedure. Owing to the recumbent position of the body, the urine secreted by the kidneys does not pass down the ureters into the bladder so easily and so quickly as it does when we are erect (though it cannot be denied that the ureters, like the oesophagus, consist of a muscular coat, and so serve not only to carry but to propel fluid, and can dilate or contract as needed). Further, the neck of the bladder is not so subject to pressure from the weight of urine in the recumbent position, and the bladder itself does not feel its burden so keenly, with the spirits collected in the brain and at rest in sleep, but, forgetting its duty, it sometimes becomes distended by a quantity of urine so great, that there is scarcely room to receive more. Hence this fluid flows back into the body as a whole, owing to obstruction to its downward flow through the kidneys and ureters; and, if purging does not occur next [p. 141] morning, or if it is not evacuated by nocturnal sweating, part of it must be deposited within the brain; and, by long continuance of such procedure, accumulate there to such an extent that it finally causes paralysis, tremor, hydrops cerebri, lethargy, or apoplexy. That this is really so I have often learned from the unfortunate and common experience of others; for I have many times seen large numbers of men, of otherwise faultless health, undergo a succession of attacks of such diseases through over-indulgence in this sort of life. In order to escape these evils, I should advise any one, who is unable to refrain from this habit of drinking, not to go to bed before he has satisfied himself that he has got rid of the greatest part of the ingested fluid via the bladder. This he will accomplish more thoroughly and quickly if he undresses, or slackens his clothing, and exposes himself cautiously to the surrounding air; for the prevention of perspiration and the constriction of the body so produced will increase the amount of urine to a remarkable extent. This is proved by the fact that the bladder passes urine more often and in greater quantity when the body is exposed to the air than when it is relaxing in the warmth of one's bed; hence, if [p. 142] one passes the urine which has accumulated throughout the night immediately one rises from bed, one will have to empty the bladder again (if the weather is cold and wintry), and will pass a larger amount of urine within a quarter of an hour of the last micturition, than had previously collected in many hours of sleep. It is just the same if one empties the bladder before going into the water to swim, for, despite this precaution, as soon as one is immersed in the cold fluid, owing to the contraction of the skin and the closing of the pores, one will once more pass urine in larger measure than before, though it had collected in the bladder for a long time.

As a result of this precaution (i.e. not going to bed before he had taken the trouble to pass a sufficiently large amount of urine) I have known a man prolong his drinking very often till late at night, and his life also for many years, and indeed, they say, to an active and vigorous old age.

But these remarks are by the way; and as the supine [p. 143] position of the body approaches nearest to the horizontal, it will be pertinent to show briefly also what inconvenience results from that position of the body in sleep. To make this clearer, I ought first to say that the brains of animals have a construction which varies with the difference in shape of their bodies, but the chief divergences are in respect of the sinuses and ventricles of the brain. In quadrupeds, which go along with their head down on the ground, the cerebellum lies a little above the cerebrum, and so the lateral sinuses which pass down between the two organs are also superior, and likewise the fourth ventricle, which lies under the cerebellum, is situated at a higher level than the other ventricles of the cerebrum.

In man, however, the head stands above the rest of the body, and the cerebrum definitely rests on the cerebellum (with the interposition, nevertheless, of the dura mater, the attachments of which to both sides of the skull are strong enough to prevent the cerebrum compressing the cerebellum by its weight), the lateral sinuses are likewise also situated at a lower level, and pass obliquely along the lower wall of the occiput on both sides before ending in the jugular veins. [p. 144] Hence, when the body is laid flat on a bed with the neck at a higher level than the occiput, the supine position it occupies must result in the blood going upwards to the jugular veins rather than flowing into them. So, through delay in its movement and circulation, the blood is continually arriving, but not so easily escaping, and therefore it forms those deep pits on both sides of the occiput. And, as a man usually goes to rest on one side or the other, these sinuses are always more hollowed out on one side than on the other. This is obvious to any one who looks at the inner side of the occiput on which the cerebellum lies. The idea that these pits are formed in the occiput as a result of hindrance to the return of blood, and the consequent swelling of the vessels, is proved by the following fact. The blood flows down freely enough from the longitudinal sinus, and above this sinus there is not the least impression caused by it on the skull, except in the lower portion, where it discharges into the lateral sinuses already mentioned. But, if such prevention of the return of blood can in time so affect a bone of this hardness, as to hollow out deep and tortuous [p. 145] pathways for itself within the bone, how much more may the blood itself and the serum flood into the brain, and exert pressure on it, though the veins receiving blood from the vein at any point do not all open directly into the sinuses, but pass for a short distance between the folds of dura mater, in similar fashion to the way in which the common duct enters the duodenum, or the ureters enter the bladder? In addition it is a very noteworthy fact that they have their openings directed, not towards the occiput (which would give the outgoing blood a straighter course to the lateral sinuses), but towards the forehead, away from which the blood is flowing. As a result the blood cannot—for instance, in laughing, convulsions, &c.—be poured or driven back from the sinuses into the cerebral veins; but the more the sinuses become swollen with accumulation of blood, the more they prevent regurgitation of blood into the veins by pressure on the folds of dura mater. These points will all be better appreciated by inspection of *Plate 5, Fig. 4.* In this figure

aa is the longitudinal sinus opened up.
b is its commencement near the cock's comb bone. The commencement is a blind end.
c is the point at which it discharges into the lateral sinuses.
dd are the two lateral sinuses.
[p. 146] *e is the fourth sinus.*
ff is the place where all the sinuses empty their blood, outside the skull, into the jugular veins.
hhhh are veins carrying blood into the sinus on each side of the brain.
iiiii are their mouths discharging blood against the stream in the sinus.

Plate 6, Fig. 1 shows the manner in which the lateral sinuses of the brain end in the jugular veins outside the skull. In this figure

a is part of the longitudinal sinus cut away.
bb are the two lateral sinuses.
cc is the place where the lateral sinuses enlarge on either side within the occipital bone and hollow out pits in the bone.
dd is where they pass their blood outside the skull.
ee are the points at which the lateral sinuses, in their exit from the skull, communicate with the vertebral sinuses.
ff are two twisting sinuses hollowed out within the skull-bone to prevent backflow of blood into the cerebral sinuses.
[p. 147] *gg are two channels just outside the skull, through which the pituitary gland in the human brain discharges into the jugular vein of either side the fluid which it receives from the ventricles of the brain.*
hh are the jugular veins.

But in whatever way the blood is checked in the sinuses or in the veins, the evil effect recoils at length on the brain, and therein amasses matter for future illnesses, and, so to speak, prepares the tinder for the spark. The serum which collects for such reasons among the convolutions of the brain stretches the pia mater until at length it either eats it away by its sharpness or ruptures it through its bulk. It flows down from here to the base of the brain, and injures the medulla and the nerves arising from it by forming a pool there, or irritates them by its sharpness. The results are hydrops cerebri, convulsions, and the accumulation within the head of the dread preparation for death. If, on the other hand, this serum is taken up by the brain-substance, it leads to paralyses, sluggishness of perception, lethargy, sleepiness, and other serious head-troubles.

[p. 148] Moreover, the fourth ventricle, lying under the cerebellum, is more on a slope and more deeply placed than the other ventricles within the brain, and even than the infundibulum itself: and so the lymph secreted by the choroid plexus into the ventricles of the brain flows into the fourth ventricle, which slopes down more than the others, rather than into the infundibulum. This is especially so if one goes to sleep with the head bent back; as a result of this recumbent position the afore-mentioned cavity is completely filled with fluid, and is so overburdened that a feeling of its weight is communicated to the precordium, and gives rises to cardiac oppression and nightmare. Almost all hydrocephalics, therefore, find it dangerous to sleep in a supine position. They are obliged to lie on one side or the other the better to avoid such injuries. Indeed, I knew one man who was formerly extremely subject to nightmare, though he was otherwise quite strong and healthy, and during the whole of two years he never slept on his back without an [p. 149] attack of that trouble. So much so that he had to take a manservant to share his bed. This man would turn his master on to his other side as soon as he heard groans and sighs, the usual prelude to the trouble, and this treatment always resulted in prevention of these attacks.

One may indeed see large numbers of new-born children unable to sleep long or quietly in their cradles, if they are subject to convulsive movements, but attacked by various spasms and twitchings of the limbs. The reason for this seems to be that their brains have an excessive amount of fluid, and, owing to the horizontal position such as exists in cradles, the fluid held in the ventricles of the brain flows into the fourth ventricle rather than into the infundibulum, on account of the more dependent position of the former. Hence it weighs on the medulla oblongata (whence arise the nerves of the precordium), and, by compressing this structure, hinders the passage of spirits into the nerves. As a result there follow heart-trouble and convulsions. This is the more [p. 150] credible, inasmuch as in the opposite position, that is to say, in the arms or in the lap of their nurses, where the head is held more upright, they sleep in comparative peace and quiet. I happened, moreover, to see the same thing in an Oxford graduate, who died four years ago of hydrops pectoris: this patient, in the last stages of his disease, could only sleep with his face flat on the bed and his head down. If he composed himself for sleep with his head resting flat on a couch, he always woke up within twenty minutes distressed by lack of sleep and by terrifying dreams. Indeed, he was troubled for a long time after waking by heart-tremor and extreme cardiac oppression. When the brain was opened after his death, the ventricles were found extremely distended with fluid, but no other abnormality of importance was seen in the whole of the head.

I am convinced by many experiments that no fluid passes down from the brain into any organs below. It will therefore be worth my while, before I lay aside the pen, to show the route and channel by which all the fluid, coming from the choroid plexus and the post-cerebellar glands, is carried and passed through to the ventricles of the brain and, through [p. 151] the infundibulum, to the pituitary gland, and then escapes outside the skull. Some time ago in a calf's skull I found that on injection of water, or of milk even, into the foramina, which are hollowed out in the skull bone to receive the serum from the gland, the whole of this fluid came pouring out of the jugular veins of either side. So all the fluid secreted by the brain in this animal finally overflows into the blood and is so discharged. This same fact I have recently found to be true in the human skull; for, although foramina never occur in the human skull-bone near this gland, yet the membrane on which it lies is pierced in many places like a sieve, and the fluid which passes through the holes is taken up eagerly by other vessels on either side of the so-called sella turcica, close to the ascending carotid arteries, and passes into the jugular veins on either side a little below the tortuous sinus. The channels of these vessels will easily be shown if water or milk is forcibly injected with a syringe into either of the jugular veins a little below [p. 152] the tortuous sinus; for it will soon be seen to burst out and gush forth in various places near the pituitary gland. A clear proof that any serum secreted by the brain is finally returned to the blood and mingles with it.

CHAPTER III

The Movement and Colour of the Blood

The rapidity of the circulation, and the difference between arterial and venous blood.

HAVING thus established the nature of the heart's structure, the source of its movement, the reasons for this movement's variation, and the kind of effects and symptoms such variations produce in the blood, it remains for me next to show how rapidly the whole of the blood circulates through the heart.

[p. 153] Whatever statements writers before *Harvey* made about the movement of the blood through the ventricles of the heart are so empty and worthless that they have already spontaneously disappeared into oblivion. And however much those of his successors who have accepted Harvey's discovery of the circulation affirm, under the necessity of that hypothesis, that the whole of the blood circulates through the heart, yet they have written about the rate of its passage and about the amount of blood forced out at any beat in such a way that I must think that they have not adequately considered the structure of the heart and its movements. For the majority of them give a few drops only, or a scruple, or one drachm, a few half an ounce, as the amount of blood expelled at each beat. I grant that, in various animals, the ventricles of the heart contain and eject more or less according to the difference in size of the animal's body; but it will be clear from what follows how ill-advised it is to state that so small a quantity is expelled at a beat in man or any larger animal.

I am convinced that the whole mass of blood is ejected [p. 154] by the heart not once or twice within an hour, but many times. To make this clearer, we must consider carefully how much blood flows into the ventricles of the heart each time they dilate, and how much flows out from them while they are contracting. It is apparent from simple inspection that the ventricles dilate maximally in each diastole, but that in systole, on the other hand, the sides of the heart come together and are contracted so closely, that you can scarcely compress the small finger (introduced through the cut apex) more strongly with the hand itself. This is the reason I am absolutely certain that each ventricle receives in diastole as much blood as it can hold, and, on the other hand, expels completely in systole all that it has previously received. This is very obvious and clearly visible with the naked eye in the hearts and auricles of new-born animals, frogs, eels, and snakes. The hearts of these creatures are so completely emptied in any systole by the output of all their contained blood, that they appear quite white; but in diastole (when the blood flows back into them) their colour [p. 155] returns again. One cannot doubt that the same thing happens in the heart of larger animals, though it cannot be seen so clearly in them owing to the thickness of the parenchyma.

If one makes this assumption and counts the pulsations, it will not be difficult to calculate how much blood passes through the heart in an hour's time. Let us assume, then, that the left ventricle in a strong, healthy, human heart holds two ounces at one time, as the great *Harvey* observed (though I have observed it hold much more in some people). If the whole of that amount of blood is expelled by the heart at each systole, and the counted beats are two thousand within the hour (and this is, indeed, the lowest estimate), then the heart must eject four thousand ounces within the hour. This number of ounces makes three hundred and thirty-two pounds: given, however, that there are twenty-five pounds of blood in this man (a greater amount than is conceded to most men by nature or by Anatomists, for they say [p. 156] that the measure of all the blood contained in the human body rarely exceeds twenty-four pounds, or is less than fifteen pounds), it will most surely follow that the whole of this man's blood circulates through the heart six times within a single hour. But as it is seldom that there is so great an amount of blood in a healthy man, or that the heart beats so few times in the passing of an hour, it is reasonable to believe that the blood in most people passes through the ventricles of the heart somewhat more often than six times.

It is so in all animals, provided they are in enjoyment of good health; but it must be supposed that the blood sometimes passes through the heart much more rapidly, for example, in fevers and in violent exercise, and during convulsive movement of the heart; for the beats are then far faster, and the blood is consequently ejected twice as often. On the other hand, the blood passes through the heart much more slowly in jaundice, scurvy, and other such diseased conditions, which cause slowing and irregularity of the heart's movements, or in cases in which the vessels and ventricles [p. 157] of the heart are blocked by means of chyle. Further, the pulse is liable to variations in respect of temperament, sex, and age, so that it is impossible to estimate and to define with accuracy the amount of blood which is ejected, and the circulatory changes. But it is clear enough from the very size of the chambers of the ventricles, and from the number of heart-beats, that the blood is carried along and passes through the heart in strong and healthy animals at a much faster rate than is commonly believed, or has yet been described. And it must definitely be so, if one properly considers the constituents of the blood, and their liability to separate and to clot, unless they are continuously stimulated by vigorous movement.

Let no one imagine, from what I have said, that part of the blood—namely, that which is carried along by the vessels of, or near to, the heart, and not very distant from its source —does not circulate through the heart much more quickly and more often than the rest, which is carried through the extremities. The very nearness of the vessels and organs proves otherwise. But what I do assert is that, although all parts of the blood are not carried along at the same rate [p. 158] or so often through the heart-chambers, yet whatever amount or quantity of blood is present circulates through the heart as often as I have stated above.

How quickly all the blood is distributed by the heart through the whole of the body can be most easily grasped by the very rapid passage through the kidneys of fluid which has been mixed with the blood. Two or three pounds of beer, taken into the stomach as a morning drink, are almost completely passed by the bladder within half an hour, or sooner if the weather is cold. This fluid, moreover, formed for the most part only half of the blood carried to the kidneys. Is it not right, therefore, to say that four or six pounds of blood are passed from the heart to the kidneys through the two (so-called emulgent) arteries? But, if this large amount of blood passes in this very short space of time through vessels which are small by comparison with the others, it will not be difficult to understand how vigorously the whole of the rest of the blood-mass is carried along in the other regions of the body. This is still more obvious in those, who drink bitter mineral waters in quantities so large, that I [p. 159] have known some who have drunk almost two gallons of water in discrete draughts in a single morning, and they have passed almost all of it through the bladder within four hours. This amount of water is more than double the quantity of blood in most men, and it is likewise certain that it passed quite often through the two ventricles of the heart in common with the rest of the blood, before it could be secreted by the kidneys or passed by the bladder. For nature provides no other passage or route to the kidneys and bladder for any fluid from the stomach or intestine than that through the blood and the heart. But, if so much fluid (which, as stated above, is only half the amount of blood brought to the kidneys) passes through arteries of this calibre in so short a time, what, I ask, are we to think of the passage of the rest of the blood through all the larger vessels?

It is easy to show by experiments, without relying only on estimates, the rapidity of movement of this blood ejected by the heart. For, if almost the whole of the blood may flow [p. 160] out from an opening in one cervical artery within five minutes, may one not suppose that the whole blood-mass circulates through the heart in a much shorter space of time? When almost the whole of the blood escapes thus quickly through one arterial branch, how much more quickly would it flow out from the trunk of the aorta or from all its branches opened simultaneously?

But for the careful estimation of the blood-flow and its remarkable rapidity it will be sufficient to quote one single experiment. I divided both cervical arteries in a fair-sized dog, and at the same time I compressed the trunk of the aorta below the heart with a finger, which I passed through an aperture made in the left side of the chest near the heart, so that no blood should pass down the aorta; finally, I took care to constrict the brachial arteries below the axillae. As a result practically all the blood (except that passing through the vertebrals) was expelled from the heart by way of the cervical arteries; and, strange to say, it all flowed out within three minutes; so that it cannot be denied that the whole mass of it had passed through the heart in that time. One [p. 161] may, indeed, see in cases of trauma, which involve section of any large artery, how brief a period suffices for people so mutilated to lose their life and practically all their blood. This blood, however, must all have first circulated through the ventricles of the heart.

But here I see it objected that the heart pulsates much more quickly, and therefore ejects blood much more rapidly, amid such woundings and torments. Yet, if the blood is held in check for a short while, after these incisions are made, so that all pain and fear first disappear—and this takes place rapidly in younger dogs, which are not so upset by, or so long mindful of, such lesions—the heart-beat is definitely not thus quickened and accelerated. And, though one must admit that the beat becomes more rapid, after most of the blood has escaped and the animal begins to weaken, yet that does not occur until all the vessels have been so emptied, that the blood which remains is insufficient to fill the ventricles of the heart. Hence, pari passu with the continued loss of blood, the heart-beat becomes progressively smaller and faster, until with the complete failure of blood-inflow the [p. 162] movement of the heart too ceases altogether.

It may, however, be objected that the blood flows out from a cut artery more easily, and therefore more rapidly, than it circulates through the body; since in the former case it is carried along in a free, full-rushing stream, and in the latter only reaches the veins through various windings and obstacles, and the narrow places and pores in the flesh—in the same way, perhaps, that a stream flows along in an open channel more quickly than it does when passing through a grating.

To this objection it will be easy to answer that, notwithstanding the narrow places of the viscera and of the body-framework, the blood flows out from open veins almost as rapidly as it does from arteries, so long as the heart's movement is strong, although, granted, the rate of flow is not absolutely so fast in the former as in the latter case. Indeed, I have often found in dogs that if, as in the previous experiment, the neck is tightly ligatured and the trunk of the aorta compressed below the heart, so as to direct the blood-flow to the head, then, when one of the two jugular veins is divided, an almost equal quantity of blood will be drawn off [p. 163] from this vein in a given time as from the cervical artery, at all events until most of the blood is removed. But, after this stage is reached, it must be admitted that the heart's movement slackens on account of so great a loss of blood, and the remaining fluid flows out from the vein in smaller amount and more slowly, in correspondence with its more feeble expulsion from the heart.

If, however, this rapid circulation of the blood is accepted (and I think I have given sufficient proof of it), it will be evident that there is not so much difference between arterial blood and that contained in the veins, as is commonly supposed.

I have spoken elsewhere of the different returns of the two kinds of blood, and of the sources from which they are derived. I have also in the same place discussed their colour-variation, and the cause of this very noticeable difference between them. But as I relied more in this matter on the authority and preconceived opinion of the learned Dr. *Willis* than on my own experience, and confused too far the torch of life with its torchbearer; as, too, the lapse of time has now [p. 164] taught me differently, I shall not be loth to exchange my former view for a better one. It is not my intention to attack the beliefs and opinions of others, or to bring scorn on myself by changing my own, but what is suggested by reason and confirmed by experience carries more weight with me and will always have my allegiance.

It is certain, then, that the difference in colour, which is found between venous and arterial blood, is quite independent of the heating of the blood in the heart (even if some such heating must be conceded there); for, granted that heating does occur chiefly in the heart, then, as the function of both ventricles is the same, and they do not differ in any other respects than, as stated above, in the strength and thickness of their fibres, why should the colour not undergo a similar change in the right ventricle? But it is quite certain that blood withdrawn from the pulmonary artery is similar in all respects to venous blood, and is only reddish on the surface. Indeed, it will be shown by a very convincing experiment that this fresh red colour is not conferred on the blood by the left ventricle either. For, if the trachea is exposed [p. 165] in the neck and divided, a cork inserted, and the trachea ligatured tightly over it to prevent any ingress of air into the lungs, then the blood flowing from a simultaneous cut in the cervical artery (or, at least, such blood as comes out some time after the asphyxiation of the lung) will be seen to be as completely venous and dark in colour, as if it had flown from a wound in the jugular vein. I have tried this fairly often, and the same truth is more evident still from the fact that the blood within the left ventricle of the heart and the trunk of the aorta of an animal, which has been strangled or has died a natural death, and in which air is prevented from passing into the blood, is found to be entirely akin to venous blood.

Finally, to abolish any possible room for doubt, it occurred to me to make an experiment on a strangled dog, after sensation and life had completely deserted it, and to see if the still-fluid blood in the vena cava would all return equally bright in colour through the pulmonary vein, after being driven to the right ventricle and to the lungs. So I drove on the blood, and carried out a simultaneous insufflation of [p. 166] the perforated lungs. The result corresponded very well with my expectation, for the blood was discharged into the dish as bright-red in colour, as if it were being withdrawn from an artery in a living animal.

I have shown that the bright red colour of arterial blood is not acquired through any heating in the heart or anywhere else at any time. In like manner also the dark colour of venous blood is independent of any extinction of its heat within the veins. For, if this were so, why should the arterial blood not take on a like colour after it has left its vessels, since it has now beyond all doubt lost its heat?

This being so, we must next see to what the blood is indebted for this deep red coloration. This must be attributed entirely to the lungs, as I have found that the blood, which enters the lungs completely venous and dark in colour, returns from them quite arterial and bright. For, if the anterior part of the chest is cut away and the lungs are [p. 167] continuously insufflated by a pair of bellows inserted into the trachea, and they are also pricked with a needle in various places to allow free passage of air through them, then, on the pulmonary vein being cut near the left auricle, the blood will flow out into a suitably placed receptacle completely bright-red in colour. And, as long as the lungs are supplied with fresh air in this way, the blood will rush out scarlet, until the whole perfusate reaches several ounces, nay pounds, just as if it were being received from a cut artery. What I had written earlier about the blood withdrawn from the pulmonary vein being like venous blood was said as a result of experimental work, but at a time when I did not yet know from experiment that one could keep life in an animal by continuous insufflation of pricked lungs; so that all the air had been forced out of the lung before I was able to seize and to lance the pulmonary vein. I acknowledge my indebtedness to the very famous Master *Robert Hooke* for this experiment—by which the lungs are kept continuously dilated for a long time without meanwhile endangering [p. 168] the animal's life—and the opportunity thereby given me to perform this piece of work.

If any one, however, argues that this bright colour of the blood is to be attributed to its fragmentation in the lungs rather than to the mixture of air with the blood, he should consider whether the blood can really be broken into fragments better in the lungs than in the muscles of the body, or even as well. For the lungs are kept constantly dilated for the right conduct of this experiment, and I fail therefore to see how the blood can undergo fragmentation save in passing through their pores, as in the rest of the body-framework.

Further, that this red colour is entirely due to the penetration of particles of air into the blood, is quite clear from the fact that, while the blood becomes red throughout its mass in the lungs (because the air diffuses in them through all the particles of blood, and hence becomes more thoroughly mixed with the blood), when venous blood is received into [p. 169] a vessel, the surface and uppermost part of it takes on this scarlet colour through exposure to the air. If this is removed with a knife, the part lying next below will soon change to the same colour through similar contact with the air.

Indeed, if the cake of blood is turned over after remaining stationary for a long while, its outer and uppermost layer takes on the red colour in a short space of time (provided the blood is still fresh). It is a matter of common knowledge that venous blood becomes completely red when received into a dish and shaken up for a long time to cause a thorough penetration of air into it. And let no one be surprised at a loss or admixture of air causing such marked colour-changes in the blood, since we see other fluids also acquiring various colorations, according as their pores take up or refract in greater or lesser amount the rays of light.

If you ask me for the paths in the lungs, through which the nitrous spirit of the air reaches the blood, and colours it more deeply, do you in turn show me the little pores by which that other nitrous spirit, which exists in snow, passes into the drinks of gourmets and cools their summer wines. For, [p. 170] if glass or metal cannot prevent the passage of this spirit, how much more easily will it penetrate the looser vessels of the lungs? Finally, if we do not deny the outward passage of fumes and of serous fluid, why may we not concede an inward passage of this nitrous foodstuff into the blood through the same or similar little pores?

On this account it is extremely probable that the blood takes in air in its course through the lungs, and owes its bright colour entirely to the admixture of air. Moreover, after the air has in large measure left the blood again within the body and the parenchyma of the viscera, and has transpired through the pores of the body, it is equally consistent with reason that the venous blood, which has lost its air, should forthwith appear darker and blacker.

From this it is easy to imagine the great advantage accruing to the blood from the admixture of air, and the great importance attaching to the air taken in being always healthy and pure; one can see, too, how greatly in error are those, who altogether deny this intercourse of air and blood. Without such intercourse, any one would be able to live in as good health in the stench of a prison as among the most [p. 171] pleasant vegetation. Wherever, in a word, a fire can burn sufficiently well, there we can equally well breathe

CHAPTER IV

The Transfusion of Blood from one animal to another. The time and occasion of its discovery by the Author

THE statements made hitherto about the blood relate to its *circular movement*, which takes place within the *sphere of a single body*; we have, so to speak, compared the credit and debit accounts, and have given a strict reckoning of the measure of fluid, and of the lapse of time necessary for the passage of the *blood* from the veins through the *ventricles* of the *heart* to the arteries of the *same animal*. With regard to our next subject, *The Transfusion of blood from one* [p. 172] *animal to another*, I do not know if the hope of accomplishing this, or the thought of trying it, occurred to any one earlier than three years ago. For, even after it was openly suggested as likely to have great applications in medicine, most people, nevertheless, withheld their hands completely from the experiment, or moved them to it in vain, either through fear of the operative difficulty, or in discouragement at its strangeness. As in the almost forgotten fable of Pythagoras, another, even less substantial, transmigration of the soul would seem to be more desired by the ignorant than hoped for by the learned.

I wish, therefore, to reveal the conduct of the whole affair, and at the same time to show by what train of thought I first *reasoned it out* and *undertook* it, and, finally, by what means and aids it was *carried into effect*.

For many years at Oxford I saw others at work, and myself, for the sake of experiment, injected into the veins of living animals various opiate and emetic solutions, and many medicinal fluids of that sort. The technical procedure for this is now quite well known, and this is not the place to describe the individual results and outcomes of these [p. 173] experiments. But when, in addition, I likewise injected many nutrient solutions, and had seen the blood of different animals mix quite well and harmoniously with various injections of wine and beer, it soon occurred to me to try if the blood of different animals would not be much more suitable and would mix without danger or conflict. And, because in shed blood (no matter how well coagulation should be guarded against by repeated shaking) the natural blending and texture of the parts must of necessity change, I thought it much more convenient to transfer the unimpaired blood of an animal, which was still alive and breathing, into another. I thought this would be more easily effected, inasmuch as the movement of blood through its vessels is so rapid and swift, that I had observed almost the whole mass of blood flow out in a few seconds, where an outlet offered. Taking hope from this, I turned mind and hands to put the matter to a practical test.

[p. 174] And first I tried to transfer blood from the jugular vein of one animal to the jugular vein of a second by means of tubes between the two; but, seeing the blood clot at once in the tube and block its own passage on account of the slow movement of the venous blood, I soon began to try another way, and guided, as it were, by nature herself, I finally determined to transfer blood from an artery of one animal into a vein of a second; and by this new device to extend the circulation of the blood beyond the boundaries prescribed for it.

As everything answered expectation as I wished, I finally showed this new experiment at Oxford towards the end of February 1665, in an interesting demonstration and under the most happy circumstances. There were present the learned Doctor *John Wallis*, *Savilian* Professor of Mathematics, *Thomas Millington*, Doctor of Medicine, and other Doctors of the same University.

Having got ready the dogs, and made other preparations as required, I selected one dog of medium size, opened its [p. 175] jugular vein, and drew off blood, until it was quite clear from its howls and struggles that its strength was nearly gone and that convulsions were not far off. Then, to make up for the great loss of this dog by the blood of a second, I introduced blood from the cervical artery of a fairly large mastiff, which had been fastened alongside the first dog, until this latter animal by its restiveness showed in its turn that it was overfilled and burdened by the amount of the inflowing blood. I ligatured the artery from which the blood was passing, and withdrew blood again from the receiving dog. This was repeated several times in succession, until there was no more blood or life left in two fairly large mastiffs (the blood of both having been taken by the smaller dog). In the meantime blood had been repeatedly withdrawn from this smaller animal and injected into it in such amount as would equal, I imagine, the weight of its whole body, yet, once its jugular vein was sewn up and its binding shackles cast off, it promptly jumped down from the table, and, apparently oblivious of its hurts, soon began to fondle [p. 176] its master, and to roll on the grass to clean itself of blood; exactly as it would have done if it had merely been thrown into a stream, and with no more sign of discomfort or of displeasure.

The report of these matters soon reached London, and I was earnestly requested by the *Honourable Boyle* in a letter to acquaint the *Royal Society* with the procedure of the whole experiment. This communication I made not so long afterwards, and it was published in the *Philosophical Transactions* of the same Society in December of the following year, 1666. Thereafter talk of it wandered across to nations abroad and to France, where, attracted by the novelty of the thing, some soon began to follow it up more thoroughly, to extend and embellish it by other further experiments, and to apply to the use of man that which I had only accomplished in animals. This is seen clearly in their writings published for the first time in the *following March*, 1667. So far so good, and all credit to that nation for their activity in the embellishment and extension of natural knowledge and of medicine. But, as this recent discovery of blood-transfusion is now a [p. 177] general subject of conversation, and a certain *Denis*, Professor of Philosophy and Mathematics, seeks in a recently published letter to deprive me of priority in the discovery of this experiment, and to claim it for himself, let me be permitted to insert here the letter of the *Honourable Boyle* to me and my reply to it, so that the reader may see how rightly or wrongly Denis so acted.

LONDON, *June* 26.

1666.

I was present last Wednesday (Honourable Sir) at the stated meeting of the Royal Society, held in Gresham's *College. Here I heard from Dr.* Wallis *that you had at last (in his presence) successfully accomplished that most difficult experiment on the transference of blood from one to the other of a pair of dogs. I judged the matter clearly worthy of being communicated to that very celebrated assembly. I therefore proposed that they should ask that distinguished gentleman for an account of the* [p. 178] *way in which it had been performed. His description of it was such as to increase not a little our opinion of your reputation. But, when asked for various details about so unusual and so unhoped-for an experiment, he voiced the opinion that it would be more profitable for you to reply in writing about the individual points than for him to attempt it orally. I therefore stated publicly that you had promised me, a little while before, that you would describe the matter to me (if at any time your desires were answered). I took it upon myself to say that you would do this, and that the more fully, when you knew that this celebrated assembly wished for a more careful account of the success of this experiment. I therefore entreat you to accede to this request, and to relate in order the whole of the highly successful procedure you adopted for the accomplishment of this task. This I urge the more strongly, because some highly gifted men with fair powers of judgement, and not over-credulous, though the experiment a difficult one, and considered that I had spoken rashly, when I mentioned it incidentally a few months ago, in reply to a question from the Royal Society as to what you had previously attempted at* Oxford*; and said that, although at that time the matter had not succeeded in every way as you* [p. 179] *wished, owing to some unsuitability of the instrumental equipment, I had not, however, given up hope of your ultimate success. I am being called away at the moment, so that I have not time to ask your pardon for putting you to this trouble. I have done so with less reluctance, because I thought it would be to your advantage, if this celebrated assembly became acquainted with you at this propitious moment. There are many* *among its members who esteem you at your right worth and are your friends, but none more so than*

Yours affectionately

Rob. Boyle.

To be delivered to
My most honourable friend
Richard Lower, Doctor of Medicine:
Oxford.

[p. 180] OXFORD, *July* 6.
1666.

I have received your letter, Honoured Sir, and, in accordance with your request, I will briefly expound to you the whole technique of transfusion in the same order as that in which I performed it. In a dog, then, or any other animal, whose blood you wish to transfuse into another animal of the same or of a different species, first lift up one Cervical Artery, *free it from the nerve of the eighth pair, and clean its surface for about the distance of one finger. Then ligature the upper, brainwards, portion firmly and tightly with a cord, as there no need to loosen it again or to unfasten it during the whole course of the operation. Next, lower down towards the heart, apply a second ligature to the same vessel at half a finger's distance from the aforesaid cord, using a* slip-knot *so that, as need arises, you can at will tighten or slacken the cord. When you have so placed your two ligatures in position, and have passed two strings under the artery in the intervening space, open the vessel with a scalpel* [p. 181] *and insert a quill into the incision in the direction of the heart. The external opening of the quill must be closed with a wooden rod. In addition pass the aforementioned strings closely round the portion of artery enclosing the quill and tie them tightly.*

In the second animal, which is to receive the blood of the first, clean a small part of the surface of the Jugular Vein *about half a finger long, and apply a ligature at each end, knotting the cord in each case in such a way that you can loosen it or tighten it at will. Two strings again should be passed under the vein in the intervening space, and, when the incision is made, two quills are to be inserted into the opening. One of these is directed towards the trunk of the descending vena cava, and is to receive* blood flowing in from the other dog; the second is pushed upwards towards the brain and is to discharge this Animal's own blood into suitable vessels. Both quills must be closed meanwhile with wooden bungs and only opened as required. Finally, the vein must be ligatured with the strings, as described above.

When you have done this you lay the dogs on their side and fasten them closely together as best you may to ensure the [p. 182] connexion of the two quills. But, as they cannot approach thus near owing to the twist of the animals' necks, some intermediate quills are necessary in addition to the two end ones, in order to join these latter together and to effect the transference of blood.

On the completion of these preliminary arrangements, open the two quills for the first time, that is to say, in the one dog the quill passing down into its Jugular Vein, and in the other the quill coming from its Cervical Artery. Then insert in between as many extra quills as will be necessary and join them together; and now, if the knots, which we decided should be slip-knots, are loosened, the blood immediately passes quite rapidly through the quills, just as through an artery prolonged by anastomosis. Quickly tighten a noose round the neck of the receiving Animal, as in venesection, or at all events compress the vein on the opposite side of the neck with your finger, then take out the stopper and open the upper Jugular Quill, so that, while the foreign blood is flowing in through the Lower Quill, the animal's own blood flows out from the upper into suitable receptacles (this, however, with intervals of rest interposed, out of regard for the animal's comfort and for the preservation of its strength) [p. 183] until at last the second animal, amid howls, faintings, and spasms, finally loses its life together with its vital fluid.

When the tragedy is over, take both quills out of the jugular vein of the surviving animal, tie tightly the former slip-knots, and divide the vein. This can be done with practically no inconvenience to the Dog, inasmuch as there is a very abundant anastomosis of the jugulars round the larynx and one of them is, therefore, sufficient for the return of blood from the head. After the vessel has been divided, sew up the skin, slacken the cords binding the dog, and let it jump down from the table. It shakes itself a little, as though just aroused from sleep, and runs away lively and strong, more active and vigorous, perhaps, with the blood of its fellow than with its own.

One further instruction I must give you, distinguished Sir.

It was impossible to tie the quills sufficiently tightly in the vessels, or to join them to one another securely enough, to prevent them from frequently getting slack and loose again. I therefore concluded that it would be better in future to use silver tubes made for this purpose. These should be provided at one end with a projecting ring, to prevent the possibility of their being torn out of the vessels into which they are inserted, and this ring is [p. 184] *to be a double one to ensure safer tying of the vessels over the tubes. Such a ring is pictured in* Plate 7, Fig. 1. *And so that the experiment can be conducted with less difficulty in Transfusion, or danger of obstruction within the vessel, especially when the animals toss and twist about, they should be united by two smaller tubes which you must insert into a Cervical Artery taken from a horse or an ox, the complete series so joined carrying blood from the donor on one side to the recipient on the other. We have this further advantage from the substitution of an artery in between, that it yields to the struggles of the animals however varied they are, and also that you will be able, if by any chance the blood inside it clots, to push it onwards, should you so wish, or to stop its flow at once, if occasion arises. I have written this to fulfil the pledge given by you on my behalf to the most illustrious Society, and, further, that you may know that you will never find me wanting in any good-will or duty towards you.*

Yours most respectfully,
Richard Lower.

To be delivered to
The Honourable Dr. *Robert Boyle*
in London.

[p. 185] I have reproduced these letters here, not so that they should shed light on the actual transfusion, which is now sufficiently well known, but that my reader should be better informed about the date and Author of the Discovery. All the apparatus for this experiment, and the technique for its accomplishment, are shown so clearly in the next plate that it would be superfluous for any one to give any further description of it. In *Plate 7, Fig.* 1

a is a silver tube.
b is the part of it which is to be inserted into the vein or artery, and is provided with a double, circular, raised ring, to make more secure the tying of the vessel over it.

Fig. 2 shows a silver tube shaped to convey blood to the human arm. In this figure

aa is the silver tube.

b is the smaller portion of it, which is to be inserted into the arm-vein.

c is its larger portion where it receives the blood.

dd are its two leaves pierced with holes on both sides for [p. 186] *the passage of the string, which is to bind the plate to the arm.*

e is the groove hollowed out between the two leaves to receive more easily the emissary tube. This groove compresses the underlying vein so that no blood could ooze or flow out from it during the operation, and it can be compared quite aptly with the recess in the middle of the upper lip in man.

Fig. 3 shows the tubes which are to be fitted into the emissary artery and the receiving vein before blood transfusion. In this figure

a is the emissary cervical artery.

b is the same artery ligatured tightly with a slip-knot.

c is the tube inserted into the artery for the passage of blood.

d is the place where the artery is ligatured tightly over the tube between the rings.

e is the tube for the reception of the blood and for its transmission into the jugular vein.

f is the jugular vein.

g is the place where the vein is bound tightly to the tube.

h is the vein ligatured with a slip-knot.

[p. 187] *Fig. 4* shows the cervical artery taken from a horse or an ox fitted on to a silver tube on either side. In this figure

a is the cervical artery.

bb are the two tubes fitted one on each side of the artery.

Fig. 5 shows in one piece the whole apparatus for the transfusion of blood from one animal to another. In this figure

a is the jugular vein near the heart of the Animal, into which blood is to be passed.

b is a silver tube inserted into the jugular vein.

c is the vein bound tightly over the tube.

d is the vein ligatured with a slip-knot beyond the tube.

eee are the tubes and intervening cervical artery, which carry the blood from the emissary tube into the receiving one.

f is the silver tube receiving blood from the emissary artery.

g is the artery of the second animal which emits the blood.

h is the place where the artery is tightly bound on to the enclosed tube.

i is the place where this artery is ligatured beyond the tube with a knot, which can be slipped as occasion arises.

[p. 188] *Fig. 6* shows the same apparatus for transfusion of blood from an animal to man. Its use can be quite well understood from the last.

Transfusion was therefore first performed by me at the end of February 1665, the *Honourable Boyle's* letter was given to me on the 6th of the *following June*, and my reply was inserted next *December* in the *Philosophical Transactions*, which were then going to press. Denis, on the other hand, made no mention of transfusion until a whole year later, and, further, he himself admits (though he says he had thought of it ten years before) that he learned first from philosophical books the possibility of transfusion and the technique for its achievement. I therefore leave it to others to judge who should receive the credit for the discovery of this experiment.

But, though some are so constituted that nothing satisfies them which they have not themselves discovered, and nothing is well and successfully planned without their claiming [p. 189] priority for themselves, I shall not take it too much to heart, as I was quite unacquainted with any transfusion plans of any other worker, and I am, in addition, abundantly furnished with evidence from very Distinguished men of its accomplishment by myself. Meanwhile, I have no doubt that this discovery, whose soever it is, will be employed with great profit for the human race, if it is practised with due consideration and care.

For there is no reason to think that the blood of other animals mixes less well with human blood than with animal blood. This view is abundantly confirmed by recent experiments of French workers, and I also found it so not very long ago in the case of a certain *A.C.*, who was the subject of a harmless form of insanity. I superintended the introduction into his arm at various times of some ounces of sheep's blood at a meeting of the *Royal Society*, and that without any inconvenience to him. In order to make further experiments on him with some profit also to himself, I had decided to repeat the treatment several times in an effort to improve [p. 190] his mental condition; he, on the other hand, consulted his instinct rather than the interests of his health, and completely eluded our expectations.

Every one, however, is not equally qualified to receive the blood of others, and no treatment is so useful that its rash and unsuitable administration does not easily bring it into disrepute. I think, therefore, that it will be worth while for me to intimate briefly, in a few words only, the sort of cases and the condition of health most suitable for the employment of transfusion.

Patients, whose blood is definitely putrid and has been long corrupt, or is very deeply tainted by a poisonous ferment from without, those, too, whose viscera are polluted and spoilt, as sometimes happens in cases of scurvy, venereal disease, leprosy, poisoning, or long-continued illness, cannot hope for any benefit or help from transfusion.

The impure blood, in its repeated passage through the viscera, imparts to them its defects and its pollutions, corrupts their ferments, and finally taints them with its own [p. 191] character and properties, so that fresh blood, substituted from without from however healthy an animal, by circulating constantly through the same organs, will pick up the disease and quickly degenerate into the same condition, just as wine soon picks up a smell and defect from a mouldy vessel.

Sour will turn whate'er you pour
In vessel not quite clean before.

But, if blood is withdrawn or is lost from bodies in good condition, by unsuitable venesection, trauma, or haemorrhage of any kind, in such amount as to require immediate replenishment from elsewhere, I have no doubt that the blood of animals can safely and advantageously be substituted in the place of that which has been lost. Further, in arthritic patients and lunatics, whose bodies are strong and viscera firm, the composition of whose brains is not yet spoilt, and whose blood is affected by no putrid disease, perhaps as much benefit is to be expected from the infusion of fresh blood as from withdrawal of the old.

Therefore, that the practice of this very celebrated [p. 192] experiment may be established by the greater Faith men have in it and by greater acquaintance with its performance, and that its usefulness may become known; I have thought the subject worthy of recommendation to the care of all doctors and to the whole world, whenever an opportunity occurs of trying it.

Meanwhile, let it at least be attributed to the felicity of our Nation, or even to its praise, that, while *Harvey* first taught that the blood by its *Circulation* within its own vessels ensures life to the body, we also first revealed that it could be *transferred* outside the confine of its own body for the health of a second.

[p. 193] CHAPTER V

The Chyle, its passage into the Blood, and its transformation into Blood

WE have discussed in the previous chapter how blood can be directly administered in certain unusual circumstances and in large haemorrhages. It now further remains to consider how the necessary loss of blood, and (so to speak) its daily expenditure are replaced. This can only take place by inflow of chyle into it. The Chyle, however, is manufactured from the ingested foodstuffs in the stomach by the help of its ferment, so I will first say in a few words how the continuous supply of this ferment is achieved, before discussing at greater length the passage of the Chyle into the Blood and its transformation into Blood.

Most of the older writers, and some even of the younger ones, who hold the authority of the older ones in veneration, express here and there the opinion, that there is some sort of communication through the vas breve between the spleen [p. 194] and the stomach, and that the stomach borrows from that viscus the acid menstruum which provides its digestive power. Although the circulation of the blood quite openly contradicts this view, the falseness of it will, nevertheless, be more evident from the actual structure and design of the vessels which are common to both, and I will give here a full description of them, so that no one through ignorance may cause any further difficulty on this point.

Apart from nerves and lymph-ducts the only vessels reaching the spleen and the stomach are veins and arteries. First, as regards the *coeliac artery*, it arises from the aorta, a little above the mesenteric artery, in a single trunk, which soon divides into several branches. Of these

The first supplies only the liver, pancreas, and duodenum.

The second is distributed throughout the whole upper region of the stomach, and is therefore called the epigastric artery.

The third branch of the coeliac artery, the largest of all, divides into two smaller vessels. Of these the First passes [p. 195] forward to the left portion of the spleen, but, when it is near the spleen, splits into two, and sends one radicle to the fundus of the stomach, the other to the spleen. The Second division of this branch is carried a little further on and divides at once near the other half of the spleen into four radicles. Two of these pass in a serpentine course to the spleen, the others, in similar fashion, to the stomach.

If ink or milk is injected with a syringe into one or other of these larger branches, it will be clearly and distinctly seen that the fluid, after reaching that point of division into two or into four, is carried simultaneously to the spleen and to the stomach. So, if the circulation of the blood were not convincing enough, it is nevertheless clearly evident that nothing can be carried through these arteries from the spleen to the stomach, or *vice versa*, as the blood passes from another source to both organs simultaneously.

Moreover, the circulation of the blood is sufficient proof that the splenic veins cannot accomplish this, but, in order [p. 196] that this too may be clearer from their arrangement, I will give a brief explanation of the splenic veins, and of their divisions, which merge their contained blood with that in the veins returning from the stomach.

While, then, all the arteries which carry blood to the liver, pancreas, duodenum, the whole of the stomach, the spleen, and omentum, arise in a common trunk from the aorta, all the veins, which come from all those organs and bring blood back from them, likewise join in one trunk and end in the portal vein.

So those veins, which communicate quickly with each other by short radicles between the stomach and the spleen, and are therefore called *vas breve*, are nothing other than venous branches descending from the fundus of the stomach, which are met half-way by others coming from the spleen, and which, joining with them for mutual advantage, unite into one trunk, which conveys the mixture of blood returning from both organs towards the portal vein. So that the blood leaving the stomach, and meeting the other coming from the [p. 197] spleen, and received with it into a common trunk, resembles two small streams flowing together into a single one, and hurrying along together to the bosom of an Ocean common to both. The same arrangement exists in other veins which are observed to make a communication between the right or anterior portion of the spleen and the right part of the fundus of the stomach. Two veins go from each to meet half-way like the union of so many roads, and then, joining to form a single trunk, end in the portal vein.

Moreover, that nothing is carried to the stomach through the vas breve or through these latter veins, is also proved by the structure of the valves, apart from any circulation of blood. For valves are present at that junction of the veins coming from the spleen and the stomach, and they prevent backflow of blood towards either the stomach or the spleen; for, if the trunk of the splenic Branch is tied below that junction, and you try to force blood from the splenic veins into the hypogastric veins, the veins at once swell up on [p. 198] the near side of the valves, and will burst rather than allow any blood to pass. This any one can test quickly and easily in a moderately large animal, in which these vessels are fairly wide.

One can also see that dogs, whose spleen has been cut out, are no less greedy and eager for food, but consume whatever they take as quickly as if they had not had that organ removed.

It is certain, therefore, that the spleen transfers nothing directly to the stomach, but that this ferment, which dissolves all the ingested food into a milky cream, is to be sought for elsewhere and in the blood itself. No light proof of this is the fact that patients suffering from hypochondriac melancholia are very often attacked by ravening hunger, when the salt fluid passes into their stomach, and are immune from all bodily pain as long as that desire for food persists; but when that fierce and bitter fluid, by a kind of transition, passes into other organs of the body, torments and convulsions are evoked, while all appetite and digestion [p. 199] in the stomach ceases completely for lack of it. This is usual in almost all hypochondriacs, and must be ascribed to bad blood-constitution rather than to any fault of the spleen.

The stomach is composed of every kind of fibre, and so, while at first it enfolds and presses gently on the food passed into it, later, when some part of this food has been dissolved and reduced to a soft substance by repeated separation of its constituents, it propels it into the intestines by a prolonged contraction of its fibres. Here it is absorbed by the lacteal veins distributed at intervals through the intestines.

And, since the lacteal vessels are extremely narrow and are provided with very fine openings, so as to take from the intestines only the purer and cleaner portion of the fermented mass, the total length of the intestines has been made very great to admit thereby a greater number of such vessels. The small size of the vessels is therefore balanced by their number. Hence, as the lacteal vessels in the upper intestines are quite insufficient either in number or in diameter for the absorption of a large amount of chyle, the intestines are cunningly contrived, so that they contract one after the [p. 200] other with a continuous movement of the fibres, which passes in succession from the pylorus right to the rectum, and they push the chyle downwards in such a way that a halt is made before the openings of all the vessels. During the passage of this juice by the mouths of these vessels, the useful and nutrient portions are separated from the refuse, and only the cleaner and purer tincture passes into the lacteal veins, the more solid and impure portion being deposited in the rectum as so much dead stock.

One can only understand the mechanism of this separation on the assumption that the various pores in the inner coat of the intestine are so arranged and shaped that they allow entry of the milky cream alone. The thicker portions, having no resemblance to, or correspondence with, the pores of the intestines, through which is the way into the lacteal veins, pass by untouched and are driven ever downwards by the movement of the intestines. If, however, the lacteal veins opened directly and widely into the lumen of the intestines, not only the more impure and unclean portion of the mass [p. 201] in the intestines, but also bad-smelling, faecal gases and fumes would pass in similar fashion into the blood, and would very seriously contaminate it.

To test this matter, I ligatured tightly the so-called jejunum, where it crosses to the lumbar region, in an animal which had previously been given a full meal; and I inflated it with a pair of bellows introduced through the pylorus.

When this intestine was sufficiently distended, I tied off the pylorus equally strongly. Then I exerted pressure with my hands on the air-filled, swollen intestine, and looked for an immediate flow of chyle within the lacteal veins towards the receptaculum commune as a result of the pressure of air from behind. This, however, did not follow at all, so the lacteal veins quite definitely do not open widely and directly into the intestines, nor do they allow any gas or flatus to pass into them.

As entry of air into the lacteal veins was definitely impossible, it occurred to me to try, in another animal similarly fed, if there was not an easier entry open to any kind of thin fluid. I therefore tied off the same portion of intestine, and poured in through the pylorus spirit of wine tinted [p. 202] with ink. I then tied the pylorus, and exerted pressure on the intestine swollen with this black tincture, under the idea that this thin and delicate fluid at all events would be able to enter as easily as chyle. But the exact opposite took place, for the chyle in the lacteal veins next to the intestine was not seen to be coloured by this dye, nor was it observed to move any further along towards the receptaculum commune. So one may venture the view that the lacteal veins do not open straight and directly into the intestines, but are carried obliquely between their coats before penetrating into the cavities of the intestines, perhaps in the same way that the common duct ends in the duodenum, or the ureters in the bladder. Hence, the more strongly the sides of the intestine or of the bladder are distended by their contents, the more tightly are their openings closed. Therefore it seems probable that the chyle is not forced into the lacteal veins at all, as such contraction and corrugation of the intestines tends to prevent its entry, inasmuch as it constricts the apertures and channels of the lacteal veins as they pass through the [p. 203] coats of the intestines. So that continuous, so-called peristaltic movement of the intestines seems to be designed solely to push the chyle already in the lacteal veins towards the receptaculum commune, to drive downwards the mass of chyle passed out from the stomach, and to deposit it for absorption by the lacteals as a whole. As, however, this movement is like that of a worm, and comes on at intervals, it is probable that chyle is taken into these veins only when some part of the intestine is at rest from movement and contraction, and when, therefore, the mouths of the lacteals are more open and distended.

Since, however, the chyle passes through such narrow pores from the intestines into the lacteals, it is not unreasonable to suppose that it is diluted and thinned by the fluid which the pancreas secretes into the duodenum in order to facilitate its passage. For that gland is so like all others as to seem the same in substance and in structure, and the fluid from [p. 204] all glands is absolutely alike, being thin and clear, so why should we not believe that it serves the same purposes? The glands situated round the mouth and fauces secrete their fluid during mastication, in order to moisten and to soften the foodstuffs, and so render them easier to move around in the mouth, and to be more rapidly swallowed. In the same way, I think, it is very highly probable that that large gland is situated there, and its duct opens into the intestines, so that the fluid it secretes may mix with the descending chyle, and this may thereby more readily enter the narrow lacteal channels, and effect its passage more freely and with less hindrance. The chyle, too, is sometimes liable to stagnate and to clot in the lacteal vessels, either through its thickness or through insufficient intake of drink (which should act as a medium for its carriage), and is therefore likely to overfill and to distend these vessels, as I once saw in a dog whose pancreas was sclerosed. So glands seem to have been placed here and there in the mesentery in order to pour a similar watery fluid into the chyle as it passes by, so that it may become ever thinner and more [p. 205] dilute (as it always quite obviously does beyond the glands of the mesentery). And, though this watery fluid may have other functions as well, yet, as there is such danger of the chyle halting within those fine hair-like ducts, and obstructing its own passage by its thickness, it would seem that the Creator provided for its mixture with the watery fluid passed into the intestines by the Pancreas—to facilitate its passage into the lacteals—and also for its dilution, in the middle of its course from the intestines to the receptaculum, by the same very thin, watery fluid secreted in the glands of the mesentery—so that it might complete the rest of its journey towards the receptaculum commune.

Into this receptaculum discharge all the lacteal veins like so many pipes into a common milk-reservoir; and, to prevent stagnation and clotting therein, all the lymphatic vessels coming from the whole of the lower part of the body, and from all the viscera and glands in the abdomen, give up their [p. 206] lymph to the receptaculum. In this their object is twofold, first, to keep it always clean and in good condition by their very thin fluid, and, secondly, to dilute the chyle further and to facilitate its passage through the thoracic ducts. And, to prevent its clotting for any reason between the receptaculum and the subclavian vein, numerous smaller glands are placed all round the thoracic viscera, and secrete their lymph into the chyliferous ducts at various points, God, apparently, making sure that the sole support of our life should not anywhere lack a free passage.

Further, the chyle ascends with greater difficulty through the thoracic vessels, especially in the erect position of the body, as in man, and is therefore more liable to clotting on account of its slow movement. So this large receptacle is placed between the tendons of the diaphragm at their spinal attachments; as a result these tendons, being strongly stretched every time the diaphragm contracts on inspiration, compress and stimulate this milk-sac very forcibly, if it is [p. 207] distended. In this way they expel its contained chyle through the chyliferous ducts into the subclavian vein, and replenish by this constant inflow the continual loss suffered by the blood-mass.

Moreover, as the blood and life itself depend on a constant inflow of fresh chyle, this fluid must always have a free, unimpeded entry into the blood. So the chyliferous ducts, through almost the whole of their course from the receptaculum to the subclavian vein, with the exception of the cardiac region, are two in number, and communicate with one another like the sides of a ladder. The object of this is clearly that the chyle may pass up by the second, if the first is blocked.

Finally, to prevent its encountering resistance or obstruction of any kind at its actual entry, it passes into the subclavian vein by two openings as a rule, and sometimes by more (or, if only one is found, by a relatively wider mouth); and, to prevent the passing blood from entering this aperture and filling it, a valve is drawn across it like a lid. This repels the blood returning from the jugular and axillary veins, [p. 208] and with the spread of its sail protects this opening from the inflow of the hurrying blood. This will be clear from the explanation, which follows later, of *Plate 6, Fig. 2.*

This is the one and only way by which the chyle from the stomach and intestines passes into the blood and into the heart. But, as some people still indulge in the same mistake as did the older writers, and state boldly that the mesenteric veins take up chyle from the intestines, I myself once gave the matter careful attention, and finally satisfied myself, as a result of many experiments, that the whole store of chyle passes into the blood by no other way than the chyliferous ducts. If the passage of chyle through the thoracic vessels is impeded, the animal, no matter how sated it is with food, will die within a few days of utter starvation. This I found in two dogs, though by different methods. In one I opened the thorax on the right side between two of the lower ribs, inserted my finger, and, using the nail which I had cut like a saw, burst and tore open the receptaculum [p. 209] commune, which was very distended three hours after food. Free exit into the thoracic cavity was thus provided for the chyle, and its passage into the chyliferous ducts was completely interrupted. After I had done this and sewn up the wound, I gave the animal as much food as it wished to take. However, when it died in a few days' time, and I made an immediate dissection of it, I found the stomach and intestines very full, and the lacteal veins themselves distended with chyle, yet no chyle was visible in the whole of the thoracic duct, while two pounds of it were discovered on the side of the chest on which I had ruptured the receptaculum commune. Hence I think it quite clear that this animal died of starvation, owing to obstruction to the passage of chyle through the thoracic ducts, although its stomach was crammed with food.

To render this more certain, however, I made a hole in similar fashion in another dog, but on the opposite or left side between the third and fourth upper ribs. In this region the two chyliferous ducts usually join to form a single trunk; this trunk then goes along on the lower side of the oesophagus, where it rests on the underlying muscle, under the common [p. 210] coat of the thorax to the subclavian vein. I inserted my finger, then, through the opening of the wound, and ruptured this duct in similar fashion; when this had been done, the chyle could get out into the cavity of the left side of the chest, but could not pass any further. I attended to the wound as before and kept the dog well fed for a few days. From this time it began to weaken, and died a little after. When, however, I dissected its thorax, I found the compartment of the thorax, where this duct was ruptured, completely filled with chyle, and the lung glued to that side. To convince myself still further that this channel had been ruptured so well that it was no longer able to transport any chyle, I injected water from a syringe into the chyliferous duct lower down, but it was unable to pass beyond the point where the channel had been interrupted, and all exuded into the thoracic cavity. A clear proof that chyle does not pass in through the mesenteric veins, and that no other way is open for it to mix with the blood, since an animal perishes so surely as a result of obstruction to the chyle's passage through the thoracic vessels. The following fact is, however, [p. 211] the most convincing argument for the chyle not flowing into the mesenteric veins. If blood is taken after a day or two from an animal so treated, no chyle will be visible in it, although it has fed very well a few hours before, while the direct opposite should have happened, if the inflow had not been completely interrupted in this way.

After this clear treatment of the subject, it will surely be a cause of wonder that any one should undertake any further defence of the Liver, and that, in order to reclaim for it its old blood-forming function, he should oppose *Pecquet* with the experiment of *Louis Bils*. I have often tried that experiment of Bils without success, and I shall also, by this experiment of my own, ensure for the future a general acceptance of the view, that the Chyle is instilled into, and mixed with, the blood by no other way than by the *ducts of Pecquet*.

All the chyle flows out into the thoracic cavity when these ducts are ruptured. In similar fashion, if this duct on the left side of the thorax (with the hole made in the same place as before) is compressed for an hour by the insertion of one's finger, the chyle is unable to pass by any other route to the blood. It therefore causes such swelling and distension in the receptaculum commune, and indeed in all the lacteal [p. 212] vessels in the mesentery and lower part of the abdomen, as a result of this obstruction, that they can never be more clearly or visibly demonstrated. It is certainly extremely pleasant to see their structure, valves, and anastomoses, their different windings in and out, the dense network they make as they pass through the whole circumference and surface of the intestines, and the swellings, like the joints in girls' necklaces, which they show in their orderly concentration below the receptaculum. All this far surpasses anything that any one has hitherto written or drawn on this subject.

It is, further, well worth noting that, as a result of this obstruction to the thoracic duct, the chyle is so thrust and pushed back into the lymphatic vessels in the chest and in the abdomen generally, despite the resistance offered by the valves, that at first glance it may perhaps deceive the unwary, and lead them to believe in the presence of the dew-bearing *ducts of Bils*; though actually this is due solely to the fact that this white juice is prevented from flowing along its proper course, and so regurgitates into those vessels. Just, perhaps, as rivers are pushed back into their beds by [p. 213] the incoming sea and yield before the force of its inrush. Similarly, just as the rivers drop to their old level when the tide has gone out, when that pressure is removed and the entry of chyle into the blood is restored, it is all absorbed back again into the thoracic ducts, and leaves behind it no trace in those lymphatic vessels.

Plate 6, Fig. 2 shows the way in which this experiment is carried out. In this figure

aa are the two chyliferous ducts joining to form a single trunk on the left side of the chest.

b is the place where this trunk is compressed by the insertion of a finger.

cccc are its valves, which swell up on both sides below the point of compression, as a result of the backflow of chyle caused by the blocking of the duct.

d is the trunk lying collapsed above the point of compression, as a result of hindrance to the passage of chyle.

e is the jugular vein.

f is the axillary vein.

g is the same vein at its junction with the descending vena cava.

[p. 214] *h is the opening of the chyliferous duct, where the chyle brought from the receptaculum commune is poured into the subclavian vein.*

i is the valve placed at that opening, which carries the blood returning from the jugular and axillary veins across it, so that they shall not hinder the inflow of chyle.

This experiment, moreover, is so pleasing, and can so easily be performed by a skilful hand, that I will describe more in detail the manner and the method of its execution.

Draw back the left forelimb of the dog, and pierce the thorax between the third and fourth upper ribs a little above the heart. Here the duct passes in a single trunk, on the lower side of the oesophagus, over the underlying muscle of the gullet. Then insert a finger and press the whole oesophagus on to that muscle; this will ensure the closure of the duct also. The finger should be inserted, however, in such a way as to keep clear of the axillary artery lying next door, and must be kept thus for an hour (and, if the limbs [p. 215] of the dog are relaxed a little after the insertion of the finger, it will suffer this more patiently). When all this has been done, it is most noticeable that no trace of chyle is apparent in blood which is withdrawn, as long as this compression interrupts the movement of chyle, provided such operation is effected immediately after feeding. Within half an hour, however, after the pressure is relaxed, a large amount of undigested milk will be seen floating on the surface of a further sample of blood.

Now that I have thus shown the whole course of the chyle from the intestines to the subclavian vein, the only thing left for me to demonstrate is the way in which it unites with the blood, and the successive changes it undergoes before it is fitted to accomplish the nutrition of the organs, or to be turned into actual blood. It will therefore be right to remark that the chyle is continuously flowing into the blood, and, joining slowly with it, is carried along in its company, and is purified and elaborated more or less in proportion as it ferments and circulates in the blood-mass for a greater or lesser time.

For, if it is deposited in the breasts and udders, while it is still fresh and has not yet been purified in the blood for [p. 216] several hours, it retains its character and original appearance to such an extent, that it cannot be distinguished from chyle itself either by taste or by colour. This I have often found in pregnant animals. For, on comparing chyle from the receptaculum commune, chyle floating on the surface of drawn blood, and milk squeezed from the udders, I was never able to perceive any difference at all (except that the chyle in the receptaculum was somewhat more salt to the taste). One cannot doubt, therefore, that the whole of the milk is deposited in the udders and breasts from the blood itself through the mammary arteries; and one must not go searching in vain for other ducts to transfer this milky juice more directly from the stomach and intestines to these glands. For the blood is turgid with such chyle, and this fluid is driven with the blood to all the organs of the body. Why, then, should one not be permitted to suppose that, at the individual arrivals of fluid, this white juice is separated off in the filter of the udders, and passes into the excretory vessels and milk-tubules?

[p. 217] For, when the chyle is mixed with the blood-mass, it does not lose its nature and character with such rapidity as to give up its whiteness at once; indeed, it remains quite unchanged for some considerable time, and circulates with the blood like milk. This any one will be able to try daily, for, if blood is withdrawn from any vein or artery in an animal four or five hours, or longer, after a fairly good meal, a large amount of actual milky chyle will be seen floating on the surface of the clotted blood, as I have stated elsewhere. I have tried this in various human beings; in these subjects all the vessels appeared fuller of milk than of blood, if a vein was incised after a good breakfast or luncheon. This Phenomenon was observed, I grant, by the doctors of earlier days, but they were quite unaware of its cause.

While, however, the chyle retains its colour for several hours despite its admixture with the blood, if it circulates somewhat longer with the blood, it completely loses its whiteness as a result of the long-continued interaction with [p. 218] this fluid, and is reduced to serum. If venesection is performed a long time after a meal, there remains no appearance of milk, and serum only will be seen floating on the surface of the blood-clot. Yet, although they appear to differ so much in thickness and in colour, this at all events the chyle poured into the blood, the serum floating on drawn blood, and the milk squeezed from udders, have in common, namely, that, if they are gently heated until they have lost their watery constituents, they all set equally into a jelly.

The better to understand how and by what successive steps the chyle is converted into blood and carries out the nutrition of the organs, you must know that the vital spirit and other active principles in the blood-fluid act on the constantly-inflowing chyle, and break it up into very fine particles. When, for example, the chyle is very full of salt, sulphur, and spirit, these active constituents acquire freedom of movement as soon as its structure is loosened by fermentation, and they at once join with the blood-constituents which are of similar or of related character. In the blood, indeed [p. 219] (as in wine and other such fluids) the spirits, on acquiring control, dislodge, and free their mass of, all thicker and cruder particles which come into contact with them, and so render the remainder of the fluid clearer and purer.

After the chyle is so perfected, it is completely fitted both for the restoration of blood-fluid and for the nutrition of the body as a whole. For, being composed of various principles and constituents, and being of diverse and varied character and properties, it is added in varying ways to the organs according to the varying functional need of each, and according as it answers and conforms to the different pores and openings. Hence the most volatile and ethereal portion of it is separated off in the brain, and is allotted to the renewal of spirits, while the more viscous portion is set apart for the body's nutrition, and the sulphurous portion is designed to renew the body's heat. Moreover, while it is being carried with the rest of the blood throughout the body, the watery saline portion of it is separated through the kidneys, and is got rid of by insensible [p. 220] transpiration or sweating: the burnt-up portion is deposited in the liver: and the refuse of it which is left departs like so many casts-off in the various cleansing processes of the body, so that its remaining mass becomes thereby purer and clearer.

The cause of our life consists in this alone, that the blood in its continuous passage through the whole of the body carries round heat and nutriment to all the organs, and that ever-fresh chyle passes into the blood in due measure and amount, restoring with equivalent supplies the daily loss of blood-fluid, and refreshing it with its continuous inflow.

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THE END

TRACTATUS
DE
CORDE.

ITEM
De Motu & Colore
SANGUINIS
ET
Chyli in eum Transitu.

AUTHORE
Richardo Lower, M. D.

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Clarissimo viro

D^no *Thomæ Millington*,

M. D.

MIrabuntur alii, forte & ipse miraris, vir ornatissime, de corde & sanguine, post tot viros celebres, qui materiam hanc non tantùm tractasse sed & exhausisse videantur, a me quicquam amplius proferri: Et quidem *Harveius* quantum ad nobilissimum circulationis inventum pertinuit, fabricam cordis, motumque ſanguinis ita deſcripſit, ut poſteris nihil fere aut addendum aut deſiderandum reliquerit. Verùm ut in cœlorum *Hypotheſi Ptolemaicâ*, præter immenſas orbium revolutiones, minores quoque epicycli planetis aſſignantur, ipſi etiam ad phænomena explicanda neceſſarii; Sic in humani corporis ſyſtemate, etiam in illo aliorum animalium, præter circulationem

culationem *Harveianam*, ſunt & alia porrò conſideranda, quæ minutiora licet, ad ſolidam tamen variorum ſymptomatum ætiologiam haud parùm faciunt. Quid quod & *Harveius*, ſi per ætatem & otium licuiſſet, plura polliceri videtur ipſe Lib. de Circul. Sang. cap. 9. *Sed quantum in unoquoque propellatur ſingulis pulſationibus, & quando plus & quando minus, & quâ de causâ, accuratiùs poſthac ex multis obſervationibus a me forſan palam fiet.*

Sed, quod maximè dolendum eſt, & ille voto ſuo,& nos ſpe noſtrâ excidimus: Cum itaque nemo hactenus, quo suppleantur iſta, vel cordis ipſius fabricam motumque plenè enarrandum, vel tranſeuntis ſanguinis velocitatem & menſuram rectè computandam, vel venoſi atque arterioſi quoad colorem diſcrimen clare illuſtrandum ſuſceperit; ſaltem in iis explicandis quicquam ſatis perfecerit, ut votis excelcellentissimi viri aliquâ in re ultra quam adhuc præstitum sit occurrerem, in ipsa cordis penetralia descendere, ipsumque vitæ fontem rimari & recludere conatus sum: Non quòd totam ejus historiam tradere, vel affectus ejus omnes & pathemata edocere aut spei nostræ sit aut consilii: Verùm ut quam dixi fabricam, motumque ejus, variasque ejusdem anomalias, earumque causas & symptomata, quantum ob-

obſervando aſſequi po-
tui, & ad rem medicam
facere videatur, matu-
riùs expenderem & fu-
ſiùs explicarem. Si quid
autem mancum adhuc
& pro partis uſu & dig-
nitate non ſatis amplè
dictum fuerit, id poſt-
hac forſan, cum plures
hâc in re obſervationes
congeſſerim, pleniùs
abſolvam.

Pudet interim piget-
que dum nonnulli in
hoc noſtro ſæculo ſani-
ori philoſophiæ promo-
vendæ tam utilem, tam-

que

que Humano generi ſalutarem operam impendunt, non deeſſe tamen alios, quorum ea eſt ſive malitia in Univerſos, ſive in ſingulos invidia, ut huic tam laudabili inſtituto ponant omne illud quantum poſſunt impedimenti, illud bene, quod per inſcitiam majus non poſſunt: Inter quos ſummæ proterviæ & ſtuporis *Meara* quidam *Hybernus* cæteris omnibus palmam præripere videtur: Cui, Im-

Imperito ipsi, alios scire quicquam dolet; id quod scripta ab illo, utcunque sub larvato titulo *Conlonis Cassinii* nuper edita, palam faciunt. Verùm ista omitto, quia eâ in parte si cum illo certandum esset, non tam esset mihi in arenam quam sterquilinium descendendum, ubi contractas sordes victoria non compenset. Atqui errores quod attinet, eos præsertim qui de cordis usu, motuque sanguinis,

nis, tum etiam de chyli naturâ, ejuſque in ſanguinem tranſitu (de quibus tam imperitè ſcrìpſit, ac ſi jam annos quadraginta altum dormiviſſet, necdùm evigilaſſet ſatis) quia eos ſilentio non præteriri aliorum intereſt, quatuor ſpeciatim ſeq. Tractat. capita a me conſcripta ſunt; quæ omnia diſtinctè tradidi, non tam ut ejus inſcitiam (ſatis utique jamdiu perſpectam) magis detegerem, quam

ut

ut communi ſtudio & commodo proſpicerem.

Dum in his ſum, de *Muſculorum Structurâ*, quam longè aliam atque hactenus credita eſt, deprehendi; de *Seri e cerebro exitu* jam primùm detecto; de *Colore ſanguinis arterioſi*, & de variis ſymptomatis non pauca a me primò obſervata hic illic interſperſi. Denique de *Transfuſione* caput integrum adjunxi, cum ob materiæ affinitatem, tum etiam

ut

ut celeberrimi hujus experimenti inventio, cui jure debita eſt, Authori aſſeratur.

Quicquid horum Judicii tui examini probatum non erit, excuſabit ingenii tui candor, nec reſpues hoc affectûs in te mei pignus & teſtimonium, neſcio apud alios quamdiu duraturum, certè a me debitum

Tui Amantiſſimo

Richardo Lower.

E R-

ERRATA.

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Cordis Anatome.

CAP. I.

Cordis Situs & Structura.

CUm ad Sanguinis naturam & affectus dignoſcendos, non tantùm circularem ejus motum inveſtigâſſe, ſed & motus illius, numeros, principia, & diverſas alterationes, earumque cauſas cognoſcere atque inter ſe conferre, nec non ipſius liquoris copiam ſingulis pulſibus trajectam juxtà æſtimare, plurimum interſit; operæ pretium existimavi rem totam (à pleriſque adhuc omiſſam, ab aliis, & ab ipſo quoque *Harveio* optatam potius quàm explicatam,) quantum conjecturâ & experimentis aſſequi potero, clarè & breviter enarrare.

Verum cum motus Sanguinis Cordis motui debeatur, abſque quo nec ſatis intelligi poteſt nec perſiſtere; de hujus Situ & Structura, quædam præfanda ſunt, quibus rite perpenſis atque invicem collatis magis in promptu erit concipere, quàm accuratè tum Fabrica tum Situs ejus ad motum comparantur, & quàm apte conſtituuntur omnia ad ſanguinem in partes univerſi corporis diſtribuendum.

Itaque Homini, & Carnivoris fere quibuſque animalibus cordis ſedes non in centro ſed in ſuperiore corporis parte conſtituta eſt, ut debitam ſanguinis portionem eò facilius ſurſum in caput effunderet: Nam cum trajectio & diſtributio ſanguinis à cordis ſyſtole omninò dependeat, nec liquor ejus ex naturâ ſuâ tam promptè in partes ſuperiores,

riores, quàm in vasa parallela aut deorsum in subjecta propellitur: si cordis Situs à capite remotiòr esset, fieri non posset, quin ant ipsum robustius formatum oportuit ut fortiore ictu liquorem projiceret, aut ob defectum sanguinis sæpenumerò caput vacillaret. In animalibus autem quæ longiore collo & quasi ad victum porrecto donantur, à capite æquè ac cæteris partibus remotus est Cordis situs; neque incommodi quicquam exinde sentiunt, quia capite plerumque pendulo victum quærunt, adeóque sanguis, ut longiore quàm in cæteris intervallo ita ductu planiore & sæpius declivi in caput transfunditur.

Pars cordi maximè vicina (de quâ pauca præmittenda sunt) est membranosa ejus capsula, *Pericardium* inde dicta quod ipsum Cor (ut cortex nucleum) undiq; amplectatur: Membrana est firma & robusta cum Pleura undique communis & continua, nisi ubi à vasis perforatur, ejusdem quoque figuræ & pœnè magnitudinis est cum ipso Corde, cui subsidium tam necessarium præstat, ut in avibus minoribus, serpentibus, ranis, & in omnibus præterea vel minimis animalculis quæ hactenus dissecare licuit, nunquam desideretur. De usu ejus optima fit conjectura ex liquore quem continet; Præterquam enim quod cordis parenchyma involucro isto munitum nec corrumpitur ab empyemate, nec pulmonibus adnascitur, & cæteris adjacentium partium injuriis minus exponitur; præterea in vacuo inter cor & membranam ambitu Serum quoddam, seu aqua tenuis, semper reperitur, quâ externa cordis superficies continuò humectatur, quæ alioqui ex Perenni agitatione & calore inarescere & corrugari, adeóque ad motum inepta reddi poterit.

Unde autem humor iste proveniat & à quo potissimùm fonte profluat, hactenus non ita recte pronuntiatum est: Plerique enim humores serosos ab æstu cordis in nubem elevatos ac densitate hujus membranæ coercitos in aquam istam condensari & proinde pro ratione temperamenti plus in calidioribus, in frigidis autem minus abundare

bundare ſtatuunt. Verum ſi hanc originem hujus aquæ atque cauſam eſſe concedamus, utique non apparet quare majore copiâ plerumque hic loci non congeritur; quippe cum humores à continuo cordis æſtu in nubem ſuſcitari atque à membranâ hâc intus cohiberi & in aquam converti debent, quid impedit quò minus in copiam juſto majorem, quantamque hæc capſula continere non poterit, augeatur; Præterea, cum continui incrementi fuerit, ni ſimul & exitum alicubi habeat, aut diutinâ ſtagnatione corrumpi, adeoque cordi infeſta reddi, aut ſaltem nimia ejus inundatione, cor ipſum obrüi neceſſe ſit.

Quare ut aquæ hujus fontem alibi quæramus, advertere oportet Naturam in variis corporis partibus ubi operis aut functionum eadem aut par ratio eſt, iiſdem plerumque machinis atque inſtrumentis uti; & quemadmodum glandulas lacrymales ad humorem ſuggerendum quo oculi illinantur atque madefiant, (abſque quo ſicci, & motui inhabiles, evaderent) pariter & juxta cordis basin diversas glandulas constituit, è quibus humor intra capsulam exstillat, & in vacuo isto spatio huc illuc agitatus cordis superficiem undique alluit, quò promptior & facilior ejus motus redderetur.

Porro humorem istum non merè excrementitium aut instar roris stillatitii aqueum, sed Seri potius nutritii è sanguine promanantis, partem esse, exinde constat, quòd ignis calori vel paululum admotus, non aliter quàm serum sanguini post venæ sectionem innatans, aut lympha è glandulis secreta in gelatinam albam incrassatur: Qualem quidem consistentiam nec sudor neque urina qualicunque coctione acquirit, sed vel omnino in auras exhalat, aut in Sabulum induratur. Unicum tantum super hâc re obiter notandum est, nempe aquam in pericardio contentam illam solummodo huic experimento idoneam esse, quæ in animali bene constituto & violentâ morte perempto reperitur, cujus utpote sanguis sero nutritio diluitur: Nam in animalibus morbo defunctis aut longâ in-

inappetentiâ & inediâ confectis, quorum nempe sanguis succo chyloso prorsus destituitur; neque eadem ratio est, & impar successus: Cæterum in sanioribus tam manifesta res est ut aperto jugulati Bovis pericardio magnam plerumque concretæ gelatinæ copiam invenias, quæ extincto tantum calore partis, aut sponte suâ aut à frigore in istam consistentiam condensatur, non aliter quàm decoctum C. cervi, ubi frigido aëri exponitur in gelatinam subito concrescit.

Verum de Liquore intra capsulam contento, dictum satis: de membranâ ipsâ adhuc inquirendum restat quæ sit causa tum finalis tum efficiens, quod pericardium in Homine septo transverso semper accrescat, cum idem in quadrupedum genere liberum & aliquanto spatio ab ipso remotum fuerit. Itaque *finalem* quod attinet, diversitatis ratio non in eo posita videtur, quod diaphragma humanum pariter ac cæterorum animalium expandi non oporteat, cum par utrinque respirationis usus & necessitas id exigat; sed cum erectus ſit hominis inceſſus atque figura, eóque faciliùs abdominis viſcera ſuo pondere deſcendant, minore diaphragmatis nixu atque ſyſtole ad inſpirationem opus eſt; porrò, cum in exſpiratione pariter neceſſarium ſit idem diaphragma relaxari & tenſionem ſuam remittere; cum capſulâ cordis omninò connectendum fuit in Homine, ne forte, quamdiu erectus incedit, ab hepatis aliorumque viſcerum appenſorum pondere deorſum adeò deprimeretur, ut neque pulmo ſatis concidere, neque exſpiratio debito modo peragi potuerit. Quocirca in quadrupedibus ubi abdominis viſcera in ipſum diaphragma incumbunt, ipſumque in pectoris cavitatem ſuo pondere impellunt, iſta partium accretio exſpirationi quidem inutilis, inſpirationi autem, debitam diaphragmatis tenſionem impediendo, prorſus incommoda fuiſſet.

Ideoque Pericardium in brutis liberum relinquitur, ne diaphragmatis ſyſtolæ officeret; in Homine autem ſepto alligatur, ut ejuſdem inter exſpirandum diaſtolem adjuvaret.

Verum

Verum si quæratur, quid sit quod hujusmodi connexionem in humano pectore *efficiat*; ego causam (si conjecturæ locus sit) certè aliam non video, quàm quod Infans in utero materno conclusus, postremis gestationis mensibus, capite deorsum ad matricem demisso (quò partui magis opportunus fiat) plerunque jaceat; unde fit ut viscera infimi ventris toto pondere suo diaphragmati incumbentia otioso adhuc & ab omni motu ferianti, ipsum cordi propiùs admoveant, & contiguum eousque detineant, donec sensim agglutinetur, & tam arctè tandem accrescat, ut liberare se non possit aut iterùm recedere.

Ex eodem hoc viscerum inferiorum in fœtûs thoracem decubitu, non tantum fieri arbitror quòd septo transverso pericardium adhæreat, sed & eundem in causâ esse suspicor, quod Conus cordis in humano genere multo magis quàm in cæteris animalibus deflectitur; neque enim apici tantum humani cordis sed & toti lateri applicatur diaphragma; id quod nisi ob molem

molem & gravamen innitentium visſcerum contingere vix poterat: quare autem cordis humani conus in ſiniſtrum latus vergat, hoc ideò fieri arbitror quòd truncus Venæ cavæ diaphragma pervadens & juxta dextrum cordis latus aſcendens, illud inibi advolvi non ſinit; cum verò in ſiniſtro pectoris clauſtro liberum detur ſpatium neque quicquam prohibeat, ab accumbentium viſcerum mole cordis conus ſemper in lævum deflectitur, ipſique lateri ſiniſtro tam prope accumbit, ut ex hâc parte vibrationes ejus (concidente præſertim pulmone inter exſpirandum, atque in lævum converſi) admota manu tam facile palpare videamur.

His ita præmiſſis proxime oſtendendum venit quibus fulcris Cor ipſum innitatur, quibus ſuſtentaculis alligetur & quàm motui ejus inſerviant hæc omnia aut ſaltem obſequantur.

Et quidem plurima ſunt quæ ſuſtinendo cordi auxiliares manus præſtant, præcipuè autem à vaſis ſanguiferis (quibus velut tot radicibus accreſcit) paren-

parenchyma ejus dependet atque ſubtenditur; quin &, cum baſis cordis in hiatus & orificia lata recipiendo exprimendoque ſanguini conformata ſit, ita omnino fieri debuit, quo muneri iſti magis opportunum atque idoneum redderetur. Quàm ſtabile autem fundamentum ad cordis motum perficiendum præſtent vaſa ſanguifera, poſtea fuſiùs, cum de cordis motu, dicetur.

Quare quod proximè reſtat, de partibus cordis agendum erit; inter quas ſiquidem nervi vaſaque ſanguifera externam ejus ſuperficiem perreptantia primò in conſpectum veniunt, primo quoque ante cæteras tractanda ſunt.

Diſceptatum eſt olim, An vaſa ſanguifera à corde originem ſumerent, aut potius in ipſum terminarentur. Verum ex quo *Cl. Harveius* prima vitæ ſtamina atque rudimenta in cicatriculâ nidulari docuit, atque ex motu & pulſu minutulæ ejus bullæ arterias velut tot fiſtulas & canales ſanguini convehendo excudi, non eſt quod diu in quæſtione hæreamus: Quod autem venas ſpectat, cùm ſanguini tantum referendo

ferendo à partibus corporis omnino natæ ſint, utique exiſtimandum eſt, ab extremo undique corpore oriri, & in cor, ubi liquorem ſuum exonerant, pariter terminari: Neque enim quis dixerit flumina à mari in quod ſeſe exonerant, ſed à fontibus & minoribus rivulis originem ſuam haurire. Verum alia ſunt *vaſa quæ* tum originem à corde capiunt, tum in ipſum quoque terminantur: Cordis enim parenchyma uti toti corpori calorem & nutrimentum porrigit, ita & ſibi eodem modo proſpicit; neque enim æſtuante intra ventriculos ſanguine ſolum calet, aut ſucco nutritio intra ventriculos cocto ſaturatur, ſed chylus qui parietibus cordis ſine manifeſto vitæ diſcrimine (ut poſtea patebit) agglutinari non poteſt, per vaſa unà cum ſanguine per totum ejus parenchyma diſtribuitur, ibique in nutrimentum ejus faceſſit, & pro continuo diſpendio novo ſubinde pabulo reparatur.

Vaſa autem quæ ſanguinem in cordis parenchyma convehunt duo tantum ſunt, ſed & in duos truncos utrinque

mox

mox ab origine divisa. Quorum orificia circa principium aortæ immediate extra valvulas semilunares aperiuntur, coronariæ inde dictæ quòd truncis non statim in parenchyma demissis, sed facto prius circuitu quo commodius undique sese explicent, cordis basin amplectuntur & cingunt: Et licet ab ipsâ origine in oppositas cordis regiones ab invicem recedant, circa extremas tamen partes rursus conveniunt & passim apertis osculis invicem communicant, adeò ut si uni liquor aliquis injiciatur, per utramque simul & semel dispergatur: Cum enim eadem ubique caloris vitalis atque nutrimenti necessitas urgeat, ne alibi deficiant, anastomôsi hâc abunde providetur.

Uti autem arteriæ duæ sanguinem ad alimentum & calorem cordi suppeditandum, subministrant, pariter & duæ venæ ab ambitu suo coronariæ quoque dictæ, reducendo sanguini inserviunt. Et ne quis in posterum dubitet an venæ capillares apertis osculis in se invicem hient, si intueatur conum cordis vitutulini aut cujuspiam animalis recens nati

in

in quo vaſa hæc planiora exiſtunt ; & cultelli apice ſanguinem ab hâc in illam venam urgeat propellatque, manifeſtò videbit, liquorem ſanguineum facilè à venâ hujus lateris in illam alterius percurrere ; & vice versâ. Idem in vaſis veſicæ, inteſtinorum, ventriculi, & cerebri evenire certus ſum, ut nullus dubitem vaſa capillaria (ejuſdem generis) per omnes corporis partes in ſeſe mutuò aperiri.

De Nervis cordi implantatis, Authores qui cordis & ſanguinis motum neſciverunt, non immeritò plerique olim ſilebant, Atque proximè accedunt, qui, circulationem licèt agnoſcant, eam tamen tam lento & teſtudineo paſſu fieri ſtatuant, ut ſanguinem guttatim inſtillari, & ebullitione ſolum excitatum è corde prolabi autument ; atque proinde, an cordis motus ad ſanguinis circuitum aliquid conferat parum ſolliciti, de muſculosâ cordis ſtructurâ, atque numeróſis nervis parum aut nihil dignum opinantur ; verum ſi quis tendinoſam & fibroſam cordis ſubſtantiam, eamque tot nervis ubique in-

intertextam perpendat, exiſtimare eum quoque oportet, non tantam vim illi fruſtra datam, ſed eidem officio cum reliquis muſculis factam atque conſtitutam eſſe: Plurimas enim nervorum fibras atque ſurculos à nervis octavi paris accipit, qui omnes inter arteriam pulmonalem & aortam incedentes in auriculas utrinque varias propagines dimittunt, & deinde in cordis ſubſtantiam varie explicantur, qui in corde vituli aut recens nati cujuſpiam animalis per totam extimam ſuperficiem maniſeſtiùs apparent; quale vero miniſterium cordi præſtant, poſteà dicetur.

Interea advertere non alienum erit, quomodo ſpiritus pro diverſâ animalium figurâ per nervos variè in cor influant: cum enim nulla vis aut facultas ſe movendi cerebro inſit, quâ ſpiritus animales (ut Cor ſuum ſanguinem) diſpellat; cúmque liquor nervoſus & ſpiritus eo involuti ex naturâ ſuâ ſolum deorſum velut aqua ex Alembico ſuo pondere deſtillant; ideo fit ut caput, aut ſpinalis medulla ſupra reliquum corpus in omni animalium genere con-

conſtituatur, aut pro libitu erigi atque attolli poteſt: Et licèt fatendum ſit, à ſanguinis in cerebrum appulſu ſpiritus per meatus & poros cerebri, prout in reliquo corpore, propelli, atque à ſubſequentibus continuâ quadam ſerie & ſucceſſione in nervos & ſpinalem medullam urgeri, cum tamen difficiliùs liquor iſte nervoſus ſurſum quàm deorſum uſque impelli atque protrudi poterit, tum fit ut cerebrum aut ſaltem Spinalis medulla ſupra reliquum corpus collocetur, quo liquor animalis facilius in omnes partes ſubjectas influat & deſcendat. Et quidem huic conjecturæ diverſus nervorum è ſpinali medulla in Homine atque in quadrupedibus exortus primam mihi anſam dedit; Quippe in Homine qui capite & ſpinâ erectâ factus eſt, nervi omnes obliquè exorti obliquè etiam deorſum feruntur; in Brutis autem quorum medulla ſpinalis ſupra corpus collocatur, nervi omnes rectè deorſum exorti, recte etiam è ſpinali medulla extra vertebras deſcendunt: Quin &, cum propagines nervoſæ à ſolo octavi paris

paris nervo in Cor humanum inſerantur, in Brutis pleriſque longè aliter ſe res habet, quippe præter propagines à nervo octavi paris diſtributas plurimi inſuper nervorum ſurculi à nervo intercoſtali ubi recta ſuper Cor tranſit in ejus parenchyma dimittuntur, quo faciliùs ad Cordis motum adjuvandum influant, prout cuilibet in vitulis,equis & majoribus Animalibus primo ſtatim intuitu occurret; manifeſto indicio hoc ideo à naturâ quaſi ſubſidium Brutis comparatum eſſe, ne capita, quæ terram prona ſpectant, non ſatis facilè aut copiosè ſpiritus animales imperti- rent.

Explicatis ad hunc modum Vaſis Cordis, tandem ad Parenchyma ſeu potius *Muſcularem* ejus *Subſtantiam* pervenimus, de quâ quidem obſervare eſt, ipſam ſupra omnes Corporis Muſculos accuratè conformari. Cum enim cæteros omnes operis neceſſitate & conſtantiâ multum excellat, utique par fuit ut ſtructuræ quoque elegantiâ eoſdem longè ſuperaret. Quanquam autem nobiliori uſui deſtinari & peculiari quadam texturâ sua multum præstare videatur, at hoc habet cum reliquis Musculis commune quòd iisdem plane fibris & instrumentis, licèt diversâ ratione dispositis, tum fabrica ejus tum motus instituuntur. Quod ut clariùs innotescat, Musculi recti cùm obliquis conferendi sunt: Musculum autem quemlibet in toto corpore cujus fibræ atque motus recti sunt non unico & simplici ventre (uti ab Anatomicis hactenus scriptum est, qui duos solummodo Musculos in collo biventres agnoscunt) neque capite & caudâ donari, neque fibras ab altero extremo tendine in alium rectà ferri certum est, (prout in *Tab. 3. Fig. 1.* delineari solet.) Sed omnes biventres sunt, & fibræ eorum carneæ prout à diversâ origine ita in diversos & oppositos fines feruntur. Prout *Tab. 3. Fig. 2.* exhibet. In quâ

a a *Tendines utrinque.*

b b *Duo ventres sive duplex Musculus cum fibris in oppositos fines respicientibus.*

c c *Tendinis utriusque pars exterior in quem fibræ omnes inseruntur.*

Atque hæc quidem est fabrica Musculorum omnium in universo corpore, sive in femore, tibia, brachio, & collo Humano; porro, Musculi abdominis, Maxillares, Temporales, Diaphragma, Intercostales externi & interni, ut vocant, (quorum quidem singuli sunt unius Musculi bini ventres) eodem ordine & modo conformantur. Atque ne unum tantùm specimen simplicis cujusvis Musculi biventris exhibeam, libet unum & alterum Musculi magis compositi Schematismum proponere: Qualem in *Tab.* 3. *Fig.* 3. 4. *&* 5. Musculi lumbaris in cane varia facies manifesto ostendit. Tertia enim Figura Musculi illius partem abdomini proximam cùm fibris omninò rectis deorsum in longum tendinem desinentibus exhibet. In qua

a *Pars ejus carnosa prope renes.*

b *Pars ejus inferior ubi tendo ossi cruris affigitur.*

c c *Fibræ recte utrinque in tendinem desinentibus.*

Quarta autem Figura ejusdem Musculi lumbaris latus exhibet quà spinæ vertebris accumbit, quod quidem diversis quasi Musculis constat, quorum cujusque tendo in diversam vertebram affigitur. In qua,

a *Musculi pars interior deorsum in tendinem abiens.*

b b b b b *Musculi parvi adversi lateris; quorum tendines.*

c c c c c c *In singulis vertebras juxta sitas implantantur, & sursum tendunt.*

Cujus quidem utriusque lateris ductus atque ordinem, in Figura quinta simul repræsentantur; Ut uno intuitu constet, eundem Musculum esse, sed fibris in diversa tendere.

In sexta autem Figura ejusdem Tabulæ, exhibetur Musculus quidam ob formam *Plumaris* mihi dictus qui in extremitate Cruris ovini occurrit, & ab osse femoris exoritur & in longum ten-

tendinem desinit, qui ossi tibiæ ovinæ annectitur: Et cùm alii Musculi plures, fibris suis plumam cùm pennâ accuratè referant, hîc quidem è duplice plumâ constat; atque uti ad Musculi biventris normam, ita & ad similem quoque motum componi videtur. Verum præ his omnibus maximè compositus est quem Musculum Deltoeidem vocant; cujus quidem plures ventres sunt atque vario in opposita respectu planè ostendunt naturam, quanquam in diversis corporis partibus circa formandos Musculos varia arte & sæpiùs ludat, at semper ad Musculi biventris ordinem atque rationem collimare. Prout in *Tab. 4. Fig. 1.* luculenter apparet. In quâ

a a a *Pars Musculi Deltoeidis tendinosa superior qua ossi scapulæ & claviculæ annectitur.*

b b b b *Pars tendinosa inferior qua medio brachio annectitur.*

c c c *Ventres ejus, superius tendentes.*

d d d d d *Ventres ejus; deorsum tendentes.*

Quare autem Musculi biventres in collo sic appellati junctis tendinibus in medio conveniunt contra quam in aliis omnibus totius corporis Musculis observari potest, in causâ conjicio esse, quòd cùm venam jugularem ex utroque colli latere transcendant, nisi ibidem attenuari & per tendines committi provisum esset, venam comprimendo sanguinis è cerebro descensum multum impedirent. Prout in *Tab. 4. Fig. 2.* planè patet. In qua

a a *Vena jugularis.*
b b *Musculus biventer.*
c c *Duo tendines.*
d *Ubi tendines utriusque conjunguntur.*

Poteram hic plures alios Musculos rectos non injucundo spectaculo delineare, sed cùm omnibus eadem texturæ ratio sit, proximè restat ut ostendam quid Musculus cujus fibræ utque motus obliquè circulares sunt cùm recto commune habet.

Ut

Ut autem, ad Geometriæ Leges, linea recta obliquæ Index est, ita ex Structurâ Musculi recti tanquam communi normâ circularis hæc Cordis Machina optimè ediscenda est. Quemadmodum enim rectus è duplici fibrarũ ordine constat, in diversas & oppositas Musculi partes tendentium, quæ ubi contrahuntur, tendines suos propiùs sibi invicem adducunt, ita & consimili plane modo in Cordis Machinâ constituendâ ejusque peragendo motu accidit. Quippe è duplici fibram ordine ab ipso ortu in contrarias Cordis partes abeuntium potissimum conformatur; quo neque quicquam luculentius apparet, sive fibrarum Cordis terminationem, sive ductum & seriem earum perpendamus.

Et quidem in Corde benè excocto & ab auriculis suis & vasis majoribus separàto, tendo satis validus apparet qui marginem ejus circa ostia undique cingit & amplectitur, cujus pars aliqua in summitate septi in quibusdam animalibus in osseam substantiam induratur. In quem quidem tendinem fibræ carneæ quæ externum Cordis ambitum complicant & conſtituunt dextrorſum ubique inſeruntur. Verum fibræ carneæ interiores quæ ventriculis proximæ ſunt, ductu plane oppoſito in ipſum illum tendinem inſeruntur, uti videre eſt in *Tab.* 2. *Fig.* 1. Ubi,

a *Oſtium quà Dexter ventriculus ſanguinem à venâ cavâ excipit.*

b *Oſtium quà ipſum in pulmomem expellit.*

c *Oſtium quà ſiniſter ventriculus ſanguinem à pulmone redeuntem excipit.*

d *Oſtium quà immiſſum in aortam expellit.*

e e e e *Tendo undique circa oſtia Cordis conſitus.*

f f f f *Fibræ ab exteriore Cordis ambitu undiquaque redeuntes, in tendinem Cordis delatæ.*

g g g g g *Fibræ interiores ductu planè exterioribus oppoſito in eundem tendinem deſinentes.*

Cum itaque conſtiterit fibras Cordis duplici & diverſo modo terminari, proximè

proximè oſtendendum eſt ductu quoque ſimili per totum utriuſque ventriculi circuitum complicari; exceptis itaque paucis & tenuioribus fibris quæ per extimam dextri ventriculi ſuperficiem rectè ſurſum elatæ in baſin terminantur, uti in *Tab.* 2. *Fig.* 2. delineatur. In quâ

a *Baſis Cordis.*
b *Conus.*
c c c *Fibræ rectæ ſurſum verſus baſin tendentes.*

Reliquæ omnes utrique ventriculo communes duplicem tantùm ſeriem atque ordinem ſed penitus contrarium affectant: Fibræ quidem rectis hiſce exterioribus in dextro ventriculo proximè ſubjectæ obliquè dextrorſum aſcendentes in baſin Cordis terminantur, & ſpirali ſuo ambitu *Helicem* ſive cochleam ſatis aptè referunt. Prout *Tab.* 2. in *Fig.* 3: videre eſt. In qua

a *Baſis Cordis.*
b *Conus.*
c *Fibræ quæ ſiniſtrum ventriculum complicant.*

d *Quæ*

d *Quæ Dextrum.*

e *Sinus in interstitio utriusque ventriculi pro vasis Cordis excipiendis excavatus.*

Externis hisce subjectæ sunt aliæ fibræ prioribus prorsus contrariæ: Uti enim exteriores à sinistro Cordis latere versus dextrum porrectæ ad basin ejus terminantur, hæ ductu plane opposito feruntur; Emergunt enim circumquaque à dextro Cordis latere unde obliquè versus sinistrum latæ, & utrumque Cordis ventriculum circumplexæ ad basin sinistri lateris assurgunt, alteramque *Helicem* inversi ordinis constituunt. Prout in *Tab.2. Fig.4.* manifestum est. In quâ

a *Basis Cordis.*

b *Conus.*

c *Dextrum latus.*

d *Sinistrum.*

e *Fibræ dextri ventriculi.*

f *Fibræ sinistri.*

Quarum omnium seriem complicationem atque ordinem facilè percipiet qui Cor bubulum aut ovinum excarnare

nare tentaverit. Quæ prioris ordinis ſunt cuticulâ Cordis vixdum ſeparàtâ primâ velut facie facilè conſpici poſſunt, aliæ autem quæ magis in profundo latent, non niſi prioribus ademptis in conſpectum veniunt. In iis autem perſequendis magnâ non opus eſt cautelâ, ipſi enim tractus eorum & convolutiones adeò planæ ſunt & obviæ ut filo quaſi ducente ultro ſe prodant. At verò licet fila craſſiora in glomeres convoluta primò aſpectu valdè referant, ad eorum tamen morem atque eodem prorſus ordine non contexuntur; neque enim continuo quaſi filo, aut repetito ſæpius circuitu ventriculos Cordis circumambiunt, ideoque velut glomeres filorum perpetuâ ſerie revolvi non poſſunt: licèt enim externâ Cordis membranâ ſeparatâ, quantum ex oculis conjicere fuerit, putaret aliquis fibras omnes oblique à baſi ad Cordis apicem uno & continuo ductu pertingere, qui tamen ipſorum ductus ab alterutro extremo emetiri tentaverit, facilè comperiet pauciſſimas earum vel dimidiatum ſaltem ſpatii

iſtius

iſtius ambitum conficere, ſed ubi paululum ab ipſo tendine emerſerint, ſub præcedentibus fibris mox intorquentur, & viſum prorſus aufugiunt: de fibris enim obliquis exterioribus neutiquam ſileri debet. Non omnes à baſi in conum pertingere, ſed quædam illarum breviores ſunt & ubi medium Cordis ambitum extra attigerunt, inſtar arcus inflexi ſtatim incurvantur, & in tendinem alterius lateris & ventriculi obliquo ductu inſeruntur. Quæ quali ordine inflectantur & fibris carneis hinc inde communicatis quaſi arreptis invicem manibus ſibi mutuò ſuccurrant, ex *Tab.2. Fig.5.* plane conſtat. Ubi,

a *Tendo circa oſtium ventriculi dextri.*

b *Tendo circa oſtium ventriculi ſiniſtri.*

c *Fibræ ab uno tendine in alium porrectæ cum fibris intermediis hinc inde in mutuum ſubſidium porrectis.*

d *Locus ubi poſtquam dextrum ventriculum*

triculum complexæ ſunt, incurvantur, & obliquè in ſiniſtri ventriculi tendinem deſinunt.

Perſpecto fibrarum utrique ventriculo communium ductu, reſtat ut, abſciſſo dextro ventriculo quo ordine ſiniſtri fibræ ferantur pariter expendamus ; & quidem uti eidem officio ambo inſerviunt, ita ſimilis ubique machinæ ratio atque forma occurrit, duplici enim fibrarum ordine iiſque in oppoſitos omninò tendines deſinentib⁹ inſtruitur. Fibræ enim exteriores per totum ſiniſtri ventriculi ambitum dextrorſum complicatæ ſpirali flexu aſſurgunt ibidemque in baſin Cordis terminantur uti Figura 6. exhibet in quâ ſiniſter ventriculus in latus recumbit ut quo ritu fibræ circa conum Cordis conveniunt, palam fiat. Ubi,

a *Baſis ventriculi.*
b *Conus.*
c c c *Fibræ obliquè dextrorſum aſcendentes verſus baſin.*
d *Latus dextro ventriculo proximum.*
e *Latus ſiniſtrum.*

At

At neque omnes in hoc ventriculo ab ipsâ basi in conum pertingunt, & non nisi pluribus abruptis eousque separari possunt, plurimæ enim in medio Cordis ambitu è communi viâ & tractu deflectunt, & sub fibris proximè præcedentibus demersæ in tendinem oppositi lateris obliquè ascendunt, adeòque breviorem ductu suo circulum describunt. Prout in Fig. 5. supra constitit.

Interiores autem fibræ contrario prorsus incedendi ordine sursum obliquè sinistrorsum omnes in basin ascendunt, ejusque tendini inseruntur atque interiorem ventriculi parietem constituunt.

Quæ quidem contrarii ordinis fibræ quotquot longiores fuerint ad conum Cordis concurrunt, & circa ipsum in sese mutuò contorquentur, adeo tamen ut relictum in medio centrum tenuissima Cordis pars sit: Cujus quidem contorsionis modum atque fibrarum in exteriore sinistri ventriculi pariete cum illis in interiore circa apicem Cordis concursum & contorsionem

ſionem apte ſatis exhibet Fig. 7. In quâ

- a *Tendo dextri lateris.*
- b *Tendo ſiniſtri.*
- c *Fibræ aliquot exterioris parietis.*
- d *Fibræ interioris parietis è fibrarum utriuſque ordinis circa conum Cordis contorſio.*

Ex quo perſpicuum ſatis videtur, fibrarum externi & interni parietis prorſus contrario ſibi modo ferri motuſque etiam oppoſitos perficere, verum adeo ut dum Cordis parietes in diverſa conſtringant, utroſque in arctius & anguſtius ſpatium contrahere. Prout infra magis patebit.

Unicum hoc comminiſcendum reſtat, Non omnes quidem fibras in tendinem circa oſtia Cordis conſitum immediate deſinere, verùm aliquas in carneas quas vocant columnas ex utroque ventriculi ſiniſtri latere protuberantes terminari; quæ tamen columnæ varios tendines in membranas mitrales dictas & cum ipſo tendine in baſi

basi Cordis conjunctas emittunt; Adeò ut ad motum Cordis perinde fuerit sive hoc aut illo modo basin Cordis assequantur.

Vidimus huc usque, quàm vario & diverso ordine fibræ carneæ Cordis latera & patietes cingunt: superest unicè, ut quàm affabrè omnes circa conum Cordis complicentur, exponamus; quod quoniam elegantiùs delineare quàm describere in promptu est, hoc solum advertere sufficiet, prout motus ordis & Sanguinis circularis est, ita & fibras omnes motrices utriusque machinas hîc velut propiùs in circulum & quasi centrum adduci. Prout conus Cordis bubuli excocti & abscissi ostendit, in Fig. 8. Tab. 2. In quâ

aaaaa *Fibræ exteriores spirali ductu in conum velut in centrum coeuntes.*

Et sicuti internæ ventriculi fibræ contrario ad externas ductu feruntur, ita si coni pars interior & ventriculi cavitati proxima perpendatur, constabit

ſtabit quoque fibras ejus, inverſo prioribus ordine, velut in circulum pariter componi.

Quandoquidem denique majore nixu & vibratione opus eſt ad ſanguinem in remotiſſimas corporis partes quàm in vicinos tantùm & laxos pulmones propellendum, ideò obſervandum eſt, ventriculum ſiniſtrum majori fibrarum robore, iiſque craſſioribus, quam dextrum firmari.

Structurâ Cordis exteriore hactenus perluſtratâ, de auriculis meritò hîc aliquid dicendum eſt, neque enim minore artificio formantur, quàm Cor ipſum, licèt minore mole conſtent; Quin & par utriuſque uſus & fabricæ ratio eſt. Muſculus enim utraque eſt & duplici fibrarum ordine conſtruuntur; Quinimo uti motus earum Cordis motum antecedit, ita & nervos ab octavi paris ſurculis prius, quam ipſum attingunt, ſortiuntur: Et quidem fibræ duplici & contrario reſpectu in oppoſitos tendines feruntur, quippe tendo in Cordis baſi auriculis etiam communis eſt, cui veluti fulcro innituntur; ex alterâ

D autem

autem parte auriculæ dextræ quà venam cavam reſpicit, duriore & tendinoſo planè circulo firmatur: inter quos fibræ aliæ in hunc, in illum aliæ terminantur, uti in Cordis Humani auriculâ dextrâ inversâ & explicatâ conſtat, in *Tab.* 5. *fig.* 2. In quâ

aaa *Baſis auriculæ ubi tendini Cordis unitur.*

bbb *Tendinoſus circulus quà à vena cavâ diſtinguitur.*

ccc *Fibræ carneæ, hinc inde in diverſos tendines delatæ cum fibrillis intermediis quaſi in plumam efformatæ.*

d *Vena magna coronaria.*

ee *Venæ aliæ minores, ſanguini à Corde referendo conſtitutæ.*

f *Pars auriculæ ſuperior.*

De uſu earum infrà dicetur: interea obſervandum eſt, inter auriculam dextram & ſiniſtram, non eam proportionem dari, qualis inter Cordis ventriculos mutuò intercedit. Ventriculi enim cum ſimul & æquis ſemper paſſibus moveantur, cumque ad regularem

&

& commodum per pulmones circuitum, plus ſanguinis à dextro Ventriculo ſuffundi non debuit, quàm per ſiniſtrum expediri potuit; neceſſe ideò fuit, ut pari ferè capacitate conſtarent; pauciſſimâ enim ſanguinis parte (quæ vaſis lymphaticis in pulmone ablegatur & pulmonis nutrimento atque irrigationi inſervit) exceptâ, utrique Cordis ſinus æqualem continent & diſtribuunt menſuram.

Cum itaque tam regularis & ubiquè in omnibus conſtans ventriculorum reſpectus & habitudo fuerit, quid in causâ ſit quòd auriculæ etiam pari invicem proportione nullatenus reſpondeant, aliud in promptu concipere non eſt, quàm cum auriculæ ad conjiciendum in ventriculos ſanguinem natæ atque conſtitutæ videantur, ſanguinis autem è venâ cavâ in dextrum Cordis ventriculum influxus lenis ſit, ideo majore illic & ampliore auriculâ opus eſt, quæ ſanguinem tantâ copiâ intra ambitum ſuum excipiat & ventriculo injiciat, quanta ferè ad ſinum illius explendum ſufficiat: è venâ pulmonali autem cùm propter pulmonis in exſpiratione collapſum & ſubſidentiam, ſanguis expreſſus confeſtim & copioſiùs urgetur; hoc ſolum requiri videtur ut præterlabenti in ſiniſtrum ventriculum ſanguini motus fortior imprimatur, ejuſque curſus promoveatur aliquantulum, adeóque tantæ auriculæ ſubſidium non deſiderat.

Poſtquam ad hunc modum externam Cordis ſuperficiem atque texturam explicuimus, proximè reſtat, ut quo intus apparatu inſtruuntur omnia, conſpiciamus. Prout autem externa Cordis facies lævis & æqualis eſt propter commodiorem motum, ita ob eandem cauſam interni ejus parietes inæquales maximè ſunt & diſpari ritu contexuntur; quippe per totam intus cavitatem in diverſa interſtitia & ſulcos Cor excavatur, & fibris carneis huc inde porrectis intertexitur: Verum nec in omnium animalium cordibus æquè hoc accidit, neque quibus adſunt, ſimili ordine atque mole fabricantur. Quippe, uti *Inſigniſſimus Harveius* obſervavit, pro diverſo animalium

malium genere, atque ejuſdem ſpeciei magnitudine atque robore plurimùm diſcrepant. In majoribus enim Animalibus, quorum ſanguis longiùs trajici & fortiore motu urgeri poſtulat, ventriculi Cordis carneis fibris & parvis quaſi muſculis multifariam hinc inde protenſis intus firmantur; atque in ſcrobiculos variè finduntur; quóque grandiora Animalia fuerint, eo majores atque pauciores iſtæ fibræ carneæ reperiuntur, ſed & ſcrobiculi altiùs imprimuntur. In humano autem Corde, fibræ minores ſunt, ſed perplexa & multiplici ſerie diſponuntur, & ſupra quàm in aliis omnium cordibus quæ hactenus videre licuit, numeroſiores exſiſtunt. Quarum quidem ſeriem atque ordinem exhibet *Tab.*5.*Fig.*1. in quâ ſiniſtri ventriculi interior ſinus explicatur. In quâ

a a *Vena pulmonalis rectè ante ingreſſum Cordis explicatur.*

b *Auricula ſiniſtra Cordis.*

c *Foramen ovale, per quod ſanguis à venâ cava rectè ante ſiniſtri ventricali oſtium influit.*

d d *Duæ membranæ mitrales.*
e e *Carneæ columnæ ex utroque ventriculi latere protuberantes.*
f *Baſis Cordis, ubi ſanguis è vena pulmonali in ventriculum influit.*
g *Locus ſub membranis mitralibus ubi emittitur in aortam.*
h *Conus Cordis.*
i i i i *Fibræ carneæ hinc inde per totam interioris ventriculi ambitum attextæ.*

Porrò, uti in majoribus Brutis ventriculi Cordis majoribus intus fibris quàm in homine; ita auriculæ quoque, nempe in equo & bove, largioribus fibris veluti digitis huc illuc protenſis in diverſa ſpatia diſtinguuntur, quibus invicem adductis latera illarum ad exprimendum ſanguinem mutuò complicantur: Quin &, de cæteris ventriculorum fibris nulli dubium eſſe debet, quin motui Cordis & lateribus ejuſdem conſtringendis inſerviant.

Uti verò fibræ iſtæ carneæ ad Cordis parietes conſtringendos plurimum conferunt, ita quò arctius hoc fiat & in-

internæ ventriculorum partes ſibi magis appropinquent, fiſſuræ iſtæ ſive ſulci in animalium grandiorum cordibus apprimè condúcunt; neque enim lævis & æqualis intus ſuperficies idem pateretur. Quocirca hujuſmodi interſtitia ſive fiſſuræ in ventriculum potiſſimum ſiniſtro occurrunt utpote quæ huic ſolum neceſſariæ atque ex uſu eſſe videntur: Quippe cùm parenchyma ventriculi ſiniſtri è fibris obliquè circularibus præcipuè conſtet, atque undique in ſeſe velut in circulum conſtringatur, non potuit tam propè, & in ambitum tam arctè contrahi, niſi excavati intus ſulci & rugæ hujuſmodi motui locum accommodarent; Ventriculi autem dextri paries cùm multò tenuior & ſiniſtri quaſi appendix, ejuſdem lateri attextus ſit, motuque tantum ſemicirculari coarctetur, in eo tam profundæ foveæ non admodum requiri videbantur: Verùm, cùm propter lateris tenuitatem ab irruente ſanguinis torrente aut ſuppreſſum Cordis motum à nimiâ ejus copiâ ultra debitum tonum diſtendi eouſque possit, ut fibræ ejus sese constringere iterum & restituere non valeant (quòd in sinistro ventriculo propter parietis robur & crassitiem neutiquam timendum est) in dextro hujusmodi incommoda quò melius præcaveantur, carneus quidam Musculus rotundus & satis validus circa mediam ipsius regionem à septo Cordis in latus oppositum porrigitur; prout in Corde ovino, bovino, aliisque videre est; in Humano autem Corde duæ vel tres carneæ hujusmodi fibræ plerunque reperiuntur; quarum quidem usum si non adducendo ejus parieti, at saltem ne nimis distrahatur, plurimùm conducunt.

Cordis internâ faciè huc usque explicatâ, proximè restat dicendum de papillis & columnis carneis, valvulisque circa diversa Cordis ostia consitis, tum quà sanguinem à venis excipit, tum quà eundem in arterias expellit.

Quæ itaque in dextro ventriculo occurrunt papillæ, sunt carunculæ quædam teretes & oblongæ, è lateribus excrescentes & sursum porrectæ, è quarum

quarum summo apice fibræ quædam tendinosæ procedunt, & membranis quæ à figurâ Tricuspides dictæ sunt, annectuntur. Membranæ autem istæ circa marginem hujus ventriculi exortæ, undique ostii ejus limen cingunt, adeò ut cùm mucro Cordis in omni Systole versus basin adducatur, papillæ quoque sursum motæ fibras suas quasi lora multum relaxata remittunt; quo fit, ut membranæ quoque, quibus alligantur, laxè pendentes à sanguine in omni Cordis Systole expresso, quasi vela à vento impleta sursum propellantur, proindéque ostium illud Cordis tàm accuratè occludant, ut liquoris ne una guttulla in auriculam refluere possit, sed in pulmones, quâ data porta, totus expellatur: Verùm, ut in omni Systole Cordis, cono ad basin propius adducto, papillæ fibras suas multum relaxant, ita in diastole conus iterum recedens, papillas eorumque fibras secum simul deducit; unde fit ut membranæ quoque detractæ ostium Cordis protinùs recludant, & sanguini ab auriculâ impulso foràs quasi aperiant.

Atque

Atque hæc quidem ita fieri & in omni Cordis ſyſtole ac diaſtole hanc eſſe actionem & munus valvularum, ſatis conſtat; verùm agendi rationem & perficiendi modum non niſi ex ſitu & ſtructurâ papillarum quibus alligantur, ita facile eſt concipere. Nam, licèt certiſſimum ſit, membranas tricuſpides à ſanguine ſurſum in Syſtole regurgitante eouſque, veli inſtar, inflari donec ventriculi orificium prorſus obturent; quò tamen modo & partium confirmatione hoc contingat, obſervatu digniſſimum eſt. In his autem tribus, rei totius ratio & machinæ artificium conſiſtit.

1 Quòd papillæ extra lateris interni ſuperficiem longiùs eminent & protuberant.
2 Quòd non in eâdem omnes, ſed in diversâ lateris parte, conſitæ ſunt.
3 Quòd papillæ in latere membranis, quibus alligantur, oppoſito, conſtitutæ ſunt.

Nimirum hoc ſitu & fabricâ papillarum efficitur, ut membranæ aliquanto
ſemper

ſemper ſpatio à lateribus ventriculi diſtantes primò quaſi ictu ſanguinis in omni Syſtole ſurſum repercuſſi, facilè attollantur; cùm enim, remiſſis papillarum fibris, tam laxè & tranſverſim ferè in medio ventriculo pendeant, fieri non poteſt, quin à regurgitante ſanguine & intra ambitum ipſorum excepto, non aliter quàm vela à vento, impellantur, & quouſque lora remittunt, explicentur: Illa autem eouſque cedere à naturâ datum eſt, donec membranæ undique extenſæ orificium ventriculi omninò occludant.

Verum eædem fibræ ſi immediatè ex ipſis lateribus ventriculi orirentur, utique membranæ interno parieti Cordis propiùs accubantes ſanguinem retrò excipere; atque ab eodem ſurſum attolli non poſſent, ſed eâdem quâ influxerit viâ iterum expelli paterentur.

Papillarum verò uſum atque rationem meliùs intelliget quiſpiam, ſi carneas columnas è lateribus ſiniſtri ventriculi extuberantes atque eidem prorſus officio deſtinatas attentè perpendat; Non enim ad motum factæ ſunt,

aut

aut membranas sibi annexas contrahunt (quòd ostiolum Cordis apertum potius retineret) sed ideò solum constitutæ sunt, & extra reliquam interni ventriculi superficiem in tantùm eminent, ut membranas à lateribus ventriculi satis distantes teneant, quò facilius à sanguine ab infra suffuso repulsæ orificium illud Cordis, cui attextæ sunt, prorsus claudant. Quam quidem membranarum sublevationem & orificii istius inde occlusionem, immisso per ostium vel conum Cordis syphone, & injectâ aquâ facilè quis imitari poterit, & aperte conspicere, modò auricula & vena pulmonalis ad basin Cordis priùs abscindantur; Idemque pariter fiet, si Cor aquâ ferè repletum circa conum comprimatur.

In dextro ventriculo membranæ omnes fibras suas à papillis haud directè accipiunt; illarum tamen ope hoc præstant, ut sanguinis recursum pariter impediant: quippe cùm undique contiguæ fuerint, quamprimùm membranæ illæ quæ rectè fibras à papillis insertas habent, à sanguine subleventur,

tur, reliquas quoque quibus conjunctæ ſunt ſimul attolli & à ſanguine ſuperius vergente impleri & diſtendi neceſſe eſt: Quòd ut commodius fiat, exiſtimare par eſt, ſanguinem in omni diaſtole in Cordis thalamos injectum inter membranas iſtas & parietes retro ſe inſinuare, eaſdemque, quo plenior ventriculi cavitas evadit, eò magis attolli & quaſi ſufflari, prout ex aquâ ad plenitudinem ei inſtillatâ, vel è ſyphone per apertum ejus orificium injectâ, apparet. Cui multum etiam conducit, quòd fibræ à carneis columnis & papillis porrectæ ſanguini apertum per ſpatia ſua tranſitum pone membranas iſtas influenti præbent; præterquam enim quòd ſanguini quaſi per cribrum ſuccutiendo & miſcendo fortè inſervire poſſint, huic inſuper uſui inprimis deſtinari videntur, tum ut membranas intra debitos extenſionis limites contineant, tum ut ſanguini aditum faciliorem patefaciant, quò ſe undique in penitiſſimos ventriculorum anfractus & receſſus commodiùs inſinuet, eóque ad dilationem Cordis &
val-

valvularum elevationem accelerandam magis conferant: Sanguis enim Cordi immissus & intra fibras receptus mox ad plenitudinem assurgit, simulque intumescentiâ suâ membranas sublevando sibiipsi hâc viâ exitum præcludit, adeò ut cùm Cor se constringat, sanguinem per patulum orificium in aortam propellere necesse habeat.

Uti autem sinister ventriculus, quia majori operi destinatur & fortiore nixu utitur, tum robore tùm parietis crassitie dextrum longè antecellere debuit; ita carneæ columnæ ejusque fibræ & membranæ ob eundem finem dextri ventriculi consimilem apparatum magnitudine atque firmitate longè superant: Quippe, uti Systole sinistri ventriculi multo fortius vibratur, ita robustioribus hujusmodi machinis opus fuit ad sustinendum ejus impetum, eumque per aortam dirigendum. Sanguis autem, postquam per arterias eruperit, ne quacunque de causâ denuò eâdem viâ in Cordis sinus regurgitare possit, membranæ tres à Figura semilunares dictæ circa utrumque Cor-

dis

dis ostium, tum quà sanguinem in pulmonem, tum quà in aortam expellit, constitutæ sunt, quæ à sanguine represso, siquando id fieri contingat, explicatæ, adeò arctè sibi invicem adaptantur, ut arteriæ canalem prorsus obturent. Prout abscisso ferè ad radicem arteriæ trunco & aqua vel spiritu immisso luculenter patet: quas quidem laxatas & sanguini emisso cedentes *Tab.*4. *Fig.*3. exhibet. In quâ

a a *Pars sinistri ventriculi aperta.*
b b b *Tres valvulæ semilunares laxe concidentes ut sanguini erumpenti exitum præbeant.*
c *Aortæ truncus apertus.*
d d *Duæ arteriæ coronariæ immediatè extra valvulas semilunares ex ortæ trunco discedentes.*
e e e *Radix aortæ ubi cum tendine Cordis unitur.*
f f *Membranæ mitrales divisæ & utrinque reflexæ ut valvulæ semilunares in conspectum veniant.*

Ex quo valvularum situ satis constat quàm facilem ejecto sanguini exitum

præ-

præbeant; quantum verò eidem, si regurgitare contigerit, reprimendo inserviant, in *Tab.* 4. *Fig.* 4. etiam constabit. In quâ

aaa *Aortæ truncus ad radicem abscissus.*

bbb *Tres valvulæ semilunares arctè invicem sibi accedentes, & plenò quasi ore sanguinis recursum obstruentes.*

cc *Duæ arteriæ coronariæ.*

Cordis domicilio hucusque per omnes partes & recessus lustrato, uti in more positum est, ita è re quoque erit invisere quali apparatu sanguini ad illud confluo & mox discessuro ductus & via sternitur.

Itaque ante limen auriculæ dextræ nempe eo loci ubi vena cava ascendens cum descendente congressa alveum suum in auriculam Cordis exonerare parata est, tuberculum quoddam a subjectâ pinguedine elatum & notatu valde dignum occurrit, cujus obtentu sanguis per venam descendentem delapsus in auriculam divertitur, qui alioquin

alioquin in venam aſcendentem decumbens ſanguinem per iſtam Cor verſùs aſſurgentem reprimeret valdè & retardaret: Et ſiquidem in erecto corporis ſitú atque figura majus inde periculum immineret, ideò vena cava in humano genere hoc majus & longè eminentius obtinuit, adeò ut ſi digitum alterutri trunco immiſeris, in alteram vix pertingas. Prout in *Tab.* 1. *Fig.*1. oſtenditur. In quâ

a *Venæ cavæ truncus recto ſitu deſcendens.*
b *Truncus venæ cavæ rectà aſcendens.*
c *Tuberculum rectè inter utramque intercedens.*
d *Auriculæ oſtium.*
e *Foramen ovale.*
f *Cor lævum in proprio ſitu recumbens.*
g *Vena Coronaria.*

In quadrupedibus autem veluti Ove, Cane, Equo, Bove, ubi curſus ſanguinis ab alterutro corporis extremo æquabilior & quaſi in plano eſt, & propter Cordis dependentis molem atque pondus uterque venæ cavæ truncus aliquantulum insuper versus Cor declives sunt, licèt tanto diverticulo opus non sit, omni tamen non prorsus destituitur. Prout in *Tab. 1. Fig. 2.* apparet. In quâ

a *Venæ cavæ ascendentis truncus.*
b *Venæ descendentis truncus.*
c *Tuberculum utramque venam distinguens.*
d *Auricula dextra.*
e *Foramen ovale.*
f *Cordis ostium.*
g *Vena Coronoria.*
h *Cor ipsum è vasis suis propendens, sed a pulmonibus in hoc situ suffultum.*

Porro ne sanguis hîc in confluvio æstum aut gurgitem faciat dum auricula contracta liberum ei ingressum non concedit, ideò vena cava hic loci in majoribus Animalibus tam Homine quàm Brutis tota circumcirca musculosa est, tum ut venæ truncum intra justos extensionis limites coerceat, tum etiam ut sanguinem quem sinu suo complectitur in auriculæ amplexum continuò

tinuò & validiùs urgeat. Quem quidem ut auricula arctiùs comprehendat & in Cordis ventriculum ulteriùs propellat, ideò fibræ ipſius internæ à radice auriculæ, ubi baſi Cordis conjungitur, rectà extrorſum verſus venam cavam porriguntur, ſanguinemque ab illa ſuggeſtum in ſe rapientes, quaſi digitis complectuntur & continuâ vice mox Cordi tradunt: Et profectò fibræ iſtæ in auriculis majoris Animalis veluti Equi & Bovis ſimiarum digitos mole ſuâ æquant, atque officium procul dubio idem exequuntur.

Et uti ante dextri ventriculi limen protuberantia iſtà in venæ cavæ aſcendentis cùm deſcendentis congreſſu memorata impedit quò minùs ſanguis ab illa defluens, alterum ab illâ aſcendentem decubitu ſuo deprimat; ita extra ſiniſtri ventriculi oſtium non minore artificio cautum eſt, ne ſanguis, qui cum impetu projicitur, in has aut illas partes iniquè diſtribuatur: cum enim oſtium illud Cordis ſurſum rectè aperiatur, ſi canalis qui primum ſanguinis impulſum excipit rectà, pariter ad capitis regionem duceret, fieri non posset quin rapidè nimis sanguinem in cerebrum suffunderet: Et propter vibrationis impetum ampliari sensim, adeoque partes inferioris corporis vitali suo genio & pabulo fraudare necesse haberet. Quod incommodum ut divinus Artifex prorsus evitaret, ideò in Animalibus quorum Corda fortiùs moventur, aortæ truncum (qui Cordi proximus est) adeò affabrè contexuit, ut sanguis in arterias axillares & cervicales non rectè, sed ambitu velut facto, incurrat; nam, in medio inter ventriculum & arterias istas spatio, aorta (vario tamen in diversis discrimine) plurimum inflectitur: quo quidem fit ut incurvatus iste angulus sanguinis ejecti impetum & primum ictum sustineat, & maximum ejus torrentem versus aortæ truncum descendentem dirigat, qui aliter superioribus arteriæ aortæ ramis nimius impenderetur, easque plus satis distenderet, & impetu suo caput citò pessundaret. Quæ omnia plenè exhibet *Tab.* 1. *fig.* 1. In quâ

a *Aortæ Humanæ radix.*
b *Truncus ejus descendens.*
c *Angulus ubi incurvatur.*
d *Arteria axillaris dextra.*
e *Arteria cervicalis dextra.*
f *Cervicalis sinistra.*
g *Axillaris sinistra.*
h *Duæ arteriæ coronariæ.*

In quâ Figurâ, aorta in [c] incurvata sanguinis à Corde projecti impetum & torrentem in truncum descendentem plurimùm reflectit; ne verò totus illac propellatur, arteriæ axillares & cervicales intermediæ eo modo constructæ sunt, ut præterfluentis sanguinis partem debitam necessariò excipiant; quippe latus arteriæ cujuslibet dextrum sinistro multò elatius est, unde liquoris in majore trunco transfusi pars aliqua intercipi oportet. Prout è *Tab. 1. fig. 2.* faciliùs concipietur. In quâ

a a a *Pars arteriæ cujusvis dextra & elatior quæ excipit.*
b *Angulus aortæ incurvatus.*
ccc *Latera arteriarum demissa quæ san-*

guinem præterfluentem intercipiunt, & ad quæ sanguis alliditur.

d *Canalis aortæ descendens.*

Si verò arteriæ istæ ex utroque latere æque rectè discederent, sanguis ferè totus illibatus earum ora præterlaberetur, uti *Tab.* 1. *Fig.* 3. ostendit; quam, licèt nunquam occurrat, apponere visum est, quò prioris ratio melius percipiatur.

Antequam verò Cordis Musculum de manu dimittamus, superest ut advertamus quòd in Fœtu adhuc in utero concluso ubi respiratio liberè fieri non potest, & proinde totus sanguis per pulmones pertransire necesse non habet, Providè cautum esse ut maxima pars ejus aliâ viâ transferatur; quippe in fœtu nodum excluso immediatè infra tuberculum illud nuper memoratum, foramen (Ovale dictum) in venam pulmonalem proximè adjunctam rectà ante sinistri ventriculi foras aperitur, per quod maxima pars sanguinis à venâ cavâ reducti immediate ante dextri

tri ventriculi limem in venam pneumonicam infusa cum reliquo sanguine a nutritione pulmonis redeunte simul in sinistrum ventriculum demittitur. Ne autem eâdem viâ redeat, membrana quædam undique foraminis ejus limbo nisi in parte infimâ attexitur, & tanquam velum infra ostii ejus infimum ambitum in venæ pulmonalis trunco laxè dependet, adeò ut sanguini a venâ cavâ affluenti facilè cedat, & foras quasi ultro pandat; ex adverso autem latere, si sanguis e venâ pulmonali in venam cavam remeare forte urgeatur, membrana ista primo sanguinis appulsu venæ pulmonalis lateri arctè applicatur, adeóque incursum ejus omnino repellit, non absimili prorsus modo ac ductus ureteris inter duplicem vesicæ tunicam perforatus, liberum & apertum urinæ influxum, refluxum verò omninò prohibet. Et siquidem sanguinis reliqui in ventriculum Cordis dextrum influentis, & ab illo in arteriam pulmonalem ejecti copiā omnem per pulmones adhuc pertransire nulla cogit necessitas, ideo ad partem ejus à pulmone divertendam canalis insuper arteriosus ex arteria pulmonali in aortam ipsam aperitur, unde sanguis e dextro ventriculo expulsus, magnâ ex parte per istum canalem in aortam trajicitur, atque unà cùm reliquo sanguine in totum corpus dispergitur; quum autem fœtus excluditur & respirare incipit, foramen & canalis iste, utpote quibus nihil ultra opus est, sensim & indies coalescunt, donec hoc tandem penitus occluditur, ille in ligamentum impervium paulatim degenerat. Cujus foraminis & membranæ figurâ, in *Tab.* 1. *Fig.* 3. constat. In quâ

aaaa *Limbus foraminis ovalis ad quem membrana ista attexitur.*

bb *Eadem membrana, infra foraminis orbitam dependens.*

c *Sanguis in venâ cavâ affluens.*

d *Ubi idem in venam pulmonalem influit.*

eee *Locus ubi membranam repellit, & per apertum quasi ostium incurrit.*

Cordis

Cordis descriptione jam traditâ, restat ut varia ejus discrimina, totum in diversi generis animalibus, avibus, piscibus, serpentibus, ranis, reliquisque minorum gentium animalculis, recenseam; eorumque rationes explicarem: verum cùm tantus sit eorum ambitus ut tædio majore quàm fructu enumeranda sint, sufficiet potiora eorum phænomena, & quæ ad Cordis in perfectioribus animalibus historiam elucidandam maximopere inserviunt, hîc loci commemorare. In Avibus itaque, veluti columbâ, gallinâ, pullo gallinaceo, ansere, aliisque, Cordis fabrica similibus omnino fibris, iisque pro proportione æquè magnis ac in grandioribus animalibus contexitur: licèt enim exterius septi transversi latus quod ventriculo dextro proximum est, lævem & æqualem faciem exhibet; at interior reliqui & extimi lateris pars tota fibrosa est, quin & valvulis semilunaribus quà in pulmonem & aortam utrique ventriculi patent, ambo donantur; in orificio autem sive ingressu in ventriculum dextrum valvulæ tricuspides omninò

omninò desunt, sed illarum vice rectè super ostium ventriculi quà auriculam respicit, carnea quædam valvula dependet, figuræ prorsus semilunaris, quæ quidem versus Cordis conum patula semper, sanguinem in omni contractione suffusum, pleno & aperto semper ore mox excipit, & quò magis repletur eò arctiùs ventriculi orificio incumbit, reliquique sanguinis ibidem effluxum prohibet: quanquam autem dexter ventriculus ex uno latere planus & lævis fuerit; sinister tamen in omni Volucrûm genere, quantum cunque parvi fuerint, ex omni parte fibrosus est, carneisque columnis extra reliquas fibras eminentibus, quin & valvulis mitralibus adeò affabrè constructis donatur, ut nihil sanguinis in pulmones remitti sinant. Jucundo enim spectaculo constat, si cono Cordis abscisso aqua è syphone in ventriculum injiciatur, membranas istas quasi sufflatas mox extumescere, & arctissimè sibi undique occurrentes, ostium illud Cordis penitus præcludere; adeò ut quâcunque vi atque impetu aqua in-

injecta fuerit, nihil præterfluere patiantur, sed per aortam tota exilit.

Et uti in minoribus hisce ad sanguinem reliquo corpori distribuendum, partis hujus conformationem æque ac in majoribus animalibus perfectam esse constat; ita dubitandum non est, in minimis omnium Naturæ productis nunquam omninò desiderari, sed Corde licèt biventre non gaudeant, simplici tamen non prorsus destitui; cujus tamen fabrica cùm oculis non adeò obvia fuerit, de illâ amplius non disseram.

CAP. II.

Cordis Motus.

IN priore Exercitatione, satis fusè egimus de Situ & Structurâ Cordis; ubi fabricam ejus perfectissimam, & supra omnem humani ingenii captum vario apparatu & arte conformatam esse constitit. Quis autem qualisque

lisque machinæ hujus admirandæ motus usúsque fuerit, jam proximè ostendendum est.

Itaque nobilis hæc Cordis compages, uti ex vario fibrarum ordine musculi nomen apud *Hippocratem* & antiquos medicos obtinuit; ita motum ejus pariter Muscularem esse, Insignissimus *Harveius* ex Vivorum dissectione rectè observavit. Nam cum *ex omni parte tendi, & secundum omnem fibrarum ductum constringi, erigi, minorari, & durescere in omni motu:* Illi videbatur, quidni actionem ejus cum reliquis musculis communem esse pronuntiaret? Id quod *Cap.* 2. de Motu Cordis conceptis ferè verbis videtur asserere, *Musculi enim,* inquit, *cum moventur & in actu sunt, vigorantur, tenduntur, ex mollibus duri fiunt, attolluntur, & incrassantur, & similiter Cor.* Postquam igitur *Harveius* Cordis motum, datâ operâ tam accuratè observavit, ipsumque cum maximo vigore atque impetu vibrari docuit, miretur fortè aliquis *Cl. Cartesium, Hogelandum,* aliosque celebres viros (sive quòd robustam Cordis fabricam,

fabricam, magnoſque ejus in omni Syſtole nixus, ſive celerem ſanguinis motum non ſatis attentè perpenderent) dubitâſſe, an Cor ſeipſum moveat, an potius à ſanguine moveatur. Quippe cum diverſos liquores chymicè præparatos, atque invicem commiſſos magnâ partium luctâ atque efferveſcentiâ ebullire, intumeſcere, &, niſi libero aeri exponantur, vaſa quibus continentur diffringere obſervarent, mutato vix nomine de ſanguine eandem fabulam narrârunt; quo autem faciliùs hæc ſententia fidem obtineat, fermentum quoddam nitroſulphureum in Cordis ventriculo prætertim ſiniſtro hoſpitari docuerunt; ſanguinem autem particulis heterogeneis, & valde fermentativis ſaturatum quamprimum hujuſmodi fomitem attigerit, illico rareſieri, inflari, ac turgeſcere; ut jam amplius ſpatium requirens ſuo potius quàm Cordis impetu in aortam erampere atque exilire neceſſe habeat.

Verum nec in ſanguine talem ebullitionem excitari, nec in Corde hujuſmodi fermentum adeſſe facile erit

oſtendere;

oſtendere; quanquam enim inter corpora quæ ex ſalibus contrariâ prorſus indole præditis conſtant, ubi commiſcentur, magna efferveſcentia atque lucta exoritur, multaque effluvia diſcedant; diſſimilis tamen omnino & magis benignæ naturæ ſanguinis liquor exiſtit, quàm ut in Corde aut vaſis ſuis tam æſtuosè & ſubitò efferveſcat; quippe novimus, quàm mitis ejus liquor, quàm benigno plerumque ſucco perfuſus, quàm lenis & placidus ejus in venis verſus Cor refluxus, atque ubi exitus ei aperitur & in vaſcula excipitur, quàm cito inſtar lacticinii concreſcit, & nullum ebullitionis aut luctæ indicium prodit.

In Corde autem hujuſmodi fermentum dari qui contendunt, unde illud continuò ſuppeditetur oſtendere debuiſſent. Si enim arterias coronarias ubique in Cor diſtributas in ventriculos ejus ſuccum quendam effundere dicant, advertere oportet membranam ventriculi interiorem adeò imperviam eſſe, ut nihil in cavitatem ejus penetrare patiatur; prout à tincturâ quâvis arteriis

arteriis iſtis vi injecti manifeſtò apparet. Si autem à particulis ſanguinis inter ſulcos & fiſſuras ventriculorum deliteſcentibus fermentum hoc provenire atque inſtaurari aſſerant, certum eſt ſcrobiculos & ſulcos iſtos ad accuratiorem ventriculi conſtrictionem factos eſſe, prout ſupra dictum; adeóque in omni Cordis Syſtole, connivere invicem & arctè cohæreſcere ut nulli prorſus appareant, nec quenquam reliquiis ſanguinis recondendis locum aut ſpatium relinquant.

Quinimo tantum abeſt, ut ebullitio ſanguinis in Corde, ſi quæ daretur, ad motum ejus quicquam conferret, ut illi prorſus obeſſe atque adverſari videatur; quippe Diaſtole non ab intumeſcentiâ ſanguinis ventriculorum parietes diſtendente, ſed partim ex pondere & quantitate ejuſdem ab auriculis injecti, nec non motu reſtitutionis ex parte provenit, ideóque Cordis diaſtole ſuam atque auricularum Syſtolem continua vice excipit. Ad Syſtolem verò Cordis perficiendam, ebullitionem non convenire, exinde conſtat; quià

quià cùm motus ejus expanſivus ſit, ad diducendos potius quàm contrahendos ejus parietes inſerviret.

Præterea quæ ebullitio tam regularis, aut æquis vicibus, aut quæ tali orgaſmo agitatur, ut poſſit tanto impetu liquorem e Corde in remotiſſimas corporis partes (& ultra longè ſi exitus daretur) ejaculari? Quinimo ſi ſanguini ſuus motus debeatur, quid opus Corde ita fibroſo & tot Nervis inſtructo? cum ſimplicioribus & planis intus ventriculis formari poſſet, ſi ſanguinem ſolum excipere, eundem autem non expellere, natum eſſet.

Deinde, ſi copiam ſanguinis qualibet diaſtole in ventriculos Cordis immiſſam perpendamus, nullus in Corde locus hujuſmodi ebullitioni aptus aut ſatis amplus reperietur. Neque enim ſanguis ex auriculis guttatim depluit, uti *Carteſio* aliiſque viſum eſt; ſed tanta ejus copia ab auriculis immittitur, ut tota Cordis capacitas penitus expleatur; quantumcunque autem in ſe qualibet diaſtole excipit ventriculus, proximà Syſtolo expellit totum, uti

infra

infrà clariùs patebit. Porrò, cur in ſiniſtro potiſſimum ventriculo fermentum hoſpitari & ebullitio longè ſpumòſior excitari dicatur; quare non in dextro ventriculo pariter cùm utriuſque eadem actio ſit, atque fibrarum craſſitie & robore ſolùm ob cauſam ſupra traditam diſcriminentur; denique quare non in auriculis præcipuè, quarum motus primarius eſt, & Cordi non tantum primos ad motum impetus ſed & fomitem continuò ſubminiſtrant, ſanè nec video, nec rationem reddi poſſe exiſtimo.

Prætereà, brevem nimis in Corde moram trahit ſanguis, quàm ut ab illo tantam ebullitionem concipiat, quippe nictu oculi citius per ventriculos ejus tranſit; ut pulvis pyrius accenſus non citius deflagret; cui etiam accedit quod ſanguis ex arteriâ emiſſus nullo modò rarefactus aut ſpumoſus ſi vaſculo propè admoto excipiatur, ſed venoſo conſiſtentiâ & pondere, & per omnia præter colorem non abſimilis.

Denique motum Cordis à ſanguinis ebullitione nullo modo dependere, hoc ipſum arguit, quòd Cor viventi animali detractum & omni ſanguine depletum vel in fruſtula diviſum, nondum tamen à motu ceſſat; quin & animalium juniorum Corda longo tempore poſtquam e pectore exſciſſa ſunt ſi leviter acicula irritentur, ſtatim pulſus ſuos repetere, eoſque diu continuare nimis notum eſt; quin &, anguillarum Corda ſimiliter acu ſtimulata pluribus horis poſtquam exempta ſunt, iterum pulſare animadvertuntur; utpote quorum ſpiritus in materiâ magis viſcosâ irretiti atque implicati tam citò avolare non poſſunt.

Verum ut experimento mihi conſtaret utrum ſanguinis ebullitio ulla omninò aliquid ad ſanguinis motum conferret, experiri ſubiit an detracto ſanguine, aliiſque liquoribus, qui minus rarefieri aut ebullire apti ſunt, pari copiâ per venam ſuppeditatis, Cor interea motum ſuum nihilominus continuaret. Itaque ſanguinem e venâ jugulari Canis ferè ad totius maſſæ dimidium

midium detraxi, injectâ per vices in venam cruralem pari cerevisiæ cum pauco vino mixtæ quantitate; & hoc alternis vicibus toties repetii, donec loco sanguinis pallidior solùm tinctura loturæ carnium aut clareto plurimâ aquâ diluto similis e vena proflueret, Corde interim de pulsu pristino paululum tantum remittente, adeò ut totum ferè sanguinem cum cerevisiâ, priusquam vitam cum morte commutaret.

At siquidem facilius est experimentum quàm fidem facere, historiam hanc unicam quam à medico fide dignissimo accepi astruere libet; Adolescenti 16 annos nato cum magna sanguinis copia (quâ de causâ non refert) per biduum continuò erumperet, neque medicamentis aut arte ullâ cohiberi potuit; jusculis eum reficere & recreare amici & astantes curarunt; cumque ea valdè avidè expeteret atque assumeret, fluxus subinde concitatior quoque factus est, & tandem res eò devenit, ut massâ sanguinis ferè totâ emissâ, quicquid jam efflueret, dilutum

& pallidum, ſanguinis neque naturam neque ſpeciem præ ſe ferret, ipſi juſculo quòd toties hauſerat quàm ſanguini ſimilius: Atque eâdem formâ per diem unum aut alterum duravit hic aqueus fluxus, conſtante interim Cordi motu ſuo, donec fluxu demum conſopito Juvenis paulatim integræ ſaluti reſtitutus eſt, & exinde in virum robuſtum & quadratum accrevit.

At priuſquam ultima huic argumento janua claudatur, advertere oportet duo *Harvæi* obſervata poſſe hîc & ſolere objici, Sanguinem ante formatum Cor, & poſt idem emortuum moveri, unde facilè arguitur, motum ipſius non poſſe à Corde dependere; verum hiſce in promptu erit referre.

1. Quanquam agnoſcendum eſſe, vitalem illam guttulam in cicatriculâ hoſpitantem, calore incubatûs excitatam ſe expandere: Verùm id dicendum erit membranæ eam continentis beneficio deberi; quæ intumeſcentem illam guttulam reprimit ſimul ac coercet. Cùm enim liquor ille ſeminalis intra cicatriculam contentus à calore

externo

externo diu fovetur, ſpiritus in eo latentes ſeſe quaquaverſum explicant; atque partim in membranam continentem impingunt, atque inviſcantur; partim, pro explicando ſibi ſpatio, membranam illam diſtendunt; quæ cum locum ſatis amplum concedere non poteſt, quò ſe à tenſione iſtâ liberet, ſeipſam contrahit & conſtringit: Quo fit, ut liquor intro compulſus, exitum quærens, viam ſibi faciat atque canalem procudat; Atque ad hunc modum ipſa vitæ noſtræ primordia & corporis ſtamina ortum ducere videntur. Cúmque omnis inſuper motus muſcularis in contractione poſitus ſit, non tam ab ebullitione illâ ſive partium ſpirituoſarum in iſtâ guttulâ expanſione, ſed à veſiculæ iſtius Syſtole motus hujus principium ordiri putandum eſt. Quippe quæ veſicula ipſo ſanguine prior erat; & poſtea, ubi in ſanguinem mutatur iſte liquor, & actuatur, ſimul ea motus ſuos exerit: Veſicula enim pulſans ab ipſo principio, liquoris in ſanguinem mutati non tantum conceptaculum, ſed & machina motiva eſt; qui hujus nixu & beneficio extra cicatriculæ ambitum ſe profert; & arterias, pro dilatando ſibi ſpatio, venaſque pro reportando pabulo, procudit.

2. Quod ad undulationem iſtam ſanguinis in venâ cavâ poſt emortuam auriculam; arbitror illam nullo ſanguinis inteſtino motu, ſed vaſorum, à ſpiritibus per nervos ubique diſtractis, corrugatione contingere: Non aliter quàm ſpiritus in muſculis ubique oberrantes, motum illum tremulum poſt mortem diu protrahunt. Atque hactenus de fermento hoc quod in Cordis ventriculo, potiſſimum ſiniſtro, imaginantur aliqui, quòd ſanguinem affluentem ebullire faciat. Sequitur aliorum quæ ad hanc proximè accedit ſententia perpendenda, qui Ignem quaſi veſtalem quendam in Corde conſtituunt, qui immiſſum ſanguinem ſic accendat, ut in arterias ſtatim exilire debeat. Parum abeſt enim, quin ſanguinem per vices influum à Cordis igne non aliter accendi & ſtatim prorumpere opinentur, quàm ſi ventriculi ejus

ejus candentes prorſus eſſent & igniti, & ſanguis velut pulvis pyrius à primo ignis contactu in flammas accendi aptus; quod quantum à ratione abſit, mox expendemus.

Præterquam enim quod arduum eſt concipere, Sanguinem eouſque rarefieri, ut, in Cordis ventriculos unaquaque diaſtole dilapſus, tam ſubitò ſolutis omnibus particulis, velut pulvis pyrius accenſus, in vaſa exiliat; (quòd nulli liquori conceſſum eſt:) hoc accedit, quòd Cordis pulſus multò celerior eſt ſtatim à paſtu & pleniore potu, dum chylus adhuc crudus, & proinde rarefieri minùs aptus, cum reliquo ſanguine Cordis ventriculos pertranſit.

Tantum ètiam abeſt ut credam ſanguinis motum à ſua in Corde accenſione ulla dependere, ut nec Cordi calorem ſuum jure aliquo debere videatur: Quanquam enim Cor caloris fons, (unde calor in totum corpus emanat,) rectè ſatis agnoſcendus ſit: non ideo tamen in illo ſolo calorem iſtum excitari, aut ſanguinem ab illo tantum incaleſcere, veriùs forte dicetur, quàm aquas thermarum à balneo ubi erumpunt, & non ab inteſtino partium æſtu, quas in viſceribus terræ in tranſitu lambunt alluuntque, calorem ſuum concipere; nihil enim in Corde eſt quod tanto calori producendo ſufficiat: Conſtat utique Cor ex ſe non calere; ſed, quemadmodum ſanguine per arterias in ſe depoſito omninò alitur, ita quoque foveri deſiderat. *Tam enim intenſum calorem*, (uti *Velthuſius* dicit,) *in Corde reperiri, qui vi ſuâ & calore proprio in affuſo ſanguine tam ſubitam & fortem ebullitionem excitet, non eſt veriſimile; neque ea Cordis firma & conſtans partium conſtitutio, ut tot annos ferendo ſit tam acrem calorem: Non experimur etiam digitis in Cor animalis diſſecti & adhuc viventis immiſſis tam intenſum calorem; nec etiam pinguedo qua circa Cor eſt, in tantam duritiem poſſet concreſcere.*

Cordi itaque non magis tribuendum eſt quàm vaſis & viſceribus omnibus, iiſque præcipuè quæ in pectoris & abdominis clauſtro concluſa ſunt, quòd ſanguis

ſanguis tantùm incaleſcat: Quippe, uti ſanguinem in extremis partibus, ubi externo aëri ferè nudus & expoſitus fertur, refrigerari accidit; ita pariter certum eſt, ubi in pectoris & abdominis cavitatem recipitur, in locis adeò concluſis protinus incaleſcere; atque hinc eſt quòd homines obeſi & pingui aquiliculo donati, quorum vaſa ſanguifera profunde magis & quaſi in carne ſepultæ latent, præ macilentis frigoris patientes ſint; quanquam Corda hujuſmodi præpinguium hominum non adeò vegeta & robuſta, ac illorum qui magis ſunt graciles & ſtrigoſi.

Sanguini itaque in totum debemus quòd Cor ipſum caleat, quòd corpora noſtra calore ſuo actuet & vivificet. Concedimus interim, licèt major illi calor quàm cæteris Muſculis à naturâ datus non ſit, in quantum tamen continuo motu & in loco adeò concluſo indeſinenter exercetur, ita præ cæteris corporis membris calore magis conſtante & vegeto donari; unde forſan fit, ut ſanguinem in ſe receptum

ali-

aliquantulum à contactu suo magis adhuc foveat, calfaciatque.

Quibus rite perpensis clarum fore arbitror, Nec motum Cordis à sanguinis ebullitione, nec sanguinis calorem à Cordis foco ullo, omninò dependere.

Sed quandoquidem certum est nos igne plusquam poetico & metaphorico incalescere, operæ pretium foret proximo in loco pleniùs explicare, quomodo sanguis ipse æstum in se concipit, & calorem toti corpori subministrat. Verum cum præter suscepti operis institutum fuerit, atque insuper *Cl. Willisium* in tractatu *De Anima, de Sanguinis quoque incalescentiâ*, aliquid meditari compererim, rei medicæ adeò injurius esse nollem, ut ei ansam hujusmodi atque occasionem præripiam.

Cùm ex præmissis satis constiterit motum Cordis non dependere à sanguine, proximè dicendum restat, quibus instrumentis & machinis perficiatur.

Ea autem sunt vel *proxima* quæ motum ejus immediatè perficiunt, vel *remota* quæ ipsum adjuvant.

Quæ

Quæ motum ejus perficiunt ab ipſo Corde proximè petenda ſunt ; quippe in illo ipſo partes motui ejus ciendo pares atque accommodas adeſſe omnes exinde conſtat, quòd nullus Muſculus iis inſtructior ſit : Nervis enim copioſe ei inſertis & per totam ejus ſuperficiem denſe explicatis ipſum inſpirari, fibris quoque omne genus, quaquaverſum intertextis & undique complicatis firmari, atque tendinoſo margine baſin ejus cingi, clarum & obvium eſt ; nec in animalis vel minimi Corde cujus fabrica oculi aciem non eludit, iſtorum quicquam omninò deeſſe aut deſiderari videtur.

Qui quidem machinæ apparatus certò demonſtrat ipſum prorſus Muſculum eſſe, motumque cum reliquis Muſculis omnino ſimilem ſortiri. Quo autem Cordis motum clarius explicemus, à ſimpliciore Muſculi recti motu tanquam reliquorum omnium norma ordiemur.

Itaque Muſculus rectus uti e duplici ventre cum appenſo utrique tendine conſtituitur, ita motus ejus duplex quo-

quoque eſt; quippe cum utriuſque ventris fibræ in oppoſitos tendines atque fines terminentur, ut ut membra, quibus per tendines conjuncti ſint, unâ eâdemque operâ propius invicem adduci videantur, non uno tamen utriuſque motu hoc perficitur: Quïppe cùm à contrariis metis licèt ad idem centrum ſe contrahant, inde tamen fit ut oppoſita oſſa aut membra cui annectuntur, utriuſque adverſæ contractioni ſimul obediant, proindeque arctius ſibi mutuò accedere debeant; adeò ut motus omnis muſcularis non aliter perfici videatur, quàm ubi duo homines acceptâ invicem dextrâ in mutuum amplexum ſeſe arctè & propiùs attrahunt. Et cùm muſculi cujuſque neque unicus venter ſit, neque fibræ unâ & continuâ ſerie ab uno tendine in alium pergant, verùm e duplici muſculo & fibris in oppoſitum reſpicientibus conſtet, dubitari obiter poſſet, Annon adverſæ eorum contractioni cujuſque muſculi motus quàm ſimplici ejuſdem inflationi, meliore jure debeatur: Quin &, ſi muſculi motus inflando

flando fieret, quid impedit quo minus cujusvis musculi fibræ (quæ rectæ sunt & per tenuissimas solummodò membranarum fibrillas inter se cohærentes) à se mutuò diffletur atque divellantur, eousque saltem, ut fibrarum distractio dolorem inferat? Cui etiam accedit, quòd Musculus ab hujusmodi inflatione extrorsum distentus vel maximè apparere deberet; verùm ex adverso constat, Musculum in omni motu admodum arctè & in sese introrsum constringi, minorari & durescere, adeóque modo inflationi prorsus contrario moveri.

Præterea si ab explosione diversæ indolis spirituum sibi mutuò in Musculo concurrentium, sive aëris cum spiritu animali concursu fiat, cum utrique continuò influant, quidni perpetuo motu partes omnes exerceantur? Et quid Animæ in nos imperium valet si solum instinctum motûs præstaret & fomiti igniario tantùm accendendo inserviret, turbinemque excitaret, quem pro libitu suo cohibere rursus non poterit? Certè vix credibile est res adcò diversas

diversas saltem in corpore benè constituto existere, aut invicem committi, aut quas anima suo nutu non poterit coercere.

Non enim tam sclopeta in nobis explodere existimanda est anima, quàm ensem quasi vibrare, & hùc illùc variè contorquere, adigere, retrahere, quem & pro placito suo recondere item potest: Cum enim motus nostros regere possimus, & quocunque placet gradu moderari, cumque Musculi in id facti videantur, ut fibrarum ab oppositis trahentium nixu atque ope motus suos perficiant, non video quare à principio tam violento ejus modum atque causam petere debeamus. Verùm hæc obiter dicta sunto.

Quoniam verò Cordis Structuram reliquis in corpore Musculis ratione, utut non figurâ, analogam esse & conformem, prius ostensum est; restat ut motum quoque ejus consimilem esse & secundum omnium fibrarum ductum peragi; evincam.

Cum itaque motus cujusque Musculi biventris ubique fiat à fibris carneis

neis oppositos tendines in sese ad medium contrahentibus & cùm ad aliorum normam Cor duplici quoque fibrarum in diversa respicientium ordine potissimùm constet; quarum quæ exteriores sunt à lævâ dextram versus porrectæ undique parenchyma ejus cingunt complicantque, quæ verò profundiùs latent, ductu planè contrario ferantur; Fieri non potest, ubi fibræ illæ simul contrahuntur, quatenus parietes Cordis undique adducunt, quin spatia ventriculorum intus coarctari multum & constringi necesse sit, adeò ut non ineptè linteo utrinque ad exprimendam aquam contorto, aut crumenæ à duplici filo in diversa trahente occlusæ comparari possit; quippe fibræ in constrigendo Corde idem omnino præstant, motumque primariò efficiunt

Quin &, cùm fibræ Cordis aliquot rectæ, aliæ omnes circa conum & universum ejus ambitum contortæ obliquo & opposito ductu spiralibus velut lineis in basin terminentur, non solùm fit, ut quoties fibræ hæ utrinque contrahuntur,

trahuntur, ventriculorum ſinus intus comprimant & anguſtent; ſed ut conum baſi propiùs adducant: Fibræ enim cùm quolibet nixu ſuo baſin Cordis deducere conentur, illa autem à fulcro tam inſtabili & firmo dependeat, ut attractioni earum neutiquam cedere poſſit, fieri nequit, quin mobile ad quieſcens accedat, unde tum Cordis compages conſtrictior fit, tum conus ejus ad baſin propiùs accedat; quòd non aliter omninò neque diſſimili plane modo fit, quàm in communi luſu quis de fune pendens adductis fortiter brachiis ſeſe erigit & in altum evehit.

Quin & (ut obitèr hoc moneam) cum omnis motus contractione perficiatur, & Cordis fibræ ad conſtrictionem ſolùm factæ ſint, apparet quoque Cordis motum totum in Syſtole poſitum eſſe; cumque fibræ ultra tonum ſuum in omni conſtrictione ejus tendantur, idcirco ubi nixus iſte abſolvitur, motu quaſi reſtitutionis Cor iterum relaxatur & ſanguine à venis influente rurſus diſtenditur; à nullo enim

enim cordis motu, niſi tenſionem ſuam remittente, & ab irruente ſanguine diaſtole ejus libratis adeo vicibus ſuccedit.

Ex perſpecto autem cordis motu, auricularum ille faciliùs cognoſci poteſt, ſiquidem fibræ utrique auricularum communes ab unâ in alteram porrectæ efficiunt forſan ut ſimul motus ineant; at cum fibræ carneæ aliæ in tendinem cordis communem protenſæ ſint, aliæ verò in circulum nervoſum venæ cavæ proximum inſerantur, quatenus ab oppoſitis partibus ſeſe invicem trahunt, ſpatium intùs coarctant valdè, adeóque ſanguinem pariter contentum in cordis ſinus depellunt.

Motum autem cordis à fibris ſuis perfici non alio opus eſt indicio, aut argumento, quàm quòd ventriculi ejus pro vario uſu atque motûs exigentiâ, tanto inter ſe diſcrimine, fibras quòd ſpectat, conſtruantur: Quippe uti non æquis viribus ad breve atque ad longum iter conficiendum opus eſt, ita prout ſanguis ad minorem diſtantiam, vel procul projici & propelli debeat, ventriculi pariter craſſioribus vel tenuioribus fibris donantur; ideóque ſiniſter ventriculus, ut labore & penſo, ita & fibrarum robore dextrum multùm antecellit. Sed licèt dextri ventriculi fibræ multò magis graciles & tenues ſunt, nullo tamen eorum ordine deſtituitur; neque inde putandum eſt, non omninò, quià non æquè fortiter pulſare; multò minus propter ſiniſtri tantum viciniam moveri; quippe licèt dexter ſiniſtro accreſcat & totus ad illum in omni Syſtole contrahatur, adeóque dimidiatum tantum circulum motu ſuo deſcribat; Non tamen alterius adminiculo, ſed propriis fibris hoc perficit: Quippe tantum abeſt ut ſiniſter ventriculus ad dextri motum conferat, ut ſepti tranſverſi latus quod cavitati dextri ventriculi proximum eſt, ferè ſemper (præſertim in minoribus animalibus) planum & in minoribus læve ſit; idem tamen ſeptum quà ſiniſtri ventriculi cavitatem reſpicit totum fibroſum & altis ſcrobiculis excavatum eſt; indicio ſatis manifeſto,

ad

ad ſiniſtri tantùm ventriculi conſtrictonem conferre, ut ſuperius monſtravi.

Atque ex hâc etiam interioris ſepti fibroſâ texturâ, abunde conſtat, ad ventriculi ſiniſtri motum multum conducere; neque vero aliter fieri potuit, cùm ſeptum hoc ſiniſtri ventriculi pars ſit, fibræque toti ejus circulo undiquaque continuæ & communes fuerint.

Et ſiquidem ſulcos iſtos & interſtitia in ſepto excavata ad arctiorem ventriculi conſtrictionem inſervire oſtenſum ſit, patet inde, quàm ineptè ad ſanguinis ab uno ventriculo in alium tranſitum iſta inſervire dicantur; cùm revera nullibi pervia fuerint, ſed huic ſolùm muneri deſtinata.

Vidimus huc uſque quam robuſta cordis fabrica, quàm fibris undique firmata fuerit. Proximè incumbit, ut quali vi motus ſuos exerat, videamus: Et revera nemo ejus fabricam ſatis mirari aut attentè ſatis perpendere videtur, qui illud non cùm maximo vigore atque impetu vibrari concedit; Siquidem non ſolum à ſanguine tantâ vi projecto, sed & ipso corde manu tractato, vel abscisso ejus cono & digito immisso, manifestò apparet, maximo illud robore & nixu moveri atque constringi; adeò ut, ex Systole ejus non solum ventriculos angustari, sanguinemque ob spatii defectum exprimi; sed cor cùm impetu & vigore vibrari, atque sanguinem vegeto & valido parietum subsultu & concussione excuti atque expelli constet; quin, ut id saltem hoc in loco commemorem, quod cor a spasmo aliquando correptum tanto impetu concitari, ut costas ipsas perfregisse, omnemque ejus Systolen à cubiculo in plateâ procul exauditam fuisse; Item, ab assiduo thoracis à cordis motu & diverberatione, indumenta veluti flabello motitata; verùm etiam thoracem atque sternum ab illo motu e sede naturali dejecta atque extuberare coacta à *Fernelio*, *Foresto*, & *C. Pisone* scriptum est; Etiam hoc accedit, quòd in equis à longo cursu redeuntibus, singulos cordis pulsus è longinquo exaudiri solenne sit; quippe sanguis tanta vi & impetu tunc

temporis

temporis per vaſa trajicitur, ut ſingulos pulſus longe procul enumerare atque æquè certò edicere poſſis ac ſi digitum ſalienti arteriæ juxta admoveris; quin & ſæpe obſervavi in viris non admodum robuſtis dum in lecto decumberent, cortinas ad omnem cordis motum ſuccuti, & accuratum pulſus rythmum ſervare.

Quæ cùm ita ſe habeant, opportunum erit in quirere quomodo cordi inſtinctus ſui motûs advenit & unde vis illa ſive robur data ſunt, ut per totum vitæ curriculum motum ſuum indeſinenter præſtare valeat.

Atque hîc de modi ratione quâ cordis motus perficitur dicendum eſſet; ſed cum nimis arduum ſit de eâ quicquam rite concipere, atque dei ſolius, qui ſecreta ejus rimatur, motum quoque ejus cognoſcere prærogativa ſit, in eo ulterius perſcrutando operam non perdam.

Sufficiet itaque hoc in loco advertere tantùm, cordi vim illam & vigorem quo ſanguinem in ſinus ſuos continuo illabentem pari & conſtanti paſſu expellit, à nullo intus contento excitari, ſed ſupernè & velut cœlitus à capite in illud deſcendere. Si quidem enim nobiliſſimi atque ſummè neceſſarii uſus fuerit, ideò pro motu ejus præſtando tam ſedula & ſolicita eſt natura, ut, præter inſignes nervorum propagines ubique in illud denſè diſtributas, pro continuo etiam ſpirituum animalium influxu, cerebellum in ſuper, quaſi perenne eorum promptuarium, ei accommodaverit: A cujus benignâ & conſtante influentiâ adeò dependet, ut, ſi ſpirituum influxus vel minimo temporis momento impediatur, motus ejus illico deficiat. Nervis enim octavi paris, in cervice arctè ligatis, aut penitus abſciſſis (quod animali perinde eſt,) mirum dictu quanta ſubito mutatio! Cor quod moderatè antea & æqualiter motus ſuos obiit, ſtatim ab injectâ ligaturâ palpitare & contremiſcere incipit, atque ita diem unum & alterum miſerum animal Corde tremulo & pectore admodum ſuſpirioſo languidam vitam protrahit, & brevi tandem exſpirat.

Quantas

Quantas autem cordis angustias ex præcisione aut ligaturâ istâ mox patitur animal, satis constat ex immediate consequenti corporis luctâ & contentione, quæ tanta & tam vehemens est, ut, nisi firmis vinculis cohibeatur animal, difficile sit ipsum in eodem loco aut corporis situ continere.

Cur autem ab hujusmodi ligatura animal non statim extinguitur, ratio hæc est; nempe, quia præter suppetias à nervo recurrente allatas, etiam infra ligaturam illam diversæ propagines nervosæ à plexu intercostali sub ingressu pectoris in nervos octavi paris, priusquam surculos suos cordi dimittunt, proximè implantantur; quarum ope pro sustentando debili motu, quousque sanguis fluxilis & tenuis est, spiritus ut ut in minore copiâ suppeditantur: Verùm cùm propter cordis languorem & fatiscentiam liquor sanguinis stagnare & grumescere incipit, subsidiariæ istæ spirituum copiæ ad pulsum continuandum diu pares non sunt, ut necesse sit vitam ob defectum istius motûs tandem extingui. Hæc ita esse tam certum est, ut nullus dubitem, si nervi isti paulo infra communicationem illam cum nervis intercostalibus ligarentur, quin animal statim syncope & cor aspheuxiâ corriperetur : cujus quidem experimentum commode fieri non potest, quia nervorum communicatio illa sub ipsâ claviculâ sit & juxta vasa sanguinis majora, ut nec oculis discerni possit, nec digitis explorari.

Cùm igitur motum cordis ab influxu in nervos, ei copiose insertos, solùm perfici ostensum sit; proximè dicendum foret, quot modis & quibus de causis motus cordis alteretur. Quoniam verò pro magno partium consensu & sympraxi, cordis motus plurimùm intenditur & remittitur, ideò ad rem fore arbitror, si prius ostendero quænam partes illæ sunt, & quale præstant subsidium.

Et quandoquidem cordis proxima est cum pectore & pulmonibus affinitas, eâque necessitudine naturæ mutua ipsorum opera conjuncta sint, ut neutrum sine altero commodè moveri possit,

poſſit, vel diu ſupereſſe; Cumque pulmones interim nullo ſuo niſu, ſed ſecundariâ tantum operâ hoc perficiant; diaphragmati potius & muſculis intercoſtalibus acceptum referri debet, quòd illi liberum aëri commeatum in ſanguinem concedant.

Quicquid igitur aut ductum pulmonum intus obſtruit, aut ipſos extra nimis comprimit, vel diaphragma & muſculos intercoſtales libere contrahi & relaxari omninò prohibet, aut valdè impedit, cordis quoque motum ſimili modo afficiet. Siquidem partium iſtarum affectus, quales ſunt angina, pulmonis vomica, tuberculum intus enatum, hydrops pectoris, empyema, paroxyſmi ſpaſmodici, riſus immodicus & continuus, quatenus vel canalem aſperæ arteriæ vel vaſa pulmonum ſanguifera occludendo, vel onere & mole ſua cor & pulmones opprimendo, vel liberam pectoris ad excipiendum aërem expanſionem cohibendo impediunt, cordis motum variis modis alterant.

Longum autem omninò esset explicare, quomodo singularis hic affectus accidat, aut in cor secundariò redundat: In quantum tamen ex motu pectoris depravato, atque diaphragmatis præcipuè, sanguinis & cordis motus sæpe & graviter pervertitur; operæ pretium erit ostendere quinam potissimum istius partis affectus fuerint & quomodo labem suam cordi affigunt:

Respiratio autem a duobus præcipue impeditur, à risu nempe & singultu.

1. In risu enim diaphragma à musculis infimi ventris, viscera sua in id impellentibus, in pectoris cavitatem sursum usque adigi, & tremulo gradu veluti ad aërem per partes excutiendum, pro formando intra laryngem risu, relaxari videtur; quo fit, ut, cùm pericardio ipsi accrescat, cor ipsum ejusque basin ad sua ipsius vasa, tam quà sanguinem excipere quàm quà ejicere solet, arctè adigat, impingatque; adeò ut, occlusis quasi cordis foribus, circuitus sanguinis pro tempore intermittatur; quòd ex tumore venarum

venarum omnium in collo, facie, & fronte planè patet. Quamprimum autem riſus deſinit, & diaphragma ad debitum ſitum rediens cor iterum deducit, ut ſyſtolen ſuam & diaſtolem repetere valeat, ſanguini circuitus ſuus redit & venarum tumor iſte, qui priùs in riſu apparuit, vaſis iterum depletis omninò evaneſcit: Rem ita ſe habere conſtat, quoniam in longiore riſu præſertim in parvulis (quem nutrices ſæpe juſtò diutius provocant) non ſolum facies à nimiâ ſanguinis copiâ, propter impeditum ejus recurſum, liveſcit; ſed & mors ipſa importunas iſtas blandirias aliquando excipit: prout hiſtoriæ paſſim teſtantur.

2. In ſingultu, (qui quidem, licèt noxam atque occaſionem ventriculo plerunque debeat, diaphragmatis tamen propriè affectus eſt; & ideò pro libitu noſtro ſpaſmum ejus imitari, aut ſpiritus retentione pro tempore cohibere poſſumus:) Cum diaphragmatis circulo nervoſo pericardium undique accreſcat, fieri non poteſt, quin convulſione ſuâ hoc in conſenſum trahat,

adeóque

adeóque motum cordis interturbet. Et licèt brevis hujusmodi affectio magnas cordi molestias non faciat, in febribus tamen malignis, ubi diutius & per plures forsan horas & dies perseverat, cordis musculum adeò lacessit & defatigat, ut, post hujusmodi irritationis tædium, nihil magis quàm de cordis dolore & anxietate conquerantur; quin & pulsus plurimum intermittit: fieri enim aliter non potest quin à partium istarum adhæsione, & alterius spasmo, mutua ipsorum opera impediatur; neque enim diaphragma toties & tam violentâ Systole corripi potest, quin cor simul secum trahat, adeóque antipraxi suâ motum ejus durante paroxysmo multum pervertat.

Uti verò sanguinis & cordis motus à cerebro totus dependet, prout supra patuit; ita ne tanta beneficia alterutri gratis data videantur, advertere obiter non alienum erit; quòd, quamquam cerebrum ipsum in partes omnes inferioris corporis velut rex in suos subditos dominatur, & pro nutu & im-

perio

perio ſuo omnia regit & gubernat; non tamen ita ſupra eas ſitum eſt, ut absque illarum ope & miniſterio, ipſum ſupereſſe poſſit, aut quicquam valeat. Quippe ſpiritus animales, vitaque ipſa, à continuo ſanguinis in cerebrum appulſu adeò ex adverſo dependent, ut omnimodæ ejus ſuppreſſioni mox ſyncope & lypothymia ſuccedant; & quidem ſi diutius affectus iſti perſeverent, animalis vita prorſus evaneſcit. Cujus ratio alia non eſt, quàm quòd, ut ſpiritus animales conſtante ſanguinis influxu pro motu cordis & pectoris continuando è cerebro per nervos deſtillant, ita conſtante ſanguinis penu in cerebrum depoſito reſarciri debeant; ideóque ſi debito & perpetuo ejus vectigali defraudetur, cerebrum quaſi ecclipſin patitur, & animal ſenſu motuque privatum ſuo pondere concidit; uti in ſyncope affectis videre eſt.

A mutuâ verò cordis cùm cerebro, & ſibi invicem accommodatà operâ, tota ſenſûs motûſque ratio dependet: Dum ſcilicet a cordis motu, ſanguis continuò in cerebrum & cerebellum,

pro

pro extillandis ſpiritibus tranſmittitur; & ſpiritus, vice versâ, per nervos in cor influentes, motum ejus perennem & conſtantem viciſſim conſervant: Adeò ut cordi debeatur, quod ſpiritus in cerebro nunquam deficiant; quin & cerebrum hoc agit ut cordis motus nunquam ceſſet.

Uti autem hæc ambo mutuum ſibi ſubſidium & miniſterium præſtant ut neutrum ſine altero ſupereſſe queat; ita non minore officii neceſſitudine a ventriculo utrumque dependet: Quippe vitæ noſtræ ratio in his potiſſimum conſiſtit, ut cibus in ventriculo in chylum præparetur, ut chylus in corde & vaſis appenſis aſſimiletur in ſanguinem, & denique ut purior & ſubtiliſſima pars ſanguinis in cerebrum extilletur; cúmque a ſanguine noſtro plurima ſemper effluvia ſecedant, atque conſtans maſſæ ſanguinis & ſpirituum animalium diſpendium fiat, neceſſe eſt ut continuo & recenti pabulo vitalis calor refocilletur; atque idcirco a naturâ cautum eſt, ut pari proventu chylus in ventriculo conficiatur, qui liquorem ſanguinis

ſanguinis pereuntem æquè certò reſarciat. Verùm neque hoc ſolùm ſufficit, ut chylus uſque in debitâ copiâ & menſurâ ſanguini ſuppeditetur; ſed, ut is rectè prius conficiatur, ſumme neceſſarium eſt: Quippe ſi, ex malâ concoctione, chylus, partibus ſpirituoſis & activis nondum fermentatione diſſolutis & liberatis, crudus & impuratus ſanguini miſceatur; nunquam poſtea volatilis aut ſpirituoſus fiet: (pari modo ac, ſi cereviſiam novellam, vel vinum infermentatum deſtillationi tradas; non niſi crudum & auſterum minimèque ſpirituoſum liquorem extrahes:) Et proinde cùm neque laudabili ſanguini generando, nec ſpiritibus rite extillandis aptus fuerit, œconomia animalis defectus hoſce ventriculi ſecundario luit; verum ita ut in ipſum cor proximè redundent. Adeóque ubi ſtomachus cibum rejicit, aut acceptum non rectè concoquit; pulſus ſtatim a naturali tenore valdè deficit: Prout in cachecticis, & crapulâ frequente debilitatis, cuilibet obſervare eſt.

Atque

Atque hæc sunt instrumenta, & causæ proxime-remotæ, quibus motum cordis sustentari aut alterari contingit. Restant aliæ propiores, & velut intestinæ causæ, quæ motum ejus alterant, & labefactant: Idque quatuor præsertim modis accidit, 1. Cordis ipsius; 2. Vasorum continentium; 3. Sanguinis; 4. Spirituum influentium culpâ.

I. Et primò quidem de iis quæ ab ipso corde, ejusve Pericardio proveniunt, dicendum.

1. Cùm enim non solum ad sanguinis motum expediendum requiritur, ut uterque cordis ventriculus tum sinûs cavitate, tum pulsuum numero invicem respondeant; sed & ad continuandum sanguinis circuitum eumque successive usque & in justâ copiâ per vasa rite propellendum, ex rei naturâ necessarium fuerit ut pari robore ad sustentandum hoc munus latera cordis firmentur: Exinde sequitur, ubi quicquam horum desideratur, sanguinis quoque motum inde multùm alterari. Quandoquidem verò iste error naturæ,

quo

quo ventriculorum cordis exacta habitudo non ſit, ratò aut nunquam occurat; non eſt quòd de eo verba faciamus. Sed cùm parenchyma cordis variis morbis & injuriis obnoxïum fuerit, motum ejus multum quoque alterari neceſſe eſt. Si enim cordis parenchyma, aut nimia pinguedine oneretur, aut inflammatione, ulcere, abſceſſu, aut vulnere laboret, adeo ut ſine magnâ moleſtiâ atque difficultate aut abſque gravi offensâ ſeſe vibrare & contrahere non poſſit; motum ſuum valdè remittit, & ſanguinem quantum poteſt, licèt non quanto opus eſt reliquo corpori diſtribuit; unde ſanguinis quoque motus debilis admodum & languidus exiſtit.

2. Uti autem cor proprio velut affectu intus aliquando laborat; ita quandoque, ſive ſuo, ſive capſulæ ſuæ vitio, ab extra opprimitur. Quemadmodum enim aqua iſta pericardio incluſa ad lubricandam cordis ſuperficiem & facilitandum motum valdè inſervit; ita nonnunquam evenit, ut nimiâ copiâ cor opprimat & inundet,

quum enim in Cordis hydrope involucrum iſtud impletum ſit, & latera ejus ab incumbente undique aquâ eouſque comprimantur, ut pro excipiendo ſanguine ſatis dilatari non poſſint; tum pulſus valdè diminuitur, donec tandem inundante magis aquâ prorſus ſupprimitur, unde ſyncope & mors ipſa ſuccedit. Pari ritu hoc fieri videtur ac in hydrope pectoris, ubi pulmo ſatis diſtendi non poteſt; quia cùm cavitas thoracis aquâ repletur, pro dilatatione pulmonum nullum reſtat ſpatium; unde morbo iſto affectis difficilis, & tandem nulla reſpiratio ſupereſt, licèt ſummo conamine ſpiritum attrahere contendant; prout in hujuſmodi ægris non raro obſervavi.

Atque, ut obiter hîc dicam, cùm aquæ iſtius pericardio contentæ nimia copia cordis motui adeò officiat, ut ipſum tandem obruat ſupprimatque, veriſimile eſt cordis palpitationi ſuccedere potiùs, quàm concitatum hunc cordis motum ab illâ irritari; quod quidem eò magis veriſimile eſt quòd affectus iſte ſanos & improvisò ſæpe,

aliiſque

aliiſque de cauſis exoritur, & nullo ſigno aut indicio adventum ſuum denuntiat; prout in affectu illo magis explicando infrà dicetur.

3. Atque, prout capſula cordis non uno nomine illi officium præſtare dicitur, tum quòd illi irrigando & ab externis injuriis muniendo inſerviat; ita neque uno modo ipſi nocumento eſſe aliquando accidit. Sicuti enim aquam nimis in ſe accumulando cordi nocumentum affert; ita, ubi illa prorſus deficit, arctè adeò cordi accedit, ut ipſi tandem undique adhæreſcat; unde, cùm diaphragmati accreſcat quoque, cordis motum cum illo confundere & committere, neceſſe habet: Quòd quanto utriuſque impedimento atque incommodo fieri debeat, ſupra oſtendi: Atque ex hâc hiſtoriâ magis patebit.

Uxor cujuſdam civis *Londinenſis* ætat. 30 Annorum, olim ſatis ſana & alacris per tres ultimos vitæ ſuæ annos mœſta valdè & melancholica, porro & ad motum quemvis anhela, cum pulſu parvo & ſemper intermittente, de dolore inſuper cum inſigni gravamine præcordia infestante continuò fere querebatur; quin & crebris lipothymiis, & a levi quovis corporis motu spirituum deliquiis & extremorum infrigidationi obnoxia demum evaserat: in quo statu a nullis medicamentis juvata, tandem viribus sensim attritis, interiit. Cadavere aperto circa viscera inferioris ventris nulla omninò vitia apparebant; dum verò alias partes perscrutamur, cordis affectionem deprehendimus, in quam omnium malorum causas merito referamus. Thorace enim aperto pulmones satis sani fuerunt, cordi tamen toti pericardium ubique adeò arctè accreverat, ut digitis non nisi ægre ab illo separari potuerit; porrò hæc membrana non, uti oportuit, tenuis & pellucida, sed crassa opaca & velut callosa evaserat; hinc cum nulla intercapedo pro libero cordis motu, & nulla, quâ humectaretur, aqua adfuerat, nihil mirum si de malis his omnibus continuò quereretur. Præterea cùm pericardio humano diaphragma semper accrescat, ubi cor ipsum quoque pericardio uniri accidit, fieri

fieri non potuit quin in omni inſpiratione cor etiam ſecum deducere, adeóque motum ejus tamdiu ſiſtere & ſupprimere neceſſe habuit; unde pulsûs iſta intermiſſio omni inſpirationi perpetuâ vice tam conſtanter ſuccedebat.

4. Quemadmodum verò (ut modò dictum erat) cordis motus ab incremento hujus aquæ omninò ſupprimi; ita ab aliis capſulæ hujus incolis valdè irritari, atque perverti nonnunquam ſolet: Quippe ſæpenumerò vermes, intra capſulam hanc geniti, arroſione ſua magnas cordi aliquando moleſtias faciunt; atque cordis tremore, anxietate, pulſu ſæpe intermittente, dolore pungente, & ſyncopê, ſe produnt: Quam quidem ſymptomatum atque animalium catervam cataplaſmate e *foliis cinaræ, tanaceti, & abſynthii vulgaris, aceto vini albi acerrimo incoctis, & cùm pauco mithridatio mixtis*, regioni cordis bis applicatio penitus diſſipatam vidi. Atque hactenus quidem de iis alterationibus dictum eſt, quæ ab ipſius cordis,

cum pericardio ſuo, culpâ proveniunt.

II. Cùm verò ad ſanguinem in omnes partes debitè diſtribuendum, utrumque cordis ventriculum, tum ſinûs capacitate tum pulsûs rythmo, invicem neceſſariò convenire, oſtenſum eſt; ita vaſorum ad ventriculos cordis accurata quoque analogia & commenſuratio mutua eſſe debet. Sed cùm cor id ipſum ſit, quod ſanguinem a ſe propellendo, vaſa ad illum convehendum ſimul procudit; non eſt quòd fieri poſſe credamus, ut pars aliqua ſit, ubi vaſa ſimul non adfuerint; Quare, cùm vaſa ſanguinis duplicia ſint & diverſo muneri deſtinata, tum cordis & ſanguinis motui reciproco inſerviant; operæ-pretium erit advertere, quomodo utrique aut opem ſuam conferre nata ſint, aut poſtea impedimento aliquando eſſe poſſint.

Notum itaque ſatis eſt, arterias pro ſanguine a corde excipiendo, & in totum corpus deferendo; venas autem ad eundem reportandum, & cordi inferendum, conſtitutas eſſe: Et, pro

ſanguinis

ſanguinis impulſu atque impetu ſuſtinendo, illas craſſiore tunicâ, has verò, in quibus ſanguis curſu magis leni decurrit, tenuiore multum donari.

At ſicuti vaſa ſanguifera ab ipſo ortu a ſanguine extra propulſo, aut intus redeunte, conformata fuerint; ita deinceps poſtea ab ipſo variè immutari poſſunt; Verùm ita, ut cordis & ſanguinis motum valdè alterent. Et ſiquidem arteriæ proximum cordi miniſterium præſtant, primum quoque earum defectus explicare oportet.

Quandoquidem igitur arteriarum trunci craſſiore & robuſtiore tunicâ donantur; idcirco, ubi ſanguini in omnes partes æquus & apertus aditus patet, intra debitum ambitum ubique continentur; ubi verò eas a materiâ aliquâ impactâ oppleri intus atque obturari, vel a partium marceſcentiâ obliterari & exareſcere, vel ab externo aliquo corpore aut accidente ductum cujuſpiam comprimi aut conſtringi contingit; Quoniam ſanguinis toti corpori commensurata, & vis illi a corde impressa eadem est; ubicunque sanguinis cursus in arteriâ aliquâ impeditur, proximæ & sociæ ejus totum impulsi sanguinis impetum sustinere debent, & copiam isti destinatam in sese omnem excipere; unde nunquam non accidit, ubi ductus alicujus arteriæ diu obstructus aut ligatus fuerit, quin sanguis in proximâ sibi spatium amplius aperire atque patefacere satagat; atque, dum hoc fiat, motus sanguinis in arteriis omnibus juxtà positis multum corripi atque impetuosiùs trajici, necesse habet. Sanguis sc. in hoc vase obstructus & præpeditus, in proxima impelli magis atque arietare debet, donec pro explicando sibi spatio illa multum dilataverit.

Quod verò arteriarum alicubi obstructio, idem earum marcescentia atque extenuatio reliquis vasis præstat. Cùm enim ventriculi cordis, & sanguis, omnibus vasis commensurati sint; si pars aliqua aut membrum corporis marcescat, sanguis isti prius destinatus

deſtinatus in alias partes corporis impendi debet; proindeque tum vaſa ejus dilatare magis, majuſque incrementum deferre; Atque ideò Doctiſ. *Glyſſonius,* in Rachitide affectis, hepatis & capitis magnitudinem ab aliarum partium marceſcentiâ rectiſſimè deducit; ingeniumque ſimul cùm cerebro, ob majorem ſanguinis copiam affuſam, incrementum capere obſervat. Quippe cùm pars aliqua corporis marceſcit & extenuatur, ſanguis iſti parti impendi ſolitus in alias corporis partes mandari debet: Et, cùm nulla pars corporis, hepate & cerebro mollior, & impulſui ſanguinis magis cedere apta fuerit; facile ab irruente ſanguinis majore copiâ diſtenduntur ea, & in tantam molem atque incrementum aſſurgunt.

Pariter omnino, & ubi arteriam aliquam conſtringi aut comprimi contingit; curſus ſanguinis in vicinis partibus majore impetu & vi acceleratur. Ligata enim arteriâ cervicali alterâ; pulſus ſtatim in adversâ cervicali, tum etiam in axillari utrâque, propter

propter majorem ſanguinis copiam affuſam, valdè augetur. Quantum autem arteriarum licet minorum conſtrictio ad motum ſanguinis in aliis corripiendum valet, ex arctâ lumborum ſtricturâ, quâ ad arcendum frigus utimur, clarè apparet; cujus quidem ratio non ea ſola eſt, quòd veſtes corpori arctiùs complicat, ſed quatenus motum ſanguinis in minoribus & exterioribus vaſis coarctat, curſum ejus in interioribus concitatum magis & plenum intus reddit. Ideóque qui renes a naturà calidos obtinuerunt, nullo modo veſtes lumborum regioni arctè alligari patiuntur, ne ſimul cum repreſſo ſanguine ab exteriore corporis ambitu, majus incendiu intus excitent. Uti autem arteriarum minorum conſtrictio ad reliqui corporis commodum aut detrimentum ſæpe fit; ita, cùm vaſorum ad cordis ventriculos exacta commenſuratio fuerit, & ſanguinis copia omni ſyſtolê ejecta aortæ ranis omnibus proportionetur; ſi decurſus ejus per ipſum ejus truncum paulo infra cor impediatur, non ſine maxima

cordis

cordis moleſtiâ & periculo contingit; quatenus nempe ſanguis toti corpori debitus, & juſtâ menſurâ proportionatus, a dimidiatâ ejus parte totus excipi non poteſt; adeò ut neceſſariò in ipſum cerebrum & cor redundet; &, cùm ab illo propter ſpatii defectum expelli non poteſt, ipſius ventriculos opplere nimis & ſuffocare neceſſe habet: Atque hoc quidem in variis canibus ſæpius expertus ſum, quòd cùm, apertâ thoracis lævâ parte, & immiſſo paulo infra cordis regionem digito aortæ truncum deſcendentem penitus ad ſpinam compreſſerim; tantâ corporis contentione atque ejulatu obnitebantur, ut cor ipſum pœne e pectore exſcindi magis tranquille ferrent. At verò cùm, ſanguine plurimo detracto prius, idem experimentum in aliis repeterem, adeò ut partes ſupra compreſſionem ſanguini reliquo excipiendo pares & ſatis capaces fuerint; nullo ferè moleſtiæ ſigno digiti adpulſum patiebantur.

Uti verò ſanguis alicubi præpeditus vaſa proxima pro expediendo ſibi tranſitu

ſitu brevi dilatat ; ita aliquando ſive vaſorum debilitate , ſive quod ſanguis in partem aliquam juſto magis quàm pro ejus uſu derivatur atque allicitur, vaſa quibus defertur copiæ ſuæ atque impetûs incremento adeò diducit atque diſtendit, ut in proximas partes minus copioſe & debitè influat. Atque hinc eſt, quod, gonorrhœa ſimplici, aut fluore uterino nimio laborantium ſpina adeo debilitetur, ut vix erecti incedere aut ſeſe quoquomodo flectere queant ; non quod ſpinalis medulla, aut nervi inde orti, ſuccum ſuum (ſi quis hujuſmodi ſit) nimis in teſtes aut uterum impendendo ſuo ſe fraudent genio ; quippe non adeò liberales ſunt aut eſſe poſſunt, prout quidam vanè commenti ſunt, pauciſſimæ enim & vix viſibiles nervorum fibræ in teſtes diſſeminantur : ratio autem potius in hoc ſita eſt, quòd arteriæ ſpermaticæ & uterinæ laxatæ, ſuccum ſanguinis nutritium nimiâ & plus ſolitâ copiâ in teſtes & uterum deponunt ; & proinde arterias vertebrales, e regione oppoſitas, ſuo ſe
ſanguine,

ſanguine, & ſpinalem medullam ab iis irrigandam ſuo quoque alimento defraudent; quod ex medelâ quoque magis patet: quicquid enim vaſa ſpermatica conſtipat & conſtringit, æqualem pariter ſanguinis diſtributionem, ſimul & debitum partium tonum reſtituit.

Sicuti verò arteriæ cujuſpiam obſtructio aut conſtrictio quævis ſanguinis motum in partibus vicinis concitatiorem reddit; ita, ubi canalis ejus aliquis aperitur aut prorſus diſcinditur, adeò ut ſanguinis torrenti exitus pateat; quoniam per apertum quaſi oſtium magis liberè & expeditè effluit, quàm per poros corporis urgeri poterat, ideò ubi facilius poteſt, copioſius affluit, & viâ quâ datur liberiore erumpit; adeò ut pulſus ſimul cùm influxu ejus in vicinis partibus multum diminuatur. Atque hinc optima reddi poteſt ratio, quare arteriotomia, ad dolores, inflammationes, & plura hujuſmodi ſymptomata mitiganda in tantum conferat, ut præſens juvamen afferre ſemper videatur: Hoc autem ideò

accidit;

accidit; quòd cùm ſanguis, per arterias e corde impulſus, ægrè magis & difficulter per poros & habitum corporis circulatur; idcirco, ubi liberam & apertam viam nactus fuerit, totus torrens ejus ſimul erumpit & exundat; unde proximis vaſis ſolito ſuo liquore depletis & deſtitutis, impetus & pulſus inibi multum diminuitur: Pari quippe ritu hòc fieri videtur ac cùm fluvius, in duos amnes aut rivulos diviſus, in plano ſolo placidè & æquis paſſibus decurrat; ſi alter dejectâ ripâ (quâ prius continebatur) extra alveum præceps ruat, non ſolum fluentum ejus quod ultra hoc apertum præcipitium pergit, quin & proximus amnis quo cùm per diverſas foſſas & rivulos (quaſi tot anaſtomôſes) communicat, ſtatim ſubſidit, & in curſu ſuo retardatur; uterque ſc. amnis, faciliorem exitum nactus, quò magis liberè poteſt, decurrit: Similem planè in modum ſe habet in vaſis corporis; expertus utique ſum, ſi arteria cervicalis ex hoc latere aperiatur, ſtatim pulſum alterius cervicalis multum fatiſcere; pariter etiam

etiam si arteria cruralis altera pertundatur, pulsum ilicò arteriæ oppositi cruris plurimum deficere.

Vidimus huc usque quantùm vasis cujuspiam arteriosi dilatatio, constrictio, atque amputatio ad motum sanguinis alterandum præstet; superest, ut idem a venis contingere posset, ostendamus.

Cùm itaque non tam refert, quibus de causis venæ dilatentur, quàm, quid earum dilatatio ad sanguinis motum alterandum faciat, explicare; notandum est aut ob partis cujusdam compressionem, aut sanguinis copiam, vel (sive id ipsius ponderi, sive relaxato venarum tono, sive cordi sanguinem non debitâ vi impellenti debeatur) refluendi difficultatem, venas potissimum ampliari; & propterea in gravidis, propter venam cavam & utramque iliacam in infimo ventre a mole uteri compressam, tum propter sanguinis & humorum incrementum & difficilem ab inferioribus partibus ascensum; & in tristibus & melancholicis, propter cordis motum languidum; venas tibi-

tibiarum in magnos varices diſtendi ſæpe numero contingit: ſanguis ſc. in reditu præpeditus, aut ſufficienti vi a tergo non impulſus, in venis inferioribus diutius ſiſtitur, & tandem pondere ſuo ac mole eas diſtendit, ut ſibi amplius ſpatium acquirat. Atque ideò ubi lecto rursùs ſe tradunt, vel iſtæ fœtum enixæ ſunt, propter faciliorem ſanguinis verſus cor recurſum, venæ iſtæ protinus inaniuntur: verùm cùm longâ conſuetudine ampliatæ fuerint, non ita facilè in priſtinum tonum reſtitui poſſunt aut coarctari, quin, ſanguinem a corde & venâ cavâ divertendo, circulationis filum ſeriemque valdè interrumpant; unde, pulsûs deficientia, & virium languor propter venas illas valdè dilatatas ſuccedunt: Atque hoc non ita pridem in quodam ruſtico, quadraginta circiter annos nato, & longâ triſtitiâ pœne confecto, accuratè obſervavi; tantâ enim varice ſive venâ dilatatâ in parte anteriore tibiæ ſiniſtræ adeò verè laboravit, ut magni farciminis inſtar a malleolo ad genu uſque turgeret, &

ejus

ejus inceſſui valdè moleſta fuerit; quantum quoque ex tumoris magnitudine conjicere potui, fere duas libras ſanguinis continebat: Cùm verò in humum reclinatus tibiam erigeret, aut manu ſacculum iſtum ſanguinis ſurſum verſus leviter urgeret, tumor ex ſanguine in venam cruralem & cavam tranſmiſſo, paulatim evanuit; cùm autem in pedes iterum erectus ſtaret, intra breve ſpatium folliculus iſte in priſtinam molem aſſurgebat; quod a ſanguinis novi influxu fieri certum eſt: Cùm verò præter ponderis illius moleſtiam ſe inſuper imbecillum, & ſi paulo diutius iſte tumor perſeveraverit ſe valdè languidum conquereretur, (quod detento ſanguini & intercepto cordis pabulo imputandum puto) ad utramque moleſtiam præcavendam conſului ut valdè ſtrictâ caligâ aut faſciâ tibiam ſemper accingeret, & emplaſtrum aſtringens imponeret, quo in poſterum valdè levatus fuit.

Uti verò venarum alicubi dilatatio, ſanguinis ſupplementum & influxum debitum divertendo, cordis motum valdè diminuit; ita ubi venæ in angustum adeò ambitum compinguntur ut sanguini commeatum satis liberum non concedant, idem omninò incommodum cordi advenit: Quippe in valdè obesis animalibus propter venas a nimia pinguedinis mole & incremento compressas, quia sanguis pro motu cordis continuando debitè suppeditari non potest, proinde in vasis suis & corde stagnare & concrescere aptus est, adeòque morti repentinæ (præsertim quibus a naturâ cor vegetum & robustum datum non est) obnoxios reddit. Ut autem venæ cujuspiam, minoris licèt, compressio sanguinis motum inihibendo aliquantulum alterat, ita quo plura & majora eorum vasa obstructa aut constricta fuerint, eo præsentius cordi periculum impendit. Et sicuti aortæ paulo supra diaphragma compressio sanguinem toti corpori debitum & omnibus simul vasis quantitate proportionatum in partes solum superiores congerendo caput ipsum & cor obruit & pessundat; ita

ita si vena cava paulo supra diaphragma in dextro pectoris latere, ubi trunco ab omnibus partibus distincto & discontinuo versus cor incedit, adeò arctè ligetur ut sanguinis per illam affluxus prorsus supprimatur, dici vix potest, quanto animalis detrimento hoc fiat: Quippe licèt ab injectâ venæ ligaturâ nullum doloris aut cruciatus sensum corporis contentione aut ejulatu fatetur, mox tamen adeò oblanguere & fatiscere incipit, ut pedibus vix stare possit; quin & non tam procumbere quàm in terram ruere & concidere semel vidi ferociorem molossum, non aliter quàm si vitâ omnino destitutus esset. Ratio autem, quare tanto discrimine venam cavam & tàm tranquillè ligari, aortam vero adeo anxiè comprimi sustulerint, alia esse non videtur, quàm quod venâ inibi ligatâ sanguis toti corpori debitus, inferiori solum parti ejus plurimum impenditur; adeóque caput vitali ejus influxu valdè orbatum spiritus pro cordis motu sustentando impertire adeo potens non est; ut utrumque vacillare & deficere multum necesse fuerit, quod nullo utriusque dolore perficitur: Compressâ autem aortâ supra diaphragma, sanguis qui maximâ ex parte inferiori corpori & visceribus ventris debetur, totus superiori & minori parti suffunditur; quem cùm excipere omnino incapax sit, nimiâ ejus copiâ prorsus opprimi & suffocari debet; atque ideò cùm mox cerebro & cordi ipsi, tantam molestiam afferat, ad primam compressionem animal rem tam iniquè patitur & summo conatu amoliri nititur. Quod quidem experimentum cùm non uno respectu observatu dignum sit, non abs re fore arbitror si administrandi methodum hic ostendero: Perforato itaque dextro latere thoracis infra septimam & octavam costam paulo infra regionem cordis, & immisso digito venæ cavæ situs palpandus est, deinde pectoris latus illud ad venam quàm prope compellendum est, quo filum ei faciliùs obducatur, atque in isto pectoris situ arcte stringendum est vinculum; dein

pectore

pectore relaxato vulnus consuendum est: Peracto autem experimento canis mox oblanguet valde, & intra paucas horas expirat. In dissecti autem abdomine magna seri quantitas innatare conspicietur, non aliter quàm si ascite diu laborasset; quod quidem ab impedito sanguinis ab arteriis in venas circuitu secerni prius expertus fueram; haud pridem enim venas jugulares subducto iis filo in cane arctè ligaveram, & post aliquot horas, partes omnes supra ligaturam mire intumescebant, & intra duos dies canis quasi anginâ suffocatus interiit: Toto hoc tempore non solùm lacrymæ copiosiùs fluebant, sed & plurima saliva ex ore profluxit, non aliter quam si mercurio assumpto fluxus ille concitaretur; post obitum cutem ejus a partibus tumefactis separavi, atque expectavi quidem ut partes tumefactæ sanguine extravasato turgerent; sed aliter omnino evenit, siquidem nullum vestigium aut colorem ferè sanguinis observare potui; sed musculi omnes & glandulæ sero limpido maxi mè diſtentæ & admodum pellucidæ apparebant; quod clarè arguit ex conſtrictione venarum cùm ſanguis ab arteriis in venas tranſire nequit, ſerum utcunque ſecerni; utpote velut in filtro meatus apertiores & poros configuratos & aptiores habens in quos fluat; craſſior autem ſanguinis pars propter meatuum diſproportionem non omnino in illos recipitur, & propterea intra vaſa ſua ſtagnare cogitur. Quantum hæc ad Aſcitis & anaſarcæ cauſas inveſtigandas conducant, aliis judicandum relinquo; hoc ſolum advertere oportet aſciten non ex ruptis lymphaticis ſemper, ſi omninò unquam, provenire; Quippe plurimas oves hydrope pectoris atque abdominis defunctas diſſecui, in quibus vaſa lymphatica ita turgida & repleta ubique inveni, ut nuſquam magis; adeò ut ſiquis venarum lymphaticarum hiſtoriam plenè abſolvere in animo habeat, nulla corpora ad votum ejus & propoſitum magis ceſſerint.

Hactenus

Hactenus ostensum est quâ cordis & vasorum ejus culpâ motus ipsius alteratur:

III. Sequitur, ut in quam criminis suspicionem venerit sanguis, & quo ejus vitio cordis motus lædatur, explicemus.

Atque tribus præcipuè modis cordis motum pervertit,

1. Incrassatione & coagulatione.
2. Abundantiâ nimiâ.
3. Defectu.

1. Motus cordis a sanguine alteratur, cùm aut ab alieni mixtione, aut propiarum partium secessione coagulatur, & grumescit, adeò ut viam sibi ipsi & transitum omninò prædudat; prout in peste & veneno aliquando accidit, unde gravissima illa symptomata, cordis sc. anxietas, tremor, palpitatio, pulsus intermissio, & tandem syncope & mors repentina succedunt. Quæ omnia in majore molosso post injectam libram semis lactis recentis modicè calefacti (experimenti gratiâ) in venam cruralem detractâ prius pari sanguinis copiâ, quò lacti recipiendo

locus eſſet, non ſine magnâ commiſeratione ſemel vidi: Vix enim ſemihora elapſa eſt, quin maximâ præcordiorum anxietate, & oppreſſione cordis, & diaphragmatis ſummâ contentione (pro expediendo ſanguinis circuitu) afficiebatur; quin & mox crebrâ palpitatione, tremore, & graviſſimis ſuſpiriis ſuccedentibus, tandem inter miſerandos planctus & querelas ſyncope extinctus eſt. In diſſecto, mox obſervavi venam cavam, utroſque cordis ventriculos, vaſa pulmonum atque aortam, lacte cum ſanguine penitus concreto impleta; & adeò inter ſe compactus cùm lacte ſanguis fuit, ut digitis non ita facile divelli aut ſeparari poterat: Unde ſimilem in peſte coagulationem eſſe non eſt quòd dubitem, cùm iiſdem prorſus ſignis & ſymptomatibus ſe prodat.

2. Sicut autem maſſæ ſanguineæ concretio & grumeſcentia vias ſibi in vaſis & corde obſtruendo ejus motum tandem eludit, ſupprimitque; ita ſi nimia ſanguinis copia fuerit, aut plus debitâ ſeri aut chyli quantitate turgeſcat,

gescat, vasa sua & ventriculos cordis ita replet aliquando aggravatque ut distendi nimis sit necesse, satis autem contrahi non possint: adeóque, nimiâ ejus plethorâ penitus obruantur. Atque ideò solenne est, homines lauto & pleno victu semper utentes, atque ebrios præcipue frequenter suffocari, nisi largâ & maturâ venæ sectione vasa sanguinis depleantur, & clysteribus aliqua pars crapulæ detrahatur, quò libera rursus circulatio fiat.

3. Quemadmodum verò sanguinis plethora cordis ventriculos ejusque vasa nimis implendo suffocat, & cordis motum opprimit; ita e contra cùm tanta sanguinis jactura & vasorum inanitio fuerit, ut ventriculos cordis irritet solum, & non satis expleat, cor in opere suo sæpe frustratum a motu desistit; uti in hæmorrhagiis magnis, & diuturna fame sæpe contingit.

IV. Hactenus ostendisse sufficiat quantum cordis motus a seipso, vasis suis, aut sanguine alteretur; ultimo explicandum restat, quomodo pro vario

vario ſpirituum influxu motum ejus alterari contingat.

Prout autem regularis cordis motus a debito ſpirituum per nervos influxu omninò dependet, ita pro vario illorum influxu motus ejus plurimum alteratur.

1. Acceleratur cordis motus in exercitio concitatiore, quatenus a motu muſculorum ſanguis in ventriculos ejus uberius urgetur atque ingeritur; quem cùm neceſſe habeat pari paſſu expedire, in cerebrum quoque non aliter ac in cæteras partes majore copia ſuffundit, unde ſpiritus etiam pro mutuo præſtando beneficio ad cordis motum corripiendum majore quoque copia in ipſum amandantur. In febribus quoque cordis motus valdè corripitur, non quod ſanguis immaniter ebulliens in aortam exiliat; ſed quia æſtus ejus & caloris ſenſus cordis ventriculis infeſtus, & in cerebellum tranſmiſſus, ſpiritus ad motum ejus pro exigentiâ accelerandum irritat; partim quoque quia partes aliquæ ſanguinis efferæ & in-

indomitæ in cerebrum depositæ, spiritus inibi hospitantes exagitant & in orgasmum rapiunt: Prout etiam a potu vini generosi & liquoris cujuslibet admodum spirituosi motus cordis mirè augetur, quia partes spirituosæ ab hujusmodi liquoribus in magnâ copiâ in cerebrum extillatæ spiritus cerebri incolas in similes tumultus incitant.

2. Diminuitur cordis motus in magnis hæmorrhagiis, jejuniis, diuturnâ quavis ægritudine seu mærore, longo languore, affectibus syncopalibus, febribus malignis; in quantum vel ob sanguinis inopiam, aut recentis pabuli defectum, aut longioris morbi deprædantem calorem, aut malam sanguinis diathesin, usque adeò degener & depauperatus est sanguis, ut exhausta, effæta, vel veterana ejus massa spiritibus in cerebrum extillandis omninò impar sit: Et exinde propter spirituum aut non rectam constitutionem, aut non debitam influentiam sive penuriam, cor motum suum remittere necesse habet; donec sanguis vel

copiâ

copiâ augetur, vel novo pabulo recreatur, aut crasis ejus emendatior evadit.

Atque hæc quidem secundariâ cerebri & spirituum culpâ accidunt; proximè ostendendum, quo suo spirituum vitio cordis motus alteratur.

3. Depravatur nempe in passionibus, veluti irâ, gaudio, terrore subito; quum spiritus nimiâ & plus solitâ copiâ aut majore impetu cordi advolant, motumque ejus maximè corripiunt, & horrendis aliquando subsultibus exagitant & convellunt. Quem quidem affectum, quum non satis forsan perpenderent, diminuto vocabulo *palpitationem* authores passim nominarunt: At revera cordis musculus uti easdem cùm cæteris musculis actiones perficit, ita ab iisdem morbis haud immunis est; quippe spasmo & motui convulsivo æque obnoxius est & sæpius multo tentatur. In palpitatione enim sic dicta (qui motus convulsivus verè est) cor tam violenta systole sæpenumero corripitur, ut ipsas costas loco suo movisse, atque perfregisse notum sit; quin &, aliorum spas-

morum

morum more, ab iisdem causis excitatur, & periodicè recurrit; & uti sic correpti occasionem plerumque subito terrore, vel irâ accipiunt, ita simili quâvis de causâ in eosdem affectus denuò incidunt, a quâ primò excitati sunt; ubi enim spiritus semel in tumultum & confusionem acti impetuosè nimis in cor delati fuerint, deinceps postea ob levem quamcunque occasionem pariter irritati; eandem viam & choream affectabunt, & simili spasmo cor corripient: prout videre est in iis qui palpitationi sic dictæ obnoxii sunt.

4. Prout autem spiritus in cerebro & cerebello in tumultus & orgasmos acti cordis musculum aliquando nimis exagitant: Ita sæpe accidit, ut, spiritibus aliò raptis aut distractis, ille adeò arctè & rigidè stringatur ut a diastole diu vacet. Quare nihil magis solenne, quàm, fœminas hystericâ passione aut epilepsiâ affectas, in gravescente paroxysmo, de cordis spasmo & constrictione (quasi manu comprimeretur) plurimum queri; quo tempore,

pore, si digitum arteriæ applices, ne minimum quidem pulsus vestigium deprehendes: Atque ideò, discusso paroxysmo, de magno cordis gravamine & oppressione conqueruntur; quia, ob impeditum cordis motum, sanguis in eo stagnans & grumescens, illud onere suo opprimit, & valdè gravat: Quâ de causâ epileptici plerique, durante paroxysmo, pectora sua repetitis ictibus concutiunt & contundunt, quò cor ad motum incitent, & a congulatione sanguinem impediant: Quòd si diutius paroxysmus duret, periculum est ne talis coagulatio sanguini inducatur, quam cor nunquam iterum dissolvet & excutiet; unde longiores epilepsiæ paroxysmi sæpe in mortem terminantur.

5. Quemadmodum verò spiritibus alio distractis cordis motus pro tempore cessat; ita ubi influxus eorum penitus intercipitur, ejus motus omnino deficit: Uti in Apolexiâ; in quâ tota medulla oblongata simul & semel obstrui, & proinde tota systasis nervosa inde orta eclipsin pati videtur; unde

unde cor ſimul cùm reliquo corpore ſenſu motuque penitus privatur, & ab opere ſuo feriatur; donec paroxyſmus fortè diſcuſſus fuerit, quod raró admodum affectui illi conceſſum eſt.

Cùm ex prædictis conſtitit, motum cordis aliunde dependere, atque ex conſenſu partium diverſas mutationes ſubire; proximè incumbit ut oſtendam, qui affectus & ſymptomata diverſas motûs ejus anomalias conſequantur.

Prout autem multæ ac diverſæ alterationes in ejus motu fiunt; ita partes aliæ quæ proximum cùm corde conſenſum habent, diverſimode noxam ejus participant. Cúmq; cordi nihil ipſo ſanguine magis affine fuerit, nihilque ſit a quo cerebrum propiùs dependet; nihil eſt quòd, iſtis citius, cordis inordinationem aut defectum luit.

Noxæ autem & ſymptomata quæ ſanguinis liquori inducuntur, duo præcipue ſunt.

1. Si cordis ſyſtole, quâ liquor ſanguinis conquaſſatur uſque, & ad ventriculi latera & vaſorum parietes alliditur,

ditur, paululum diutius elanguescat; succus ejus nutritius in partes secedere, grumescere, & gelatinæ in modum incrassari, tandemque intra fibras cordis hinc inde pendentes implicari; & ipsis ventriculorum parietibus accrescere, & a cordis æstu indurari incipit; eâque quantitatis mole sæpenumero augeri, ut utramque cordis cavitatem ferè expleat, motumque ejus multum diminuat. Atque hoc in tabidis, cachecticis, scorbuticis solenne & familiare est (utpote quorum pulsus debilis & intermittens est;) ventriculos cordis & vasa omnia sanguifera chylo coagulato infarcta & ferè repleta esse; prout in pluribus hujusmodi defunctis & longa ægritudine attritis, præsertim si sub isto languore in lecto decubuerint, sæpe observavi; adeò ut mirandum fuerit cor ullo modo constringi, aut reliquum sanguinem ad huc fluidum ad vitam & calorem in partibus conservandum in vasis istis præterlabi potuisse; quin & semel, in quodam *Oxonii* tabe extincto, & paulo ante obitum lipothymiæ

miæ frequenter obnoxio, obſervavi, dextri ventriculi oſtium uſque adeò ab hujuſmodi carneâ concretione obturatum, eamque tam arctè inter fibras tricuſpides impactam fuiſſe, ut pennæ anſerinæ aditus in ventrieulum, pro influxu ſanguinis, vix reſtaret: Quin & ſiniſter ventriculus pari fere modo obturatus fuit, ut ægre oſtium cordis digitis recludi potuerit Quin & hujuſmodi concretiones uſque adeò in carnem mutatas vidi, ut plurimas venas & fibras in iis adverterem; quas cùm in fruſtula diſſecarem, ſanguïnem non liter quàm ſi pars aliqua corporis incideretur, recentem effuderunt; claro argumento, nutritium in ſanguine ſuccum alimentum partibus præſtare, cùm ita intra vaſa ſua non ſolùm in parenchymata concreſcere, ſed in ipſum carnis colorem & ſubſtantiam mutari aptus ſit. Cujus quidem coagulationis hæc ratio eſſe videtur, quòd, cùm cordis motus diu elangueat, & ſimul æger lecto affixus ſit; ex plano & æquali iſto corporis ſitu, ſanguis lento fluxu delatus, ob motus istam tarditatem & moram (præsertim cùm succus nutritius in sanguine admodum glutinosus sit,) sensim concrescit, &, pro cordis & vasorum continentium figurâ, variè configuratur; unde pro cordis polypo, verme, & serpente interdum habitus est. Ex quibus constat, quantâ cùm utilitate exercitia & agitationes corporis ad salutem conferant; nam quò sæpius in corde sanguis conquassetur, ad vasorum parietes allidatur, in habitu corporis a contractione musculorum agitetur & concutiatur, & denique per poros corporis urgeatur; eò magis attenuari, & a stagnationibus istis liberari necesse est, in quas aliter pars sanguinis nutritia satis prona est.

2. Uti a debili & parvo cordis motu sanguinis stagnatio & concretio inducitur; ita, e contra, ubi motus cordis cùm robore aliquali & vigore vibratur, mixtio ejus optimè conservatur: Si verò intensior fiat motus, ex violentâ concussione sanguinis liquor valdè attenuatur, unde exercitio, balneo, laconico sicco aut vaporario, sudor supervenit:

venit: Qui si diutius & ultra quàm per est provocetur; propter seri defectum, sanguis, vehiculo suo spoliatus, circulationi ineptus redditur; & cor ipsum, propter spirituum dispendium, in opere suo delassatur; unde lypothymia & syncope succedunt.

Atque hæc sunt symptomata & effectus, quæ, ob cordis motum hoc aut illo modo alteratum, in ipsum sanguinem proximè redundant; alia autem sunt quæ partes continentes pariter afficiunt.

1. Cùm motus cordis debilis & intermittens est, hos capitis affectus, sc. vertiginem, scotomiam, caliginem oculorum, & lypothymiam inducit; Quorum symptomatum ratio in hoc sita est; quia, cùm spiritus animales vitaque ipsa a continuo sanguinis in cerebrum appulsu dependent, si cursus ejus sistatur paululum aut sufficienti copiâ non suppeditetur, tum, propter ejus defectum, caput statim vacillat, oculi caligine obducuntur, & tota corporis compages in pronum ruere apta est; atque ideò syncope affectos in

dorſum & humum ſternimus, ut citius ad vitam reſtaurentur; quoniam, utut cor debile fuerit, poterit tamen, in eo ſitu, ſanguinem quaſi ductu horizontali in caput projicere, quamquam in erecto corporis ſitu ſanguinem eò ſuffundere non potuerit; ex cujus influxu ſenſus & vita redit, & imago iſta noctis ſtatim evaneſcit.

2. Ex adverſo autem, ubi cordis motus corripitur, & ſanguis impetuoſe nimis in caput trajicitur; membranas vellicando & ſuccutiendo, capitis dolorem infert; & ſpiritus animales, per ſomnum in cerebro concentratos & quaſi ab opere feriantes, rapidiore motu ſuo exagitans & loco pellens, vigilias inducit. Non abſimili forſan ritu ac, juxta lenem & placidè murmurantem rivulum, ſomnus nos citò occupat; at, juxta vortices & cataractas, terrore potius excitamur & expergiſcimur.

Atque hi ſunt effectus præcipui qui motus cordis varios velut umbra corpus ſequuntur: Proximè reſtat, ut oſtendam, quomodo fluxus ſanguinis, pro

pro diverſo corporis ſitu & figurâ, alteratur; &, quid alterationem iſtam conſequitur.

Quemadmodum (ut prius dictum) pro animalium diverſitate, influxus ſpirituum in cor diverſus quoque eſt; ita, pro vario corporis ſitu & figura, ſanguinis per partes fluxus diſcrimen ſubit. Cùm enim certiſſimum ſit ſanguinis venoſi refluxum non ab attractione cordis ullâ, ſed a propulſu arterioſi ſanguinis provenire; facile eſt concipere, quantum partium quoque ſitus ad facilitandum aut retardandum hunc motum conferat. Veluti enim in homine, cùm in pedes erigitur, ſanguis a venis jugularibus, & venâ cavâ deſcendente, citius & facilius ſuo quaſi pondere in cordis ſinus delabitur; (ſimili modo atque venæ, in manu elevatâ mox vacuæ; in demiſſâ verò, turgidæ & plenæ cernuntur;) qui verò eſt in partibus inferioribus, & venâ cava aſcendente, difficilius & contra naturam ſuam, ſolum ab arterioſo ſanguine verſus cor propellitur, & vi quadam urgetur, in planum autem jacente corpore ſanguis æque facilè ab utriſque redit: Operæ pretium erit advertere, in quo membri ſitu ſanguis citius partem eam pervadat, & quid citior & tardior ejus curſus producat.

Prout itaque nox & dies, ſomnus & vigilia, mutuò ſe excipiunt & vices mutant; ita ſitus corporis humani, pro naturæ indigentia, erectus aut proclivis eſt.

1. In Homine itaque erecto, quoniam ſanguis a ſuperiore corpore nullo ferè alterius adminiculo ſatis facilè in cor defluit; & ſanguis in inferiore parte corporis non niſi ſanguinis arterioſi impulſu, & quandoque muſculorum contractione in exercitio, ægrè uſque ſurſum urgetur: Ideò circuitum ejus in partibus ſuperioribus celeriorem quoque fieri neceſſe eſt. Quod & poſtea magis patebit.

2. In proclivi autem corporis ſitu, cùm corpus a motu quoque quieſcit, prout partes extremæ magis reliquo corpore elevantur, ita circuitus ſanguinis citiùs aut tardiùs per illas expeditur.

Effectus

Effectus autem & incommoda quæ celerior aut tardior ſanguinis tranſitus in partibus poſt ſe relinquit, duo præcipuè ſunt.

1. Humoris ſeroſi accumulatio.

2. Vitalis coloris diminutio.

Quæ & in extremas corporis partes (pedes & caput) maximè redundant.

1. In pedibus, præſertim morbidorum, & eorum qui exercitio commode uti non poſſunt, cùm ſanguis ægriùs (dum erecti ſunt) verſus cor aſcendat, ideò ſtagnatione ſuâ & tranſitus morâ vaſa capillaria minora ſuâ copiâ diſtendit, & in habitu corporis aggeritur; unde pedum tumores ædematoſi & hydropici: Rem ita ſe habere conſtat, quoniam cùm lecto ſe tradunt, & pedibus cum reliquo corpore in æquali ſitu collocatis recumbunt, ſerum illud cum venoſo ſanguine percircuitus reſorbetur, unde partibus iterum inanitis, tumor ante proximum diem prorſus evaneſcit.

2. Præter autem humorum congeſtionem & tardiorem in partibus inferioribus circulationem, etiam caloris

diminutio ſupervenit; ut ut de die minus frigoris ſentiamus, quia exercitio & ambulatione ſanguis uſque propellitur, & proinde novo ſanguini & a cordis quaſi incude adhuc recenti via aperitur. In lecto etiam repoſiti ſi pediqus reliquo corpori declivioribus quieti nos tradamus; non ante incaleſcent, quàm pedibus magis elevandis lectus componitur: Cujus quidem hæc ratio eſſe videtur, quia ex elevatione iſtâ ſanguis venoſus citius a pedibus recedit & proinde liberiùs & copioſiùs ſanguis arterioſus influit; &, cùm illo calor in partem reſtituitur.

Atque hoc adeò familiare eſt pleriſque frigidioris temperaturæ hominibus, quorum ſanguis ſeroſo latice magis abundat, ut propter frigoris ſenſum ſomnus non ante obrepat, quàm lectus ad pedes altius erigendos de novo ſternitur.

Uti autem pedes propter tardiorem ſanguinis venoſi recurſum intumeſcunt, & infrigidantur; ita cerebrum, ſi caput in ſomno nimis demiſſum

ſum fuerit, licèt calvariæ integumento incluſum frigus minùs ſentiat, quia tamen ex iſto ſitu ſanguis non ita facilè redit, inundationem & irrigationem nimiam confitetur; quis enim ex illis eſt qui ita cubat, quin proximò mane de capitis torpore, ſomnolentia, gravedine, aurium tinnitu, faciei in tumeſcentiâ conqueritur? qui omnes affectus, poſtquam exporrectus eſt, & ſanguis denuò humores iſtos ſeroſos in tranſitu reſorbens ſecum in cor detulerit, paulatim evaneſcunt.

Et cùm ſomni obiter hic mentio incidit, opportunum erit hic paucis oſtendere, quis capitis ſitus inter dormiendum maximè ſaluti confert. In quantum igitur cerebrum humanum rete mirabili (quod ſeri ſuperflui partem a ſanguine excipiat & a cerebro prævertat) omninò deſtituitur, atque vaſa ſanguiſera tortuoſo licèt ductu ad frangendum ſanguinis impetum formata fuerint, eum tamen illibatum in cerebrum deponunt, prout *Tab.* 5. *fig.* 3. oſtendit. In quâ a a *Arteriæ duæ carotides ubi os calvariæ intrant.*

b b *Vbi ſinuoſo ductu per ipſum feruntur.*

c c *Vbi oſculis rectà ſurſum hiantibus in cerebri baſin ſanguinem emittunt.*

d d *Arteriæ vertebrales ubi intra calvariam penetrant.*

e e *Vbi ambo earum trunci in unum coeunt & canali recto verſus arterias carotidas incedunt ut cum iis anaſtomoſi jungantur.*

Ideò fieri non poteſt quin ſeroſior & aquaſior ſanguis, præſertim ſuper planum jacente corpore & capite pariter relinato, in cerebrum influat: Cúmque præterea in ejuſmodi ſitu ſanguis in caput ſuffuſus, non tam promptè & ſubito quàm cùm erecti ſumus a cerebro recurrat; neceſſe omninò eſt, ut ipſum, & præterea totum ſyſtema nervoſum, a nimio ſero irrigetur. Id quòd malo ſuo experiuntur, quotquot affectibus ſpaſmodicis, hydropi cerebri, vertigini, paralyſi, ſenſuum torpori, corpori, & hujusmodi capitis morbis obnoxii sunt: Si enim, capite demisso & cum reliquo corpore æquali, somno se tradant; propter cerebrum & nervos sero nimis irriguos, proximo mane de vertigine, scotomiâ, capitis gravedine, membrorum tremore, linguæ balbutie, totius faciei tumore passim queruntur, & præ se ferunt; quin & sæpenumero inter dormiendum aut turbulentis insomniis aut incubo tentantur, & toto mane insequente torpidi, somnolenti, & graves sibi videntur, somnumque vix aut ne vix diu postea excutiunt: E contra qui capite altiore decumbunt, quia ex isto situ sanguis ejusque serum suo pondere a cerebro facilius delabitur, ideò dulces & quietos licèt breviores somnos capiunt, & proximo mane multo alacriocres & vegetiores evigilant, & ad omne opus & studium magis prompti atque expedit. sunt.

Atque hic advertere obiter alienum non erit in pessimum illum aliquorum morem qui nocturnis & seris potationibus (præsertim in magnis urbibus

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& academiis quo tempore a ſtudiis & negotiis maximè vacant) potiſſimum indulgent; quo quidem nec cerebro magis adverſum aut injurium quicquam poteſt eſſe. Cùm enim propter proclivem corporis ſitum, urina a renibus ſecreta non ita facilè & promptè uti cùm erecti ſumus in veſicam per ureteres delabatur (quanquam nec diffitendum eſt ureteres non aliter quàm æſophagum ex tunica muſculoſa conſtare, adeóque non ſolum convehendo ſed propellendo etiam ſero inſervire, atque pro rei exigentia dilatari aut conſtringi poſſe). Cumque veſicæ cervix, ex proclivi ſitu, urinæ pondere non adeò gravetur, atque ſpiritibus per ſomnum in cerebrum aggregatis & quieſcentibus veſica oneris ejus ſenſum non ita percipiat, ſed officii quaſi oblita, eâ copiâ urinæ aliquando diſtenditur, ut majori recipiendæ ſpatium vix detur; inde fit ut, propter impeditum per renes & ureteres urinæ decurſum, in totum corpus regurgitet; & niſi diarrhæâ proximo mane ſecedat, aut nocturno
ſudore

ſudore evacuetur, in cerebrum pars ejus deponi debet: Et, longâ hujuſmodi conſuetudine, eouſque illic accumulari, donec tandem in paralyſin tremorem, hydropem cerebri, lethargum, aut apoplexiam coniiciat. Rem ita ſe habere, malâ & crebrâ aliorum experientiâ ſæpe edidici; multoties enim obſervavi plurimos homines, inculpatæ aliter valetudinis, in hoc vitæ genere ſibi nimis indulgentes, hujuſmodi morbos frequenter incurriſſe. Quæ mala ut effugiat aliquis, qui bibendi tamen conſuetudine abſtinere non poteſt, conſulo ut non lecto prius ſe tradat quàm conſcius ſibi fuerit ſe maximam ingeſti liquoris copiam per veſicam iterum reddidiſſe; quàm multò largius & citius evacuabit, ſi, veſtibus exutis aut paululum relaxatis, aëri ambienti ſe cautè exponat; prohibita enim tranſpiratio & conſtrictio corporis illa mirè auget urinæ copiam. Quod ex hoc conſtare poteſt, quia ſæpius veſica & majore quantitate urinam reddit cùm corpus aëri expoſitum eſt, quàm cùm tepore lecti relaxatur;

laxatur;

laxatur; adeo ut si quis lecto experrectus statim urinam totâ nocte collectam reddat, vesicam iterum exonerare coactus erit, & majorem urinæ copiam (si hyemalis & frigida tempestus fuerit) intra quartam horæ partem ab ultima mictione reddet, quàm pluribus horis per somnum prius accumulata fuerat; non aliter quàm si quis vesicam exoneret antequam natandi gratia in aquam descendat, quamprimum tamen frigidæ immersus fuerit, ex contractione cutis & pororum occlusione majori mensurâ urinam mox iterum deponet quàm antea, licèt longo tempore in vesicâ congesta fuerit.

Quin ex cautâ hâc (a lecto abstinentiâ priusquam largam satis urinæ copiam reddidisse securus esset,) novi quendam pocula ad seram plerumque noctem, vitam quoque suam ad multos annos imò ad vividam, viridemque ut aiunt senectutem protulisse.

Verum hæc obiter; & quoniam supinus corporis situs ad planum proxi-

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mè accedit, non abs re erit paucis oſtendere quid incommodi quoque ex iſtâ corporis poſitione, in ſomnis evenit. Quòd ut clarius fiat, præmittere oportet, animalium cerebra pro diversâ corporis figurâ variè quoque conſtituta eſſe, nullibi verò magis quàm quoad ſinus & ventriculos cerebri diſcrimen occurrit. In quadrupedibus enim quæ prono in terram capite feruntur, uti cerebellum ſupra cerebrum aliquantulum incumbit, ita & ſinus laterales inter utrumque deſcendentes ſuperiores quoque ſunt, & ventriculus pariter quartus cerebello ſubjectus ſupra reliquos cerebri ventriculos collocatur.

In homine autem, cui caput ſupra reliquum corpus eminet, cerebrum utique cerebello incumbit, (intercedente tamen dura matre & ad utrumque calvariæ latus ſatis firmiter attensâ, ne cerebellum pondere ſuo comprimat) pariter quoque & ſinus laterales magis in demiſſo ſiti ſunt, & ex latere inferiore occipitis utrinque obliquè feruntur antequam in venas jugulares

jugulares terminantur; unde fit ut proſtrato in lectum corpore ex ſupino ejuſdem ſitu, ubi collum occipite magis attollitur, ſanguis in venas jugulares aſcendere potius quam influere neceſſe habet; atque hinc eſt quòd, propter retardatum ejus motum & circuitum, continuo aggeſtus, nec facilem exitum nactus, profundas iſtas foveas utrinque in occipite imprimit; atque prout homo in hoc aut illud latus quieſcere ſolet, ita ſinus illi plus in uno latere quàm in alio ſemper excavantur; prout cuilibet internam occipitis partem in quo cerebellum recumbit contemplanti facile patet: Ob ſanguinis autem refluxum impeditum, & vaſorum exinde intumeſcentiam, foveas iſtas in occipite imprimi, ex hoc conſtat, quia ſupra ſinum longitudinalem, e quo ſanguis ſatis libere decurrit, ne minimum ejus in calvariâ veſtigium extat, niſi in inferiore parte ubi in ſinus iſtos laterales ſeſe exonerat. Si verò refluxûs iſta cohibitio in tam durum os temporis tractu adeò valeat, ut ſinuoſos & profundos tractus in in eo ſibi excavet; quanto magis ſanguis ipſe ejuſque ſerum in cerebrum redundet, ipſumque aggravet: & licèt venæ omnes ſanguinem quaquaverſum a cerebro excipientes in ſinus non directè aperiantur, ſed velut ductus communis in duodenum, aut ureteres in veſicam, &c. intra duplicaturam duræ matris aliquanto ſpatio incedant; Et, quod maxime obſervari dignum eſt, non oſculis verſus occiput (qui rectior exeunti ſanguini in ſinus laterales via foret) ſed verſus frontem, retro quam curſus ejus eſt, apertis hiant; quo quidem fit, ut in riſu, ſpaſmis, &c. in venas cerebri a ſinubus refundi aut urgeri non poſſit; ſed quo magis ſinus ejus copiâ turgeſcunt, eò magis duplicaturam iſtam comprimendo, regurgitationem ejus in venas prohibet, quæ omnia melius percipientur ex *Tab.* 5. *fig.* 4. In quâ

a a *Sinus longitudinalis apertus.*

b *Origo ejus circa os criſtæ galli ubi imperia eſt.*

c *Vbi in ſinus laterales utrinque ſeſe exonerat.*

d d *Duo ſinus laterales.*

e *Sinus quartus.*

f f *Locus ubi ſinus omnes ſanguinem extra calvariam in venas jugulares deponunt.*

h h h h *Venæ ex utroque cerebri latere ſanguinem in ſinum deferentes.*

i i i i i *Oſcula illarum ubi ſanguinem retro quam ſanguinis in ſinu curſus eſt exonerant.*

Tab. 6. *Fig.* 1. Exhibet ſinus cerebri laterales prout in venas jugulares extra calvariam terminantur. In quâ

a *Pars ſinus longitudinalis abſciſſa.*

b b *Duo ſinus laterales.*

c c *Locus ubi ſinus laterales utrinque in oſſe occipitis ampliantur & foveas in oſſe excavant.*

d d *Ubi ſanguinem extra calvariam deponunt.*

e e *Ubi ſinus laterales in egreſſu extra calvariam cum ſinubus vertetralibus communicant.*

f f *Duo ſinus tortuoſi in calvariæ oſſe excavati ad reprimendam ſanguinis regurgitationem in ſinus cerebri.*

g g *Duo*

g g *Duo ductus immediate extra calvariam per quos glandula pituitaria in humano cerebro aquam, quam a ventriculis cerebri excipit, in venam jugularem utrinque exonerat.*

h h *Venæ jugulares.*

At verò quocunque modo ſive in ſinibus ſive in venis ſiſtitur, malum tamen in cerebrum reſilit, atque inibi futuris morbis & materiam congerit & fomitem abunde ſubminiſtrat; quippe ſerum ob hujuſmodi cauſas inter anfractus cerebri accumulatum, piam matrem eouſque diſtendit, donec tandem vel acrimoniâ ſuâ eam erodit, vel copiâ ſuâ perrumpit; unde in baſin cerebri defluxens, medullam oblongatam atque nervos ex ea ortos, ſtagnatione ſua corrumpit, aut acredine ſuâ continuo laceſſit; unde hydrops cerebri, convulſiones & dirus mortis apparatus in capite accumulatur: Si verò ſerum illud a ſubſtantiâ cerebri imbibatur, paralyſes, ſenſuum torpores, lethargum, ſomnolentiam, alioſque graves affectus capiti inducit.

Præterea, cum ventriculus quartus cerebello ſubjectus, multo declivior & magis in profundo ſitus ſit quam reliqui in cerebro ventriculi, & quam ipſum etiam infundibulum; ideò fit ut lympha in ventriculos cerebri e plexu choroeide ſecreta, in ventriculum quartum reliquis magis declivem, potius quam infundibulum defluat; præſertim ſi capite reclinato ſomnum quis capiat; ex quo quidem humorum decubitu cavitas illa plurimum repletur, & eouſque aggravatur, ut, ponderis ejus ſenſu nervis præcordiorum communicato, ſæpe cordis oppreſſio, & incubus inducantur. Atque ideò ſolenne eſt hydrocephalis ferè omnibus, ut nunquam ſupini impunè dormiant; quin in latus hoc aut illud decumbere cogantur, quo melius hujuſmodi moleſtias prævertant: Imo novi quendam incubo olim maximè obnoxium, virum alias robuſtum & ſatis ſanum, qui per duos annos nunquam in dorſum converſus dormivit, quin ſimul affectu iſto corriperetur; adeò ut neceſſe haberet ſervum contubernalem

tubernalem in eodem lecto decumbentem admittere, qui ſtatim ac gemitus & ſuſpiria, quibus affectus iſte incipere ſolebat, exaudiret, ipſum in latus alterum converteret; quo quidem factum eſt ſemper ut inſultus iſti præcaverentur.

Quin & plurimos infantes recens editos, ſi motibus convulſivis obnoxii fuerint, nunquam diu aut placide in cunis dormire, ſed variis ſpaſmis & artuum ſubſultibus corripi obſervare eſt. Cujus quidem hæc cauſa videtur, quod ſiquidem eorum cerebra multâ aquâ abundent, ex hujuſmodi ſupino decubitu, qualis in cunis eſt, aqua in ventriculis cerebri contenta propter ſitum magis declivem in ventriculum quartum potius quam ad infundibulum defluit, & proinde medullam oblongatam (ex quâ nervi præcordiorum oriuntur) valde aggravat, & comprimendo illam, ſpirituum in nervos tranſitum impedit; unde cordis gravamen, & motus convulſivi tandem ſuccedunt. Atque hoc ideò magis veriſimile eſt, quia in contrario ſitu, ſc. intra ulnas nutricum, vel in earum ſinu, ubi caput magis attollitur, placide & ſecure magis obdormiunt: Hoc ipſum præterea obſervare contigit in Academico *Oxon.* 4. ab hinc annis hydrope pectoris extincto; qui poſtremo morbi decurſu, ſomnum niſi pronâ facie & inclinato capite capeſſere non potuit; ſi enim capite in pulvinar reclinato ſomno ſe componeret, intra tertiam horæ partem horrendis inſomniis & terroribus triſtis ſemper evigilavit; quin & tremore cordis & ejuſdem oppreſſione maximâ diu poſtea afflictus fuit. In cerebro autem poſt mortem aperto ventriculi aquâ ſummè diſtenti reperiebantur, nulla autem præterea notabilis culpa in toto capite apparuit.

Et ſiquidem pluribus experimentis certò mihi conſtet nihil catarrhi a cerebro in partes inferiores ullas deſcendere, priuſquam hic de tabulâ manum aufero, operæ prætium erit oſtendere quâ viâ atque ductu aqua omnis e plexu choroeide & glandulis pone cerebellum in ventriculos cerebri, &

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per infundibulum in glandulam pituitariam depoſita & percolata, extra calvariæ limites deſcratur. Et quidem in cranio vitulino olim expertus ſum aquam aut lac ipſum in foramina, in oſſe calvariæ pro ſero a glandulâ excipiendo excavata, injectum, ſtatim omne in venas jugulares utrinque exilire & effundi; adeò ut humor omnis a cerebro ſecretus in hoc animali in ſanguinem denuò redundet, atquè exoneretur: Quòd ipſum in cranio humano nuper etiam expertus ſum; quanquam enim in oſſe calvariæ humanæ, glandulæ huic ſubjecto, foramina occurant nunquam, at membrana in quam recumbit, pluribus in locis ad modum cribri perforatur, per quæ aqua deſtillans ab aliis vaſis ex utroque ſellæ turcicæ, ut vocant, latere, ubi arteriæ carotides juxta aſcendunt, hiantibus quaſi oſculis excipitur, & in venas jugulares utrinque paulò infra ſinum tortuoſum effunditur; quorum ductus facile patebunt, ſi aqua aut lac e ſyphone in venam jugularem utramvis paulo infra tortuoſum ſinum vi injiciatur, mox enim conſpicietur, prope glandulam pituitariam diverſis in locis erumpere atque ſcaturire: certo utique indicio, quicquid ſeri a cerebro ſecernitur, in ſanguinem denuò refundi, eique commiſceri.

CAP. III.

Sanguinis Motus & Color.

De celeritate circulationis & quæ ſit differentia inter ſanguinem venoſum & arterioſum.

POſtquam ad hunc modum conſtitit qualis cordis fabrica ſit, unde ejus motus provenit, quibuſque de cauſis motus ejus alteretur, & quales effectus & ſymptomata alterationes iſtæ ſanguini inducant, reſtat ut quàm celeri curſu ſanguis omnis per cor circuletur proximè oſtendam.

De

De motu ſanguinis per ventriculos cordis quæcunque ante *Harveium* authores tradiderunt, tam inania & futilia ſunt ut ſponte ſuâ jam evanuerint: Quinimò & inter poſteros qui inventam ab ipſo circulationem amplexi ſunt, utcunque, ipſa hypotheſi cogente, totum ſanguinem tranſire cor & circulari ſtatuunt, de tranſitûs tamen celeritate & quantitate ſanguinis qualibet vibratione expreſſi ita ſcripſerunt, ut fabricam cordis motuſque ejus non ſatis attendiſſe videantur: Nam plerique guttulas aliquot, aut ſcrupulum, aut drachmam unam, pauci ſemiunciam tantùm ſanguinis ſingulis pulſibus expelli concedunt. Et quidem fatendum eſt in diverſis animalibus pro variâ corporis magnitudine, cordis ventriculos plus aut minus continere & ejicere; verum in homine aut majore quovis animali tam exiguam quantitatem quolibet pulſu tranſmitti, quàm ſit inconſultum aſſerere ex ſequentibus patebit.

Equidem in eâ opinione ſum totam ſanguinis maſſam qualibet horâ non ſelem ſemel atque iterum ſed ſæpe cor trajicere, quod ut magis perſpicuum reddatur, ſedulò advertendum eſt quantum ſanguinis in cordis ventriculos, quoties dilatantur, influit; quantumque ex iis, dum conſtringuntur, effunditur: Cùm autem in omni diaſtole ventriculos ſummâ diſtenſione dilatari ex autopſiâ appareat, contra verò in ſyſtole cordis latera tam ſtrictè invicem coire & coarctari ut digitum minorem (ſi cono abſciſſo intromiſeris) ipsâ manu vix fortius comprimas; hinc eſt quòd certiſſimum arbitrer utrumvis ventriculum in diaſtole tantam ſanguinis copiam, quantam capere poteſt, recipere; in omni autem ſyſtole, quicquid prius receptum eſt, totum penitus expellere. Atque hoc quidem in cordibus & auriculis animalium recens editorum, ranarum, anguillarum, & ſerpentum oculis ipſis plane obvium & perſpicuum eſt; quippe quorum corda & auriculæ in qualibet ſyſtole, excuſſo omni ſanguine, ita penitus deplentur ut prorſus albæ appareant; rubicundus verò color in diaſtole (cum ſanguis iterum

iterum in eas influit) per vices ipsis redit; quin & idem cordibus majorum animalium contingere extra dubium est, licèt ob parenchymatis crassitiem tam claré oculis percipi non possit.

Quo supposito si pulsus etiam numerentur, haud arduum erit conjicere quantum sanguinis intra horæ spatium per cor trajicitur; supponamus itaque in sano & vegeto homine cordis ventriculum sinistrum duas uncias, prout *Clariss. Harvæus* observavit, simul capere (quanquam multò capaciorem in aliquibus sæpe observaverim) & si tota illa sanguinis quantitas in omni systole e corde expellatur; numeratis intra horam duobus millibus pulsuum (quæ quidem minima omnium computatio est) necesse est sanguinis uncias quatuor mille intra horam cor trajicere. Totidem verò unciæ trecentas triginta & duas libras constituunt, dato autem in hoc homine viginti quinque libras sanguinis inesse (quæ major est quantitas quàm plerisque hominibus a naturâ aut ab Anatomicis concessa est, dicunt enim

enim totius sanguinis in corpore humano contenti mensuram raro viginti quatuor libras excedere, aut minorem esse libris quindecem) certissimè sequetur, totum hujusce hominis sanguinem intra unicam horam sexties per cor circulari. Verum cùm raró accidat tantam sanguinis copiam homini sano inesse, aut cor tam paucis pulsibus intra horæ decursum moveri, rationi consonum est sanguinem in plerisque aliquanto sæpiùs quàm cordis ventriculos sexties pertransire.

Atque ita se habet in omnibus animalibus modo integra valetudine fruantur; aliquando autem multò celerius prout in febribus, exercitio violento, & motu cordis convulsivo transire putandum est; pulsus enim tunc longè velociores sunt, & proinde sanguis duplo sæpiùs trajicitur. E contra autem in ictero, scorbuto, aliisque hujusmodi affectibus, propter quos cordis motus languidus & inæqualis evadit, aut si quando vasa & ventriculi ejus chylo grumescente inferciantur, sanguis multò tardius pertransit; Quinetiam respectu

ſpectu temperamenti, ſexûs, & ætatis pulſus variari ſolet, ut trajecti ſanguinis menſuram, atque circuitûs vices accuratè æſtimare atque definire impoſſibile ſit; at in ſanis & robuſtis animalibus ſanguinem multò velocius ferri & cor ipſum pervadere, quam vulgò creditur aut hactenus ſcriptum eſt, ipsâ ventriculorum cavitate & pulſuum numero ſatis patet: Atque ita omninò fieri debuit, ſi partes ſanguinem ipſum conſtituentes, & niſi perpetuo & concitato motu exagitentur, ab invicem ſecedere & grumeſcere aptas quis recte perpendat.

Verùm ne quis hæc ita dicta intelligat, quaſi ſanguinis portio aliqua, utpote quæ vaſis cordi propriis aut vicinioribus, & ab ejus fonte non adeò remotis feratur, non multò citius & frequentius, quàm reliquus per extrema corporis delatus, per cor circuletur; ipſa enim vaſorum & partium vicinitas aliud arguit. Verùm hoc eſt quod contendo, licèt omnes ſanguinis partes non æquis paſſibus aut tot vicibus per cordis ſinus deferantur, quæcunque

tamen

tamen ea ſanguinis copia aut quantitas fuerit, tantam certe & toties per cor circulari, prout prius dictum eſt.

Quàm celeri autem paſſu ſanguis omnis a corde per totum corpus trajicitur, non aliunde facilius eſt concipere, quàm ex ſeri cum eo mixti citiſſimo per renes decurſu: Quippe cùm duæ vel tres libræ cereviſiæ matutino hauſtu in ventrem demiſſæ intra ſemihoram ferè totæ, & citius multò ſi frigida tempeſtas fuerit, a veſicâ iterum reddantur; & cùm ſerum illud plerumque dimidiata tantum ſanguinis in renes delati pars fuerit, quidni aſſerere fas ſit quatuor vel ſex libras ſanguinis ſero diluti per duas arterias emulgentes (ut vocant) in renes a corde tranſmitti. Si autem per vaſa tam parva, ſi cum reliquis conferantur, tanta liquoris ſanguinei copia tantillo ſpatio pertranſeat, haud arduum erit intelligere, quàm concitato motu reliqua ſanguinis maſſa omnis in cæteris corporis partibus feratur: Quod magìs adhuc manifeſtum apparet in iis qui aquas acidulas minerales tantâ

copiâ

copiâ exhauriunt, ut aliquos noverim qui duos ferè congios aquæ unico mane partitis haustibus epotaverint, atque intra quatuor horas totam ferè iterum per vesicam reddiderunt. Quæ aquæ copia sanguinis quantitatem in plurimis hominibus plus duplo excedit, & pariter certum est eam per utrosque cordis ventriculos unà cum reliquo sanguine sæpius pertransiisse, antequam per renes secerni, aut a vesicâ deponi potuit: neque enim alius a ventriculo & intestinis liquori cuilibet nisi per cor & sanguinem in renes & vesicam transitus aut via a naturâ conceditur; si autem tantâ copiâ aquæ (quæ ut prius dictum dimidiata tantùm sanguinis in renes delati portio est) tam exiguo tempore & per tam exiles arterias pertranseat, quid precor de reliqui sanguinis transitu per vasa omnia majora existimandum est?

At neque conjecturis solùm sed & experimentis insuper demonstrare facile est celerem hunc sanguinis a corde projecti motum; si enim sanguis ex unicâ arteriâ cervicali apertâ

intra

intra duodecimam horæ partem ferè totus effluat, quidni conjicere licèt, totam ſanguinis maſſam multo breviore ſpatio per cor circulari: Qui enim tam citò per unicum arteriæ ramum ferè totus effunditur, quanto citius idem ex trunco aortæ, aut omnibus ejus ramis ſimul diſciſſis efflueret?

Sed ut accuratè magis ſanguinis curſus & admiranda celeritas æſtimetur, experimentum hoc unicum proferri ſufficiet. Nimirum in cane majore utramque arteriam cervicalem diſcidi, ſimulque per orificium in ſiniſtro pectoris latere e regione cordis factum digito aortæ truncum infra cor compreſſi ne quid ſanguinis per illam deſcenderet, & arterias denique brachiales ſub axillis coarctari curabam, quo factum eſt ut omnis ferè ſanguis per cervicales (præter illum in vertebrales tranſmiſſum) e corde impelleretur; atque mirum dictu, intra vigeſimam horæ partem totus effluxit; adeò ut negandum non ſit omnem ejus maſſam iſto ſpatio cor tranſiiſſe: Quinetiam obſervare

ſervare eſt in vulneribus, ubi arteria aliqua magna diſcinditur, quàm brevi momento ita truncati ſanguinem ferè omnem cum animâ profundunt, quem tamen neceſſe fuit totum priûs per cordis ventriculos circulari.

Verùm hic objici video cor inter hujuſmodi vulnera & torturas multò celerius pulſare & proinde ſanguinem multò citius trajicere; at ſi ſanguis, poſtquam iſtæ inciſuræ factæ ſint, paulò ſupprimatur, adeò ut dolor omnis & metus priùs evaneſcant, quod citò in junioribus canibus fit, qui hujuſmodi injurias neque tam ægrè, nec tamdiu in animo ferunt, pulſum cordis non ita corripi & accelerari certum eſt. Et revera licèt fatendum ſit, poſtquam plurimus ſanguis profuſus eſt & animal pœne fatiſcere incipit, pulſum celeriorem reddi, id tamen non antea fit, quam vaſa omnia ita depleta fuerint, ut reliquus cordis ventriculis ſatis implendis non ſufficiat; atque ideò pro continuo ſanguinis diſpendio pulſus continuò minor & crebrior redditur, uſque dum ſanguinis influxu penitus deficiente etiam cordis motus omninò ceſſet.

Si autem objiciatur ſanguinem facilius & proinde citiùs ex arteriâ diſciſſâ effluere, quàm per habitum corporis circulari; cum illic libero & pleno torrente, hic non niſi per varios anfractus & obices, & ipſius quoque carnis anguſtias atque poros in venas feratur, non alio forſan diſcrimine, ac cum fluvius aperto alveo magis celeriter decurrit, quàm ſi per cribrum trajiciatur.

At huic objectioni facile erit referre, quod, non obſtantibus viſcerum & habitus corporis anguſtiis, ſanguis licèt non æquè celeriter a venis ac ab arteriis apertis effluat, in ipſis tamen venæſectionibus quamdiu cordis motus viget, non multò tardius effunditur; quippe in canibus ſæpenumero expertus ſum, ſi collo arctè ligatò & aortæ trunco infra cor, prout factum prius, compreſſo, quo fluxus ſanguinis in caput dirigatur, vena jugularis altera diſcindatur, pari pœne ſpatio ac copiâ ex venâ iſtâ, ac ex arteriâ cervicali

vicali detrahetur, ſaltem uſque dum maxima pars ſanguinis adimitur: Poſtea verò cum ob tantum ejus diſpendium, cordis motus oblangueat, reliquum, prout debilius a corde propelli, ita multò parciùs & tardiùs e venâ quoque profluere agnoſcendum eſt.

Poſito autem tam celeri ſanguinis circuitu (quem etiam me ſatis probaſſe arbitror) utique non apparebit tantum eſſe diſcrimen inter ſanguinem arterioſum & illum in venis contentum, quantum vulgo creditur.

Qui ſunt utriuſque ſanguinis varii reditus, & vectigalia ex quibus conſtant, alibi a me dictum eſt, eodemque in loco diſſerui de coloris diverſitate & a quâ causâ differentia hæc inter utrumque maximè notabilis procedit; Verùm cum pro tuendâ & continuandâ nimis per omnia biolychnii cum lampade analogiâ, Doctiſſ. *Willisii* authoritati & præconceptæ opinioni, quàm propriæ encheiriæ hac in re magis confiſus fuerim, atque longior dies me aliud jam edocuit, ſententiam priorem meliore mutare non pigebit; neque enim aliorum dogmata & opiniones vexare, aut propriam mutando mihi ipſi ludibrium facere in animo eſt, ſed quid ratio ſuggerit & experientia confirmat, apud me plus valuit & ſemper obtinebit.

Itaque coloris diverſitatem quæ inter ſanguinem venoſum & arterioſum invenitur, a ſanguinis in corde accenſione (ſi qua tamen illic concedenda ſit) neutiquam dependere certum eſt: Poſito enim illam potiſſimùm in corde fieri, cum par ſit utriuſque ventriculi officium, neque alios ob uſus quàm ut ſupra dictum eſt fibrarum robore & craſſitie diſcrepent, quidni color in dextro pariter immutari debuit? At certò conſtat ſanguinem ex arteriâ pulmonali eductum venoſo per omnia ſimilem eſſe, craſſamentum ejus nempe atri coloris eſt, & ſuperficie tenùs ſolùm rutilat: Quinimò nec a ſiniſtro cordis ventriculo novum hunc ruborem ſanguini impertiri certiſſimo experimento conficietur; ſi enim aſpera

arteria

arteria in collo nudara discindatur, & immisso subere arctè desuper ligetur, ne quid aëris in pulmones ingrediatur, sanguis ex arteria cervicali simul discissâ effluens (saltem qui aliquandiu post præfocatum pulmonem erumpet) totus venosus pariter & atri coloris perspicietur, non aliter quàm si ex venâ jugulari pertusâ profusus esset. Hoc ego sæpius expertus sum, idemque ex eo adhuc clariùs apparet quōd sanguis intra sinistrum cordis ventriculum & aortæ truncum strangulati animalis aut morte naturali confecti, in quo aëri in sanguinem commeatus præcluditur, totus venoso similis semper reperitur.

Postremo ne quis ultra vel dubitandi locus supersit, experiri animum subiit in cane strangulato, postquam sensus illum & vita omnis deseruerunt, an sanguis adhuc fluidus in venâ cavâ undique in dextrum cordis ventriculum & pulmones impulsus, pariter floridus per venam pneumonicam totus rediret; itaque propulso sanguine, atque insufflatis simul, nec non

& perforatis pulmonibus, expectationi eventus optimè respondit, siquidem æquè purpureus in patinam redditus est ac si ex arteriâ viventis detraheretur.

Quemadmodum verò sanguinis arteriosi colorem floridum & purpurascentem non ab accensione in corde ullâ, aut alibi alias acquiri ostensum est, ita neque ater sanguinis venosi color ab ullâ ejus in venis extinctione dependet: Si enim hoc fieret quidni sanguis arteriosus postquam extravasatus est, cum jam procul omni dubio penitus extinguatur, similem colorem obtineret.

Quocirca cum ita se res habeat, proximo in loco videndum est, cui tandem sanguis acceptum refert quòd colore tam rutilo & purpureo penitus imbuatur: Atque hoc pulmonibus totum tribuendum est, siquidem expertus sum sanguinem, qui totus venosi instar atro colore pulmones intrat, arteriosum omninò & floridum ex illis redire; si enim abscissâ anteriore parte pectoris & folle in asperam arteriam

riam immiſſo pulmonibus continenter inſufflatis, &, quo liber per eos aëri tranſitus fiat, acu ſimul undique perforatis, vena pneumonica prope auriculam ſiniſtram pertundatur, ſanguis totus purpureus & floridus in admotum vaſculum exiliet; atque quamdiu pulmonibus recens uſque aër hoc modo ſuggeritur, ſanguis ad plures uncias, imo libras per totum coccineus erumpet, non aliter quàm ſi arteriâ pertusâ aliquâ exciperetur. Quòd verò ſanguinem e venâ pneumonicâ detractum venoſo ſimilem prius ſcripſeram, id etiam expertus dixi, ſed cum pulmones perforatos continentèr inſufflando animali vitam tamdiu conſervare nondum experimento mihi innoteſceret: Adeò ut aër omnis e pulmone prius excluſus fuerit, quàm venam pneumonicam arripere & pertundere potuerim: Quod experimentum quo pulmones in continuâ diſtentione, ſalvâ interim animalis vitâ, diu continentur, Celeberrimo Domino *Rob. Hooke* deberi, atque inde mihi ansam hujus conficiendi datam esse agnosco.

Verùm si quis comminutioni sanguinis in pulmonibus, potius quàm aëris cum sanguine mixtioni, floridum hunc ipsius colorem tribuendum esse contendat, perpendere oportet an revera sanguis in pulmone magis quàm in corporis musculis, si omninò æquè, comminui atque confringi possit; quippe cum pulmones in continuâ dilatatione ad experimentum hoc rectè conficiendum contineantur, non video quomodo aliter quam per poros eorum transeundo, sicut in reliquo corporis habitu, comminuatur.

Præterea colorem hunc rutilum particulis aëris sese in sanguinem insinuantibus omnino deberi ex eo satis perspicuum est, quòd sicut in pulmonibus per totum floridus redditur, quia in illis aër per omnes sanguinis particulas diffusus cum ipso intimiùs permiscetur; ita sanguinis venosi in vase excepti superficies & pars summa, quatenus aëri exposita est, coccineum quoque colorem

colorem aquirit: Quæ ſi cultello auferatur, proxima quæ ſubjacet a ſimili aëris contactu in eundem brevi mutabitur. Quinetiam ſi placenta ſanguinis poſtquam diu reſederit, invertatur, brevi ſpatio cuticula ejus exterior & ſumma (dummodò ſanguis ſit incorruptus) purpureum colorem induit, quin & vulgò notum eſt ſanguinem venoſum in patinâ exceptum & diutina agitatione commotum, quo aërem penitius intromittat, purpureum omninò evadere: Nec miretur aliquis ſecretionem aut admixtionem aëris ſanguini tantas colorum mutationes conciliare, cum videamus alios etiam liquores, prout eorum pori lucis radios plus minuſve excipiunt aut refringunt, diverſas quoque colorum ſpecies ſortiri.

Si per quos pulmonum meatus ſpiritus aëris nitroſus in ſanguinem tranſit, eumque copioſiùs imbuit, a me quæras, oſtende & tu mihi quibus porulis alter ille ſpiritus nitroſus qui in nive eſt, per delicatulorum pocula tranſit & æſtiva vina refrigerat: Quòd ſi

vitrum

vitrum aut metallum ſpiritui huic non ſint impervia, quantò faciliùs laxiora pulmonum vaſa penetrabit? Denique ſi fuliginibus & ſeroſo humori exitum non negamus, quidni per eoſdem porulos vel ſimiles nitroſo huic pabulo introitum in ſanguinem concedamus.

Quare ſanguinem in ſuo per pulmones tranſitu aërem haurire, ejuſque admixtioni floridum ſuum colorem omninò debere maximè veriſimile eſt; poſtquam autem in habitu corporis & viſcerum parenchymatis aër rurſus a ſanguine magnâ ex parte avolavit, atque per poros corporis tranſpiravit, ſanguinem venoſum illo privatum obſcuriorem & nigriorem illicò apparere, rationi pariter conſentaneum eſt.

Ex quo conjicere facile eſt, quantum ſanguini beneficium ab admixto aëre accedat, quantumque interſit, eum ſalubrem ſemper & ſerenum haurire, quantumque aberrant illi, qui aëris hoc cum ſanguine commercium omninò negant; abſque quo fieret ut poſſet aliquis non minus ſalubriter verſari in pædore carceris quàm inter

amæ

amæ miſſima vireta, ubicunque ſc. ignis ſat commodè ardere poteſt, ibi & nos æquè commodè reſpirare.

CAP. IV.

De Transfuſione Sanguinis ex animali alio in aliud: Quo tempore & quâ occaſione ab Anthore inventa ſit.

QUæ hactenus dicta ſunt de ſanguine ea pertinent ad *circularem* ejus *motum*, qui intra *ſphæram unius corporis* abſolvitur; Nimirum collatis quaſi rationibus accepti atque expenſi, menſuram liquoris & temporis ſpatium, quo *ſanguis* per *ventriculos cordis* e venis in arterias *ejuſdem animalis* trajicitur, ad calculos revocavimus. Nunc quòd porrò tradituri ſumus, *De ipſius transfuſione ex hoc in aliud*

aliud animal neſcio ante triennium proximè elapſum, an cuiquam injecta ſit aut perficiendi ſpes aut experiendi cogitatio. Nam & poſtquam in publicum propoſita res eſt tanquam magnos uſus in medicinâ habitura ; plerique tamen operis difficultate abſterriti & novitate perculſi, aut manus ab experimento abſtinebant prorſus, aut fruſtra admovebant: Ut tandem veluti obſoleta *Pythagoræ* fabula, & vanior altera μετεμψυχωσις optari potiùs ab inconſultis quam a ſapientibus ſperari videretur.

Itaque lubet mihi rem totam, ut geſta eſt, exponere, ſimulque oſtendere, & quâ ratiocinandi ſerie, a me primum *excogitata* atque *ſuſcepta*, & quibus demum mediis & auxiliis *ad effectum perducta ſit*.

Complures anni ſunt cum alios *Oxonii* viderim, & ipſe experiendi causâ, varios liquores opiatos, emeticos, multoſque id genus medicinales in vivorum animalium venas injecerim; quo id fiat artificio jam ſatis notum, nec hujus loci eſt dicere quos

eventus

eventus atque exitus singula experimenta habuerint: Cum verò insuper plures alimentares succos simili modo infuderim, atque cum variis vini, tum cerevisiæ injectionibus sanguinem diversorum animalium satis aptè & amicè congruere vidissem, animum mox subiit experiri, annon multò magis sanguis diversorum animalium inter se conveniret & sine periculo aut luctâ commisceretur. Et quoniam in cruore extravasato (utcunque satis præcaveri posset, crebrâ agitatione, ne coaguletur) nativa tamen crasis partiumque textura ut immutetur necesse est; idcirco longe mihi commodius videbatur, animalis vivi & adhuc spirantis sanguinem illibatum in aliud transmittere; quod etiam facilius peragi videbatur, quod motum sanguinis per vasa sua tam citatum & rapidum, ut in momentis aliquot totam ferè sanguinis massam quâ datâ portâ effluere observassem; Quare spem hinc animo concipiens ad experimentum ejus tentandum animum & manus adhibui.

Et

Et primùm fiſtulis hinc inde adaptatis a venâ jugulari hujus, in jugularem alterius tranſmittere conatus ſum; ſed cum propter languidum ſanguinis venoſi motum, eum in fiſtulâ concreſcere ſtatim & ſibi ipſi viam obſtruere viderem, mox aliam viam tentare cæpi & præeunte quaſi ipsâ naturâ ſtatui tandem ex arteriâ unius in venam alterius ſanguinem tranſvehere, novoque hoc artificio ipſius circulationem quaſi ultra præfinitos limites extendere.

Quocirca cum ex voto omnia expectationi reſponderent, tandem *Oxonii* ſub finem *Februarii*, anni 1665. præſentibus Doctiſſ. viris Doctore *Iohanne Wallis* Mathematices Profeſſore *Savilliano*, Domino *Thomâ Millington*, Medicinæ Doctore. Aliiſque ejuſdem Academiæ Medicis experimentum hoc novum jucundo ſane ſpectaculo atque optimis auſpiciis exhibui.

Nimirum comparatis canibus, cæteriſque quæ ex uſu eſſe videbantur, ex eorum uno mediocris magnitudinis,

apertâ

apertâ venâ jugulari, ſanguinem eouſque detraxi, donec ejulatu & ſummâ contentione vires jam fatiſcere & ſpaſmos imminere ſatis conſtaret: Deinde ut tanto hujus diſpendio alterius ſanguine ſubvenirem, e cervicali arteriâ moloſſi majoris ad latus ipſius alligati atque compoſiti ſanguinem eouſque immiſi, uſque dum ab irruentis ejus copiâ ſeſe impleri nimis atque opprimi inquietudine ſuâ rurſus fateretur: Quocirca arteriâ immittente iterum ligatâ, e cane recipiente rurſus ſanguinem detraximus, quod alternis vicibus toties repetitum eſt, donec in duobus majoribus moloſſis, (quorum utriuſque ſanguinem minor canis exceperat) nec ſanguis amplius nec vita ſupereſſet: Interea ut minor iſte, licèt tantum ſanguinis per vices ipſi detractum ſit immiſſumque, quantum opinor totius corporis pondus æquaret, jugulari tamen conſutâ, & vinculis, quibus detinebatur, ſolutis, a mensâ protinùs deſiliit, & quaſi injuriarum oblitus mox domino ſuo adblandiri, & quò a ſanguine ſe mundaret, in gramine

mine ſeſe volutare, non alitèr omninò, neque majore incommodi aut offenſæ indicio, quàm ſi in profluentem ſolummodò conjectus fuiſſet.

Horum fama cum mox *Londinum* pervolaret, acceptâ Epiſtola a *Clariſſimo Boylæo* impenſè rogatus ſum, ut totius experimenti methodum *Societati Regiæ* Impertirem, quòd non ita multò poſt a me præſtitum, in *Philoſophicis* ejuſdem Societatis *Tranſactionibus Decembre inſequente anno* 1666. publici juris factum eſt. Et tum rumor ejus ad exteras gentes & *Galliam* pervagatus eſt, ubi mox rei novitate allecti diligentiùs illam proſequi, & aliis ſubinde experimentis augere, illuſtrare, quodque ego ſolùm in brutis perfeceram, ad hominis uſum accommodare cæperunt; uti in ſcriptis illorum *Seq. Martio*, *anni* 1667. tunc primùm editis apparet: Atque hæc ſatis bene & ad gentis iſtius laudem quòd philoſophiam & medicinam quoquo modo ornare vel adaugere ſatagunt. Verùm cum per hominum ora jam ubique volitet hæc nuper inventa

venta sanguinis transfusio, & *Dionysius* quidam Philosophiæ & Mathematices Professor, in Epistolâ nuper editâ celeberrimi hujus experimenti inventionem mihi præripere & sibi arrogare conetur: Ut quo jure, quâve injuriâ id fecerit, lectori appareat, liceat *Clarissimi Boylæi* ad me literas & meum ad eas responsum hic loci inferere:

LONDINI, *Junii* 26. 1666.

A*Deram (vir Clarissime) proximo die Mercurii, in solenni Societatis Regiæ conventu, in Collegio* Greshamensi *habito, ubi cum a D. D*^{re}. Wallis *exaudiveram, difficillimum illud experimentum de sanguine ex Canum altero in alterum transmittendo te tandem (se præsente) feliciter absolvisse: Rem planè dignam judicavi quæ celeberrimo isti cœtui innotesceret. Adeóque author eram ut illi, a Reverendo viro, rei prout gesta fuerat narrationem exigerent: Cujus* *ille eam reddidit rationem quæ apud nos existimationem famæ tuæ non parum commendaret. Verùm de tam insolito & insperato conamine varia particulatim interrogatus, expedire potiùs censuit, ut tu de singulis scripto responderes, quàm ille vivâ voce. Quapropter & ego coram indicabam, te mihi dudum pollicitum esse, rem illam (siquando votis responderet) te mihi enarraturum: Quod & te præstiturum in me suscepi; idque eo pleniùs cum cœtum hunc tam celebrem de ejusdem successu accuratius enarrando solicitum intelligeres. Hoc itaque ut jam dignari velis obnixe rogo, totamque hujus negotii peracti methodum ordine exponere, quâ tam prosperè successit. Quod eo presiùs urgeo, quod ingeniosi admodum viri aliquot & satis Critici, nec creduli nimiùm, rem arduam judicaverint, & audacter dictum, cum ego ante aliquot menses obiter indicaveram, a Societate Regiâ ad id rogatus, quid tu antehac jam tum* Oxoniæ *tentaveras; & quanquam tum temporis, propter instrumentorum apparatum non satis idoneum,*

neum, non per omnia res ex voto successe-rat; Non desperasse tamen me, quin illud postmodum absoluturus esses. A-vocor ego jam hoc momento, ut non vacet mihi veniam deprecari quòd hæc tibi fa-cesserim negotii. Quod tamen eo minus invitus feci, quoniam tuo non cessurum incommodo judicavi si hâc occasione tam auspicatâ celeberrimus hic cœtus te cog-noverit. Inter quos complures sunt qui te & debitè æstimant & amicè colunt; & quidem præ cæteris,

Tui amantissimus

Rob. Boyle.

Amico plurimum honorando
D. *Richardo Lower*, Medi-
cinæ Doctori, tradantur,

Oxoniæ.

OXONII, *Julii 6.* 1666.

ACcepi literas tuas, Honoratissime vir, & prout a me expetis, totam transfusionis methodum eodem, quo ipse ordine perfeci, tibi breviter exponam; Itaque canis aut cujuscunque animalis sanguinem lubet in aliud seu ejusdem seu diversi generis transfundere, primò attollatur Arteria Cervicalis *altera, eademque a nervo octavi paris separata ferè ad digiti longitudinem denudetur: Deinde pars ejusdem superior cerebrum versus vinculo stringatur firmo arctoque utpote quod laxare iterum aut solvere per totum operationis processum non opus est. Mox inferius quà cor respicit, eidem vasi ad distantiam semidigiti a prædicto vinculo altera colligatio aptetur* nodo *ita* solubili, *ut pro datâ occasione, vinculum adducas cum velis aut remittas. Ligaturis ad hunc modum ex utrâque parte dispositis & spatio intermedio duobus filis sub arteriâ trajectis scalpello ipsa aperiatur & calamus inci-*

sura

suræ cor versus inseratur, cujus exterius foramen ligneo bacillo obturandum est: Arteria autem, quà calamo incluso superjacet filis istis arctius circumductis firmiter vinciatur.

In altero animali quod prioris sanguinem admittere oportet, denudanda est Venæ Jugularis *portiuncula semidigiti longa, cujus utrique extremo adhibenda ligatura nodis utrinque ita connexis, ut ad libitum laxare possis aut constringere; quorum insterstitio bina quoque fila subter venam ducenda sunt, exinde factâ incisione, foramini duo Calami Inserendi, quorum alter truncum venæ descendentem spectans cruorem ex alio cane influum excipiat atque ad cor deferat; alter sursum versus cerebrum intrusus proprium hujusce Animalis sanguinem in scutellas effundat: Utrumque autem, non nisi ex occasione aperiendum, ligneo interim epistomio obturare oportet, & filis denique, ut supra, venam circumligare.*

Quo facto tandem ipsi canes in latus inclinati juxta se invicem quàm commode fieri potest ita deligentur, ut calamorum unum alter excipiat: Verùm quia *obtortis collis tam prope admoveri non poßint, ideò præter extremos duos calamos, aliquot intermediis opus eſt, quibus & copulentur illi & ſanguis tranſvehatur.*

Jamque rebus ad hanc rationem inſtructis atque apparatis, jam primùm aperiantur duo calami, nempe in hoc Animali is qui in venam *ipſius* Jugularem *deſcendit; in altero qui prodit ex* Arteriâ *ejus* Cervicali; *inter quos poſtquàm alii, quot uſus erit, interjecti ſunt atque invicem coaptati, ſi in utroque laxentur* Nodi, *quos pro arbitrio* Solubiles *eſſe jußimus, ſanguis illicò per calamos, non alitèr quàm per continuatam arteriam factâ veluti Anaſtomoſi, impetuoſiùs tranſilit: Quamprimum igitur* Animalis recipientis *collum laqueo ſtrinxeris, ut fieri ſolet in Phebotomia, aut ſaltem in oppoſiti cervicis latere venam digito compreſſeris, exempto protinùs obturaculo aperiatur* Calamus Jugularis ſuperior, *nimirum ut, ſanguine alieno per* Inferiorem *irruente, proprius interim ex iſto in patellas effluat (partitis tamen hoc vicibus atque interpolatim habitâ ſemper* ἐυφοϱίας *& virium ratione) donec tandem*

dem alter canis inter ejulatus, languores, & spasmos postremò animam cum vitali succo effuderit.

Peractâ hâc Tragædiâ, e Iugulari superstitis Animalis eximatur uterque calamus, nodisque, qui prius erant solubiles, jam firmiùs obnexis discindatur vena, id quod fieri potest nullo ferè Canis incommodo, eò quòd, Iugularium circa laryngem prælargâ existente ἀναστομώσει, *una earum sufficiat sanguini e capite deferendo. Disscisso vase consuatur cutis, laxentur vincula, & permittatur cani prosilire è mensâ: Enimverò ille tanquam suscitatus e somno, concusso paululùm corpore, vivus valensque abit alterius sanguine alacrior forte & vegetior quàm suo.*

Vnicum hoc insuper monendus es, Præstantissime vir, siquidem calami non ita strictè vasis alligari aut sibi invicem adaptari possent, quin ex animalium contentione laxari atque solvi denuò & sæpe contingat; ideò consultius duxi in posterum fistulis argenteis in hoc constructis omninò uti: Quæ ne a vasis, quibus inseruntur, rursus avelli possint, ideò in altero extremo, circulari aliquo annulo *eminenti, & quò ſecuriùs vaſa deſuper ſtringantur, eo duplici firmentur, qualem* Tab. 7. fig. 1. *exhibet. Et quo minore Transfuſionis incommodo, ſive vaſorum periculo aut impedimento, præſertim ubi animalia variè ſe jactant & contorquent, res peragatur, uniendæ ſunt per duas minores fiſtulas inſerendas Arteriæ Cervicali ex equo vel bove exemptæ, quæ omnes ita conjunctæ ſanguinem ab immittent ex Illâ, ad recipientem ab hâc parte fiſtulam convehant: Cujus Arteriæ intermediæ atque ſubſtitutæ hoc habemus amplius beneficium, quòd animalibus variè licet renitentibus obediat, tum quòd ſanguinem in illâ contentum, ſi fortè ſtagnare contigerit, pro libitu propellere ulterius & urgere, vel pro re datâ prorſus ſupprimere poteris. Hæc ſcripſi quo fidem veſtram Illuſtriſſimæ Societati prò me datam liberarem, atque amplius ut innoteſcat nullo ſtudio aut officio tibi unquam defuturum*

Tui obſervantiſſimum

Honoratiſſimo D. D. *Roberto Boyle*, tradantur *Londini*.

Richardum Lower.

Hæc

Hæc igitur non eo in hunc locum tranſtulimus, ut transfuſioni ipſi, jam ſatis notæ lucem fænerentur, ſed ut lectori de Inventionis tempore atque Authore melius conſtaret, omnis enim ad experimentum illud apparatus atque in illo præſtando operatio in ſequente tabula tam clare exhibetur, ut alioqui ſupervacuum fuerit de eâ quicquam amplius memorare. *Tab. 7. fig. 1.* In quâ

a *Fiſtula argentea.*

b *Pars ejus, quæ venæ vel arteriæ inſerenda eſt, & circulari annulo duplici & eminenti donatur quo ſecurior deſuper ligitura fiat.*

Fig. 2. Exhibet fiſtulam argenteam pro ſanguine in brachium humanum convehendo formatam. In qua

a a *Fiſtula argentea.*

b *Pars ejus minor quæ venæ brachii inſerenda.*

c *Pars ejus major ubi ſanguinem excipit.*

d d *Duo ejus folia utrinque perforata*

pro

pro trajiciendo filo quo bractea brachio alligetur.

c *Sinus in medio inter utrumque folium excavatus pro fistulâ immittente commodius excipiendâ, qui venam subjectam adeò comprimit, ut nihil interim sanguinis ex illa extillare aut erumpere posset, atque satis aptè comparari potest fovea in medio labii superioris humani.*

Fig. 3. Exhibet fistulas arteriæ emittenti & venæ recipienti adaptandas ante sanguinem transfundendum. In qua,

a *Arteria cervicalis emittens.*

b *Eadem arteria nodo iterum solubili arctè ligata.*

c *Fistula pro sanguine convehendo arteriæ immissa.*

d *Locus ubi arteria super fistulam inter anaulos arctè ligatur.*

e *Fistula pro sanguine excipiendo & in venam jugularem transmittendo.*

f. *Vena jugularis.*

g *Locus ubi vena ad fistulam arctè alligatur.*

h. *Vena ligata. nodo iterum solubili.*

Fig

Fig. 4. Exhibet arteriam cervicalem ex equo vel bove exemptam & fistulæ argenteæ utrinque adaptatam. In qua

a *Arteria cervicalis.*

b b *Fistula utrinque arteria adaptata.*

Fig. 5. Exhibet totum simul apparatum sanguinis ab uno animali in aliud transfundendi. In qua

a *Vena jugularis ad cor Animalis in quod sanguis transmittendus est.*

b *Fistula argentea in venam jugularem immissa.*

c *Vena arctè ligata super fistulam.*

d *Vena ligata nodo facilè solubili ultra fistulam.*

e e e *Fistula & cervicalis arteria intermedia qua sanguinem a fistulá immittente in recipientem convehunt.*

f *Fistula argentea ab arteriá emittente sanguinem excipiens.*

g *Arteria alterius animalis sanguinem emittens.*

h *Locus ubi arteria ad fistulam inclusam actè alligatur.*

i *Locus ubi eadem ultra fistulam ligatur nodo pro occasione iterum solubili.*

Fig.

Fig. 6. Exhibet eundem apparatum pro transfundendo ſanguine a bruto in hominem, cujus uſus ex priore ſatis intelligi poteſt.

Cùm igitur exeunte *Februario*, *anni* 1665. *Transfuſio* a me primo perfecta fuerit; atque *Clariſſ. Boylæi* literæ ad me datæ ſexto *Iunii Sequentis*; & proximo *Decembre* Reſponſum noſtrum *Philoſophicis Tranſactionibus*, quæ jam tum typis mandabantur, inſertum: *Dionyſii* autem nulla ſuper ea re mentio niſi integro poſt anno facta fuerit, & præterea ipſe fateatur (utcunque jam ante decennium, ut ait, de ea aliquid animo conceperat) eſſe tamen transfuſionem poſſibilem & quo ea modo fieri poſſet ex libellis philoſophicis primùm intellexiſſe; Cui demùm tribuenda ſit hujuſce experimenti inventio aliis judicandum relinquimus.

Sed cum quorundam hominum ea indoles atque animus ſit ut nihil placeat, quòd ipſi non invenerint, nihil bene & feliciter excogitatum ſit, cujus

ſeſe

sese Authores esse non venditent, non erit mihi admodum molestum, utique nullatenùs conscio vel cogitati de ea re cujuspiam a quopiam alio, atque insuper de ea a me perfecta Clarissimorum virorum testimoniis abunde ornato: Nullus interim dubito quin magno generis humani commodo inventum illud, cujus cujus sit, celebrabitur si consultâ & prudenti manu peragatur.

Quippe non est quòd cogitemus sanguini humano illum cæterorum animalium minùs quàm inter se mutuò congruere, quod tum nupera Gallorum experimenta abundè confirmant, & nos etiam non ita pridem experti sumus in quodam *A. C.* amabili quadam insania detento, cujus brachio diversis temporibus sanguinis ovini aliquot uncias in conventu *Regiæ Societatis* immitti curavimus, atque id absque omni ejus incommodo: Verùm amplius ut nos hoc in eo cum aliquo etiam ipsius fructu experiremur, statueramus hoc idem ad mentem illi saniorem procurandam aliquoties repetere,

repetere, nisi genio ille magis quàm saluti suæ consulens spes nostras omninò elusisset.

Verùm enim verò cum ex æquo non omnibus competat alienum sanguinem admittere, neque ullum sit tam utile remedium cui temeraria atque importuna administratio infamiam non facile intulerit, operæ pretium fore existimo si paucis saltem & breviter innuam, in quibus corporibus & quo potissimum valetudinis statu transfusio tentanda sit.

Quorum igitur sanguis valde putridus diuque corruptus est, aut extraneo & venenato fermento penitissimè imbutus, tum quibus viscera inquinata & labefactata sunt, prout in scorbuto, lue venerea, lepra, veneno, aut morbo aliquo diuturno & putrido infectis passim accidit, non est quòd beneficium aliquod aut juvamen ex transfusione expectent.

Nimirum impurus sanguis repetito per viscera transitu vitia atque inquinamenta sua iis affigit, fermenta eorum corrumpit, & tandem propria qualitate

ac

ac indole ita imbuit, ut novus aliunde e quocunque licèt ſano animali ſubſtitutus, dum per eaſdem partes continuò circuletur, contracta labe in eandem diatheſin citò degenerabit, non aliter quàm vinum a mucido vaſe odorem & vitium mox contrahit.

Sincerum niſi vas quodcunque infundis aceſcit.

Verùm e corporibus benè conſtitutis ſi forte importuna venæ ſectione, illato vulnere aut quacunque demùm hæmorrhagia, ſanguis ea copia detractus aut deperditus ſit ut ſubſidium aliunde præſentaneum requirat; nullus dubito quin brutorum ſanguis in amiſſi locum ſecurè poſſit & cum fructu ſubſtitui. Quinetiam in arthriticis & maniacis quorum corpora robuſta, firma viſcera, & cerebri craſis nondum vitiata, quin & ſanguis nulla putredinis labe infectus eſt, fortaſſis non minus beneficium ex recentis ſanguinis infuſione quàm veteris detractione ſperandum eſt.

Quamobrem ut majore hominum fiducia & operandi conſuetudine celeberrimi

berrimi hujus experimenti uſus confirmetur, atque utilitas innoteſcat; mihi profectò res viſa eſt non indigna quæ medicorum omnium curæ & ubicunque experiundi occaſio ſeſe obtulerit, univerſo orbi commendetur.

Interim hoc ſaltem Gentis noſtræ ſeu fœlicitati, ſeu etiam laudi tribuatur, quòd uti *Harveius* ſanguinem intra propria vaſa *Circulantem* corpori ſuo vitam præſtare primò docuerit: Ita & eum extra corporis ſui ambitum ad alterius ſalutem *transferri* poſſe a nobis primò detectum eſt.

CAP. V.

De Chylo, ejusque in Sanguinem transitu, & transmutatione.

QUâ ratione, in casibus quibusdam extraordinariis & magnis hæmorrhagiis, sanguis immediatè subministrari possit in capite superiore disseruimus. Jam porrò considerandum restat, quomodo necessaria ejus dispendia, atque (ut ita dicam) quotidianæ expensæ instaurantur; quod aliunde fieri non potest quam ex Chyli in illum influxu. Chylus autem cum ex ingestis alimentis in ventriculo, fermenti ipsius ope, conficiatur, unde illud continuò suppeditetur paucis prælibabimus, prius quàm de Chyli in Sanguinem transitu atque transmutatione fusiûs disseremus.

A veteribus plerisque, & quibusdam etiam Neotericis, apud quos sacra in omnibus veterum est authoritas, passim statuitur per vas breve commercium quoddam dari inter lienem &

ventriculum, atque ab illo viſcere ventriculum menſtruum acidum mutuari quod facultatem ejus concoctricem conſtituat. Cui opinioni licet circulatio ſanguinis ſatis apertè reclamet, cum tamen ex ipsâ fabricâ & conformatione vaſorum quæ lieni cum ventriculo communia ſunt, magis eluceſcet, & quo nemo ignarus hâc in re amplius moleſtus ſit, eorum hic deſcriptionem plenè abſolvam.

Vaſa itaque ad lienem & ventriculum præter nervos & lymphæductus, nulla niſi venæ & arteriæ pertingunt, & primò quidem quòd *arteriam cæliacam* ſpectat, illa ex aortâ paulò ſupra arteriam meſentericam exoritur, unico trunco, qui mox dividitur in plures ramos, quorum.

Primus hepati pancreati & inteſtino duodeno totus impenditur;

Secundus ubique per totam ventriculi ſuperiorem regionem diſſeminatur, atque ideò arteria epigaſtrica appellatur.

Tertius verò arteriæ cæliacæ ramus qui & omnium maximus eſt, in duas

propagines

propagines dividitur, quarum Prior versus sinistram lienis partem procedit, sed ubi lieni appropinquat, diffisa quasi in bivium, surculum unum in ventriculi fundum exporrigit, alium in lienem rèflectit: Secunda verò ramī hujus propago paulò ulterius provecta prope alteram lienis partem simul in quatuor surculos dividitur, quorum duo in lienem reliqui in ventriculum hùc illùc quaquaversùm explicantur.

Si autem alterutri horum ramo majori atramentum vel lac e syphone iniiciatur, clarè & perspicuè videbitur, postquam liquor ad commune istud bivium vel quadrivium pervenerit, in lienem & ventriculum simul & semel deferri; Adeò ut si circulatio sanguinis id ipsum non suaderet, clare tamen pateat nihil per has arterias a liene in ventriculum, aut vice versâ deferri posse, cum sanguis aliunde simul in utrumque projiciatur.

Venas autem splenicas hoc non posse præstare circulatio sanguinis multò magis probat, verum ut hoc quoque clarius adhuc ex ipsorum confor matione appareat: Venas lienares, earumque divaricationes, quæ liquorem ſuum cum venis a ventriculo redeuntibus communicant, breviter explicabimus.

Uti igitur omnes arteriæ quæ ſanguinem in hepar, pancreas, duodenum, ventriculum totum, lienem & omentum deferunt unico trunco ex aortâ oriuntur; ita pariter venæ omnes quæ ab omnibus iſtis partibus proveniunt & ſanguinem ab illis reducunt, in unum truncum coeuntes in venam portam terminantur.

Venæ itaque illæ quæ inter ventriculum & lienem brevibus ſurculis ſibi invicem cito occurrunt, & ideò *vas breve* appellantur, nihil aliud ſunt, quàm rami venarum a ventriculi fundo deſcendentes, quibus in medio ferè ſpatio, alii a liene provenientes obvii fiunt & melioris conductûs gratiâ ſimul juncti in unum truncum coeunt, qui ſanguinem ab utroque redeuntem & jam commixtum verſus portam convehit; adeò ut ſanguis a ventriculo reductus, alteri a liene obviam factus

factus & in unum truncum exceptus, ſit quaſi duo rivuli minores in unum fluvium confluentes & verſus communem utrinque Oceani gremium ſimul properantes. Eodem modo fit in aliis venis quæ inter dextram ſive anticam lienis partem, & ventriculi fundum dextrum commercium quoddam facere videntur: Nimirùm duæ venæ utrinque prodeuntes in medio inter utrumque ſpatio quaſi plateæ plures in communem aream excurrentes, & poſtea in unicum truncum coaleſcentes in venam portam terminantur.

Quòd autem nihil per vas breve ſive venas iſtas a liene in ventriculum deponitur, præter circulationem ſanguinis, valvularum etiam ſtructura ſatis probat; Quippe in iſto venarum a liene & ventriculo provenientium congreſſu valvulæ adſunt, quæ refluxum ſanguinis in ventriculum aut lienem utrinque impediunt, nam ſi truncus Rami ſplenici infra congreſſum iſtum ligetur, & ſanguinem a venis ſplenicis in venas hypogaſtricas urgere tentaveris, ſtatim venæ citra valvulas in-

 tumeſcent,

tumeſcent, & diſrumpentur potius, quàm aliquid ſanguinis tranſmittent, prout cuilibet promptum & facilè erit in animali majore experiri, in quo vaſa hæc ampliora exiſtunt.

Quin obſervare eſt canes, quibus lien exſectus eſt, nihilo minus voraces eſſe atque ciborum avidos, ſed aſſumpta quælibet æquè citò conficere ac ſi viſcere illo mutilati non eſſent.

Conſtat itaque lienem nihil ad ventriculum immediatè transferre ſed aliunde atque ex ipſo ſanguine petendum eſt fermentum hoc quod ingeſta omnia in cremorem lacteum diſſolvit. Cujus quoque id non leve eſt argumentum quòd melancholiâ hypochondriacâ affecti, humore ſalino in ventriculum depoſito, magnâ boulimiâ ſæpiſſimè tentantur, & quamdiu appetitus iſte durat, ab omni dolore corporis immunes ſunt; humore verò iſto acri & ferino, mataſtaſi quaſi factâ, in alias corporis partes depoſito cruciatus & ſpaſmi cientur, interea etiam ut ventriculi appetitus omnis & digeſtio propter defectum ejus penitùs flac-

flacceſcat; quod hypochondriacis ferè omnibus ſolenne eſt, atque malæ ſanguinis diatheſi, quàm lienis vitio proximè imputari debet.

Cùm autem ventriculus omni fibrarum genere inſtructus ſit, uti cibum demiſſum primò undique complicat & blandè amplectitur, ita poſtquam pars ejus aliqua diſſoluta & in mollem materiam disjunctis ab invicem particulis redacta fuerit, continuatâ fibrarum contractione in inteſtina propellit, ubi a venis lacteis paſſim per inteſtina diſpoſitis abſorbetur.

Et quoniam vaſa lactea anguſta admodum & perexiguis orificiis prædita ſunt, ut puriorem tantùm & defæcatiorem maſſæ fermentatæ partem ex inteſtinis excipiant, ideò tantus inteſtinorum ambitus factus eſt, ut eo plura hujuſmodi vaſa admittant; quo fit ut vaſorum parvitas ab ipſorum numero compenſetur: quare cum vaſa lactea in ſuperioribus inteſtinis ſufficienti Chyli copiæ aſſumendæ tum numero tum meatu omnino impares ſint, ideo inteſtina eo ingenio conſtituta ſunt, ut continuo fibrarum motu a pyloro uſque ad inteſtinum rectum' ſucceſſivè propagato, ſeſe perpetuâ vice contrahant, & ita chylum deorsùm detrudant, quo vaſorum omnium orificiis ſiſtatur. Dum verò eorum ora præterlabitur iſte ſuccus, utiles & alimentoſæ partes ab excrementis ſeparantur, atque tinctura ſolum defæcatior & purior in venas lacteas tranſit, craſſiore & fæculentiore parte, velut capite mortuo in inteſtinum rectum, demiſsâ. Quo autem modo ſecretio hæc perficitur non aliunde datur intelligere, quàm quod diverſi pori in interiore inteſtinorum tunicâ ita diſpoſiti & configurati ſunt ut cremorem ſolum lacteum admittant; craſſiores verò partes, cum nullam habeant ſimilitudinem aut proportionem cum inteſtinorum poris, per quos in lacteas tranſitus fit, ideo illibatæ prætereunt & a motu inteſtinorum deorſum uſque depelluntur; ſi autem venæ lacteæ in ſcavitatem inteſtinorum apertis oſculis & immediatè hiarent, non ſolum fæculentior & impurior pars maſſæ in inteſtinis

stinis contentæ, sed & flatus & halitus fætidi & stercoracei perinde in sanguinem transirent, eumque pessimè inquinarent.

Verùm ut hujusce rei experimentum facerem, in animali cibis prius optime satiato intestinum jejunum, vulgò ita dictum, ubi in ilia transit, arctè ligavi atque folle per pylorum immisso aerem valide immisi, cumque intestinum illud satis distentum fuerit, pylorum pariter fortiter strinxi, & dein postea intestinum aëre usque adeò repletum & tumefactum manibus compressi, & expectavi ilicò chylum in venis lacteis statim ab insequente aëre versus commune receptaculum urgeri, quòd neutiquam tamen successit, adeò ut certum sit venas lacteas in intestina rectè non hiare, neque spiritum ullum aut flatum in illas admitti.

Et cùm præpeditus aëri aditus in venas lacteas constaret, experiri subiit in alio animali similiter pasto, annon facilior liquori cuilibet tenui ingressus pateret; ligatâ itaque eâdem intestini parte per pylorum spiritum vini atramento

mento tinctum infudi, eoque conſtricto inteſtinum atra hâc tincturâ tumidum leniter primò, deni arctiùs compreſſi ſuſpicione quâdam ductus, tenui ſaltem & ſubtili huic liquori æquè ac chylo aditum præberi, ſed aliter omnino evenit; neque enim chylus in venis lacteis inteſtino proximis colore iſto infici, aut ulteriùs quicquam verſus commune receptaculum impelli videbatur; quare opinari licet venas lacteas non directè & immediatè in inteſtina hiare, ſed obliquè inter eorum tunicas ferri antequam in cavitates inteſtinorum penetrent, non aliter forſan ac ductus communis in duodenum, aut ureteres in veſicam terminantur; quo fit, ut quo fortiùs latera inteſtini aut veſicæ ab intus contentis diſtenduntur, eo arctiùs eorum oſtia claudi contingat. Quare veriſimile etiam videtur chylum non omninò in venas lacteas exprimi, cum hujuſmodi inteſtinorum contractio & corrugatio ipſi potius aditum præcludat, in quantum ſc. lactearum meatus & canales inter tunicas inteſtinorum perreptantes

tes conſtringit. Adeò ut motus iſte inteſtinorum continuus & periſtalticus, ut vocant, eum ſolummodo in finem fieri videatur, tum ut chylum in lacteas receptum verſus commune receptaculum urgeat, tum etiam ut maſſam chyli e ventriculo demiſſam deorsum uſque propellat & lacteis omnibus abſorbendam ſiſtat; cum autem motus iſte vermicularis & per vices interpolatus fuerit, probabile eſt tunc temporis tantùm chylum in venas iſtas aſſumi quando pars aliqua inteſtini a motu & corrugatione conquieſcit, & proinde orificia lactearum laxiora & patentiora fiunt.

Cùm autem chylus per hujuſmodi poros & anguſtias ex inteſtinis in lacteas tranſeat, a ratione alienum non videtur ab humore e pancreate in duodenum ſecreto pro faciliore tranſitu magis dilui & attenuari; quippe cùm glandula illa reliquis omnibus adeò affinis fuerit ut ejuſdem ſubſtantiæ atque texturæ videatur, atque humor omnis e glandulis quibuſcunque ſeparatus

ratus ſimilis omninò, & velut lympha tenuis & pellucidus ſit, quidni eiſdem uſibus inſervire credendum ſit. Quocirca uti glandulæ circa os & fauces conſitæ lympham ſuam inter maſticandum extillant, quâ cibos perfundant & emolliant, tum ut faciliùs in ore volutandos, tum ut prompte magis deglutiendos reddant, ita maxime veriſimile mihi videtur magnam illam glandulam eo loci conſitam eſſe, atque ductum iſtum in inteſtina aperiri, ut lympha inibi ſecreta deſcendenti chylo miſceatur, quo anguſtos lactearum canales promptiùs ineat & magis liberè & expeditè pertranſeat; & ſiquidem chylus in vaſis lacteis aut ob craſſitiem ſuam aut liquoris potulenti inopiam (qui pro vehiculo eſſet) aliquando ſtagnare & concreſcere, & proinde vaſa illa penitus opplere & infercire aptus ſit, prout in cane cujus pancreas obduratum eſt ſemel obſervavi, ideò glandulæ in meſenterio paſſim quoque conſtitutæ videntur ut ſimilem præterlabenti chylo lympham affundant, quò tenuior & dilutior (qualis

lis ſemper ultra glandulas meſenterii apparet) continuò evadat. Et licèt in alios præterea uſus lympha hæc inſervire poſſit, cum tamen tantum periculum ſit ne chylus intra minutos & capillares iſtos ductus ſubſiſtere & craſſitie ſua ſibi ipſi viam obſtruere, aut longiore morâ concreſcere poſſit, ideò præcipuè a ſummo conditore cautum eſſe videtur, tum ut lymphâ e Pancreate in inteſtina tranſmiſsâ perfunderetur, quo faciliùs in lacteas tranſeat, tum ut in mediâ inter inteſtina & receptaculum viâ, eâdem tenuiſſimâ lymphâ iterum in glandulis meſenterii ſeparatâ dilueretur, quo reliquum cursûs ſui ſtadium verſus commune receptaculum abſolveret.

In quòd receptaculum venæ lacteæ omnes velut totidem fiſtulæ in commune lactis caſtellum ſeſe exonerant; & ne inibi ſtagnare & concreſcere contingat, vaſa lymphatica omnia quæ ex toto inferiore corpore, tum & viſceribus & glandulis omnibus in abdomine contentis proveniunt, lympham ſuam in receptaculum deponunt,

tum

tum ut tenuiſſimo liquore ſuo illud nitidum ſemper & elime conſervent, tum ut chylum pro faciliore per ductus thoracicos tranſitu magis diluant: Et ne in medio inter receptaculum & venam ſubclaviam itinere quâcunque de causâ concreſceret, glandulæ plurimæ minores ubique circa viſcera pectoris diſpoſitæ lympham ſuam in ductus chyliferos diverſis in locis extillant, Deo quaſi providente ne vitæ noſtræ ſubſidium unicum commeatu libero ullibi careret.

Et quandoquidem chylus per vaſa thoracica, præſertim in erecto corporis ſitu ſicut in homine, difficiliùs aſcendit, & proinde ob motûs tarditatem ad coagulandum proclivior fuerit, ideò inter tendines diaphragmatis, ubi ſpinæ alligantur, magnum hoc receptaculum conſtituitur, quo fit ut quoties diaphragma in omni inſpiratione contrahitur, tendines iſti valdè attracti ſacculum hunc lacteum, modo chylo turgidus fuerit, plurimum comprimant, & exagitent, adeóque chylum in illo contentum per ductus chyliferos

feros in venam ſubclaviam propellant, & conſtante vectigali maſſam ſanguinis continuò pereuntem æquè certò inſtaurent.

Quoniam autem ſanguis, vitaque ipſa a continuo recentis chyli influxu dependet, neceſſe fuit ut viâ liberâ & expeditâ ſemper in eum tranſeat; quare ductus chyliferi per totum ferè tractum a receptaculo ad venam ſubclaviam uſque, niſi prope cordis regionem, duo ſunt & velut ſcalæ latera mutuò inter ſe communicant; non alium certè ob finem, quàm ut ſi alter obſtructus fuerit, chylus per alterum aſcendat.

Ne denique ad ipſum limen impingat aut quoquo modo præpediatur, ideò oſtio plerunque duplici, nonnunquam etiam pluribus (aut ſicubi unicum tantum reperiatur, eo laxiore hiatu) in venam ſubclaviam ſuffunditur; & ne ſanguis præterlabens aperturæ ejus incurrat, ipſamque oppleat, ideò valvula iſti quaſi operculum obducitur, quæ ſanguinem a venâ jugulari & axillari redeuntem rejiciat & obtento

quaſi

quaſi velo foramen illud ab irruentis ſanguinis affluxu præmuniat, prout in *Tab.* 6. *Fig.* 2. infra explicatâ apparebit.

Atque hæc via ſola atque unica eſt quâ chylus e ventriculo & inteſtinis in ipſum ſanguinem & cor infunditur: Verùm quia nonnulli in eodem cum veteribus errore etiamnùm verſantur, venaſque meſaraicas chylum ex inteſtinis excipere confidentèr ſtatuunt, ipſe ut de hâc re certior fierem, ſeriam aliquando impendi operam, atque non uno experimento tandem mihi conſtitit, totum chyli penum nullâ aliâ viâ quàm per ductus chyliferos, in ſanguinem infundi; ſi enim curſus ejus per vaſa thoracica impediatur, animal qualicunque cibo ſatiatum intra paucos dies fame penitus interibit; quod in duobus canibus diverſo licèt modo expertus ſum. Alterius enim thorace dextri lateris intra duas coſtas inferiores aperto, digitum immiſi & ungue velut in ſerram reſecto commune receptaculum tribus horis a paſtu valdè turgidum perfregi

&

& laceravi, ut chylo in cavitatem thoracis exitu dato, tranſitus ejus in ductus chyliferos penitùs interciperetur; quo facto & conſuto vulnere animal hoc cibo quantum capere voluit, poſtea ſatiavi. cum autem intra paucos dies expiraret, & a me ſtatim diſſecaretur, ventriculum atque inteſtina valdè repleta, quin & venas lacteas chylo plenas inveni, nihil autem ejus in toto ductu thoracico apparuit, verum in eo pectoris latere, in quod commune receptaculum diſruptum eſt duæ libræ chyli repertæ ſunt; unde certò conſtare arbitror ob præpeditum chyli per ductus thoracicos tranſitum animal hoc ventriculo licèt cibis referto utcunque fame periiſſe.

Quod tamen ut certius redderem, alium canem ſimili modo, ſed in adverſo ſeu ſiniſtro latere intra tertiam & quartam coſtam ſuperiores perfodi, quâ in regione ambo ductus chyliferi, in unum plerunque truncum coeunt, qui deinceps ex latere æſophagi inferiore ubi muſculo ſubſtrato incumbit, verſus venam ſubclaviam ſub communi

P pectoris

pectoris tunicâ incedit; immisso itaque per vulneris orificium digito ductum istum pariter diffregi, quo disrupto, chylus in cavitatem lævi pectoris exire, ulterius vero penetrare neutiquam potuit; quare vulnere ut prius curato canem per paucos dies benè pastum detinui, ex quo tempore elanguescere cæpit, & paulò post obiit; Cum autem thoracem ejus dissecarem, claustrum illud pectoris, ubi ductus iste disruptus fuit, chylo penitus repletum, & pulmonem lateri isti agglutinatum inveni, quo autem certior forem, canalem istum usque adeò perruptum esse, ut nihil chyli ulteriùs deferre potuerit, aquam e syphone in ductum chyliferum inferius injeci, verùm ultra quam canalis iste perruptùs fuerat, penetrare non potuit, sed in cavitatem pectoris tota exiliit; claro satis argumento, chylum per venas mesaraicas non intrare, neque ullam aliam dari viam quâ sanguini misceatur, cum animal ex transitu per vasa thoracica impedito tam certò intereat. Quin & hoc denique ante omnia confirmat,

firmat chylum in venas mesaraicas non influere, quia si sanguis ab animali ita tractato post diem unum aut alterum adimatur, nihil chyli in illo apparebit, licèt paucis antea horis optime pastus fuerit, quod aliter omninò fieri debuit, nisi influxus ejus hoc modo prorsùs intercipiretur.

Et profectò mirandum erit, quenquam re ita clare petractatâ Hepatis patrocinium ampliùs suscipere, atque ut ipsi sanguificationis munus postliminiò asseratur, *Ludov. Bilsii* experimentum *Pecquetto* objicere. Nam & *Bilsianum* illud frustra semper tentavi, & experimento insuper hoc nostro conficiam, ut Chylus nullâ aliâ viâ nisi per *duct: Pecquettianos* sanguini instillari & commisceri in posterum credatur.

Quemadmodum enim ductibus istis disruptis chylus omnis in cavitatem thoracis effluit, ita si ductus iste in lævo pectoris latere (orificio ubi prius facto) immisso digito per horam comprimatur, chylo, quia alius in sanguinem transitus non datur, commune receptaculum, quin & vasa lactea omnia in

P 2 me-

meſenterio, atque infimâ parte ventris ab hâc obſtructione adeò turgeſcunt & diſtenduntur, ut nunquam clariùs aut perſpicuè magis oſtendi poſſint; ſiquidem jucundiſſimo ſpectaculo conſtat, qualis eorum fabrica, valvulæ, anaſtomoſes, quam varii præterea Mæandri eorum fuerint, quam densâ ſerie totum inteſtinorum ambitum & ſuperficiem perreptant, quam infra receptaculum multiplici ordine diſpoſitæ non ſecus ac uniones in puellarum monilibus turgeſcunt, ut certè quicquid de iis hactenus a quopiam ſcriptum aut delineatum fuerit prorſus nihil ſit.

Quin & obſervatione præterea valdè dignum eſt ex obſtructo hoc ductu thoracico, chylum in vaſa lymphatica tum in pectore ubique & abdomine diſpoſita, renitentibus licèt valvulis, adeò inſinuari & retrò urgeri, ut primo forſan intuitu incautis imponere & *ductus Bilſii* roriferos adeſſe ſuadeat; licèt revera non aliunde hoc evenit, quam quod ſuccus iſte albus propriâ viâ præpeditus, in vaſa illa regurgitat, non aliter forſan quam ab inundante

undante mare flumina in alveos suos repressa irruenti æstui locum cedunt: Atque ideò uti refluente mari flumina iterum intra ripas suas subsidunt, ita remotâ istâ compressione & chyli in sanguinem introitu restituto totus iterum in ductus thoracicos resorbetur & in vasis illis lymphaticis nullum sui vestigium post se relinquit.

Cujus experimenti administrati modum exhibet *Tab-6.fig-2.* In quâ

a a *Ductus chyliferi duo in unum truncum in sinistro pectoris latere coeuntes.*

b *Locus ubi immisso digito truncus iste comprimitur.*

c c c c *Valvulæ ejus quæ a regurgitante chylo ex obstructo ductu utrinque infra compressionem intumescunt.*

d *Truncus supra compressionem propter impeditum chyli transitum flaccescens.*

e *Vena jugularis.*

f *Vena axillaris.*

g *Eadem vena ubi venæ cavæ descendenti accedit.*

h *Oſtium ductûs chyliferi ubi chylus a communi receptaculo allatus in venam ſubclaviam infunditur.*

i *Valvula aperturæ iſti appoſita quæ ſanguinem a vena jugulari & axillari redeuntem ita tranſvehit ut influenti chylo impedimento non ſit.*

Cum autem experimentum hoc adeò jucundum fuerit, atque facile ab exercitatâ manu perfici poſſit, ejus expediendi modum atque rationem paulò accuratiùs enarrabo.

Retracto itaque canis, ut ita dicam, brachio ſiniſtro, perforetur thorax paulò ſupra regionem cordis intra tertiam & quartam coſtam ſuperiores, quâ in regione ductus iſte ex latere æſophagi inferiore ſupra muſculum gulæ ſubſtratum ſingulari ferè trunco incedit, dein immiſſo digito totus æſophagus ad muſculum iſtum compellendus eſt, quo fiet, ut ductus quoque obturetur; ita tamen inſinuari digitus debet, ut ab arteriâ axillari proximè incumbente abſtineat, atque ita per horam detineatur (& ſi artus canis poſt

immiſſum

immissum digitum paululùm laxentur, magis tranquillè feret) quibus peractis notatu dignissimum est, quamdiu compressione istâ motus chyli intercipitur, nihil ejus in detracto sanguine apparere, modò hujusmodi operatio statim a pastu administretur; intermissâ autem compressione intra dimidium horæ sanguini rursus detracto lactis crudi magna copia innatabit.

Postquam autem totum chyli tractum ab intestinis ad venam subclaviam usque ad hunc modum exhibui, unicum restat ut ostendam, quomodo illi cum sanguine conveniat, & quot mutationum vices subeat antequam in nutrimentum partium facessere, aut in ipsum sanguinem assimilari aptus fuerit. Quare advertere oportebit chylum perenni influxu sanguini instillatum, eique sensim commissum simul cum illo deferri, & pro longiore aut breviore ejus in massâ sanguinis fermentatione & circuitu plus aut minus excoqui & elaborari.

Si enim dum adhuc recens est & nondum per plures horas in sanguine excoctus in mammas & ubera deponitur, adeò naturam & priſtinam faciem ſuam retinet, ut neque guſtu aut colore ab ipſo chylo diſtingui poſſit, prout in gravidis animalibus ſæpe expertus ſum; cum enim chylum e communi receptaculo exceptum,& ipſum ſanguini detracto innatantem, & lac ipſum ab uberibus expreſſum inter ſe conferrem, nullum omninò diſcrimen percipere unquam potui (niſi quod chylus in receptaculo aliquantum ſalſior) atque ideò dubitandum non eſt lac omne in ubera & mammas ab ipſo ſanguine per arterias mammarias deponi; neque fruſtra quærendi ſunt alii ductus qui immediatè magis e ventriculo & inteſtinis lacteum hunc ſuccum in illas transferrent; nam cum ſanguis hujuſmodi chylo turgeſcat, cumque is continuò ſimul cum ſanguine in omnes partes corporis propellatur, quidni conjicere liceat ad ſingulos ejus appulſus album hunc ſuccum in uberûm colatorio ſeparari & in vaſa excretoria & tubulos lacteos tranſire.

Neque

Neque enim chylus ſanguinis maſſæ confuſus naturam & indolem ſuam mox adeò exuit ut albedinem ſuam ilicò deponat, quin diuturno aliquo ſpatio crudus omninò, & lacti ſimilis cum illo circulatur, quod quiſpiam quotidie experiri poterit, ſi enim animali quatuor vel quinque horis, aut longiore temporis intervallo poſt largiorem paſtum ſanguis e quacunque venâ vel arteriâ detrahatur, magna ipſiſſimi chyli lacteſcentis copia cruori coagulato innatare conſpicietur, prout alibi obſervavi. Quin & hoc ipſum in diverſis hominibus expertus ſum, quibus cum poſt largum jentaculum aut prandium vena incideretur, vaſcula omnia lacte magis quam ſanguine repleta videbantur; quod Phœnomenon licèt ab antiquis medicis obſervatum fueritratio tamen ejus eos prorſus latebat.

Uti autem chylus ſanguini licèt commiſſus colorem ſuum pluribus adhuc horis retinet, ita ſi diutiùs cum illo illo circuletur, a diuturnâ illius cum ſanguine coctione, albedine prorſus depoſitâ in ſerum attenuatur; ſi enim

longo

longo post pastum intervallo venæ sectio fiat, nulla lactis species superest, sed serum solummodò cruori coagulato innatabit. At verò licèt crassitie & colore multum inter se differre videantur, hoc tamen chylus ille sanguini suffusus, tum serum cruori detracto innatans & lac ipsum uberibus expressum commune habent, quod si lento igni admoveantur, quousque partes aquotiores exhalaverint, in gelatinam pariter omnia concrescant.

Quibus verò modis & quali mutationis gradu chylus in sanguinem assimilatur & in nutrimentum partium facessit, ut melius intelligatur, sciendum est spiritum vitalem aliaque in liquore sanguineo principia activa in chylum jugiter instillatum agere, eumque minutissimè subigere; quin & cum chylus sale sulphure & spiritu copiosè turgescat, quamprimum compages ejus a fermentatione laxatur, particulæ istæ activæ motus libertatem adeptæ, cum partibus sanguinis quæ similis & congeneris naturæ fuerint sese promptè associant; quin & in sanguine, (uti in vino aliisque ejusmodi

ejusmodi liquoribus) accidit, ut ubi spiritus dominio potiti sint, particulas omnes crassiores & fœculentiores quibus impinguntur, a massâ suâ deturbent & expediant, quo reliquam liquoris partem defæcatiorem & puriorem reddant.

Postquam verò chylus ita perficitur, idoneus omninò fit, tum qui liquori sanguineo restaurando, tum corpori toti enutriendo sufficiat, cum enim ex diversis principiis & partibus constet, atque variæ & diversimodæ indolis & naturæ fuerit, ideò pro vario partis cujusque usu & indigentiâ, & juxta ac poris diversis & meatibus respondet & configuratur, ita varie partibus apponitur; unde pars ejus maxime volatilis & subtilis in cerebro secernitur & spiritibus reficiendis addicitur, pars verò glutinosior corpori nutriendo apponitur, pars ejus sulphurea calori redintegrando destinatur; Dum verò per totum corpus unà cum reliquo sanguine trajicitur, pars ejus serosa & salina per renes separatur & transpiratione insensibili aut sudore evacuatur, adusta in hepate

hepate deponitur, reliquaque ejus recrementa in diversâ corporis emunctoria quasi totidem secernicula abscedunt, unde reliqua ejus massa depuratior usque & clarior evadit.

Atque in hoc solo vitæ nostræ ratio omnis consistit, tum ut sanguis continuo suo per corpus universum ambitu calorem & nutrimentum undique circumferat, tum ut recens usque chylus debitâ copiâ & mensurâ sanguini instilletur, qui liquorem ejus indies decrescentem pari pabulo recreet, & perenni irrigatione exhilaret.

FINIS.

Elenchus Capitum.

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Q *in*

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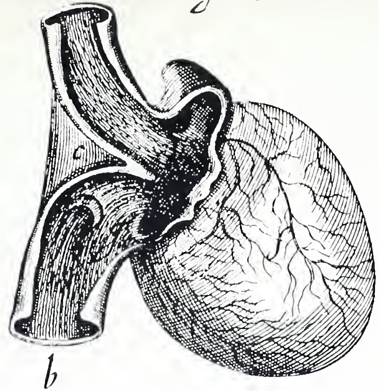

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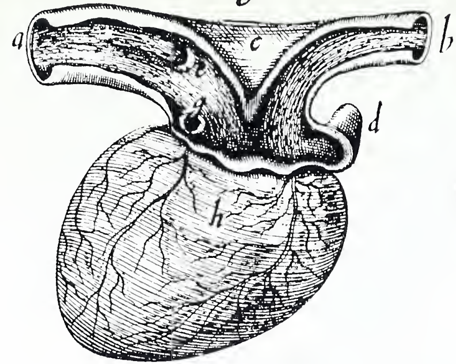

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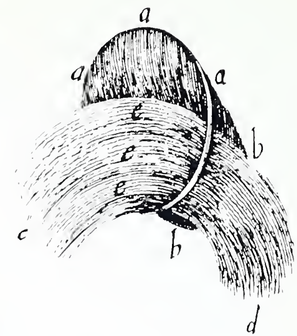

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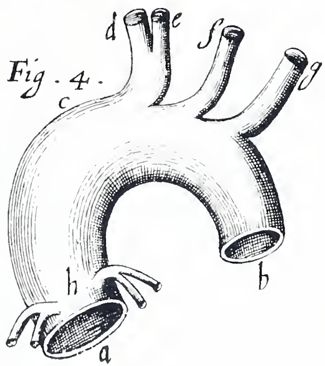

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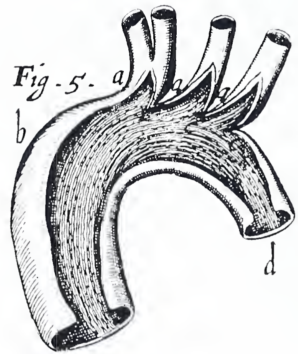

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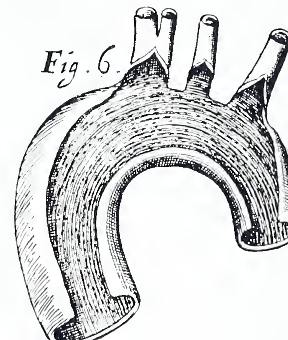

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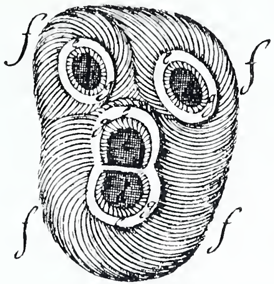

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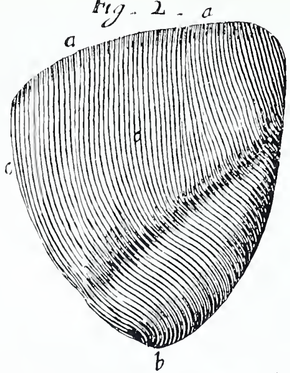

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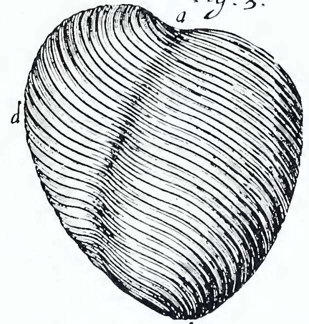

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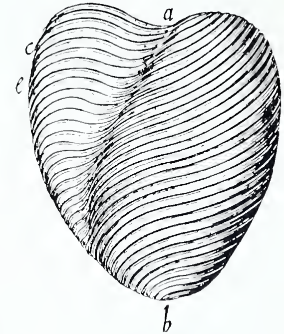

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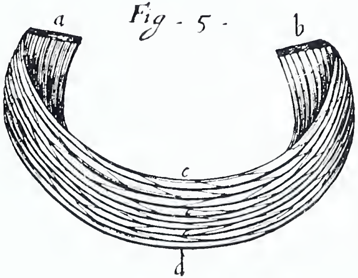

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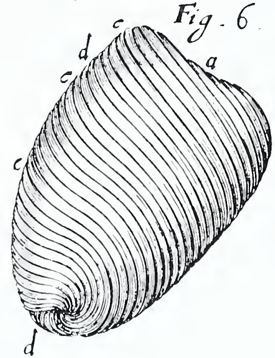

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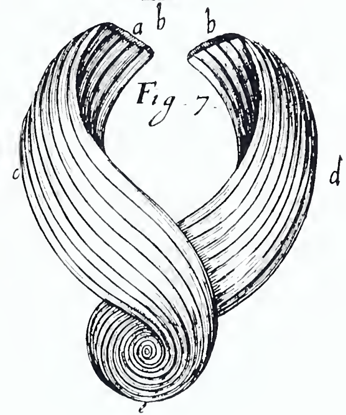

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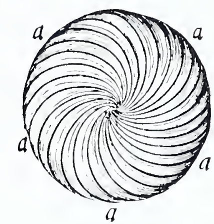

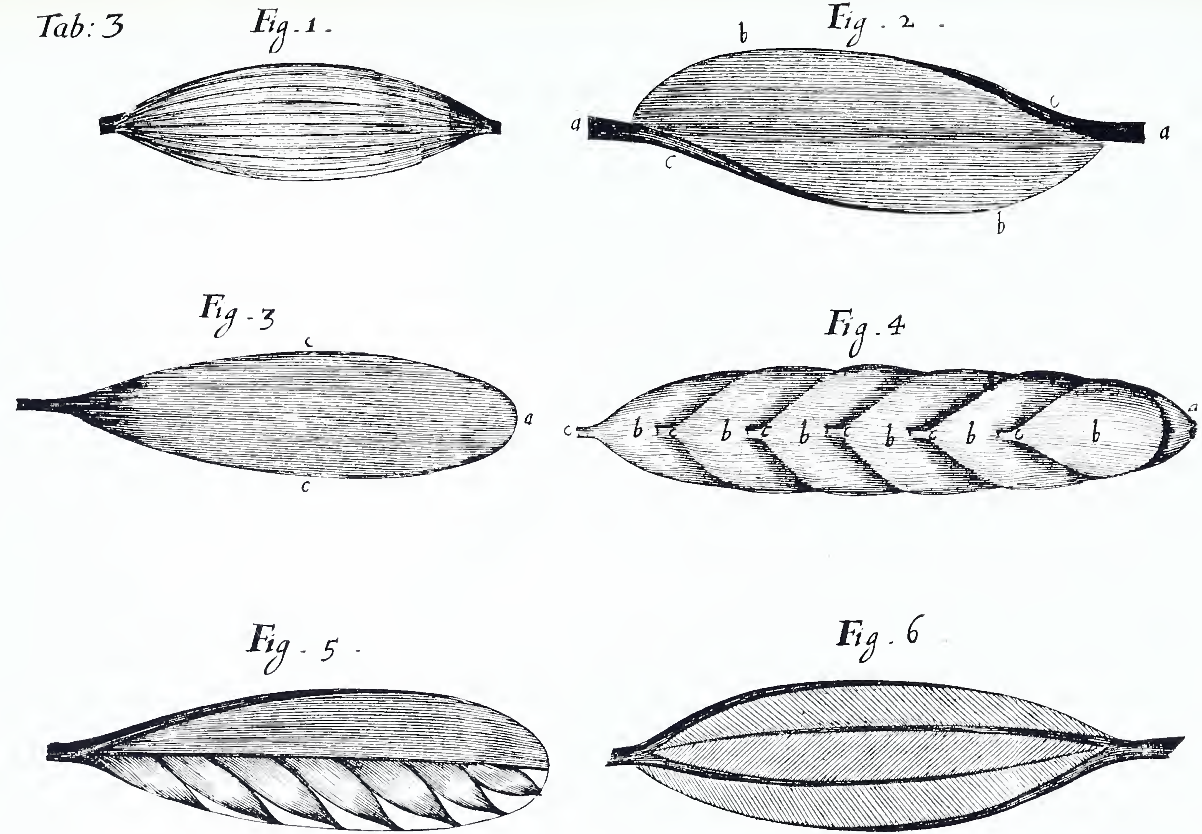
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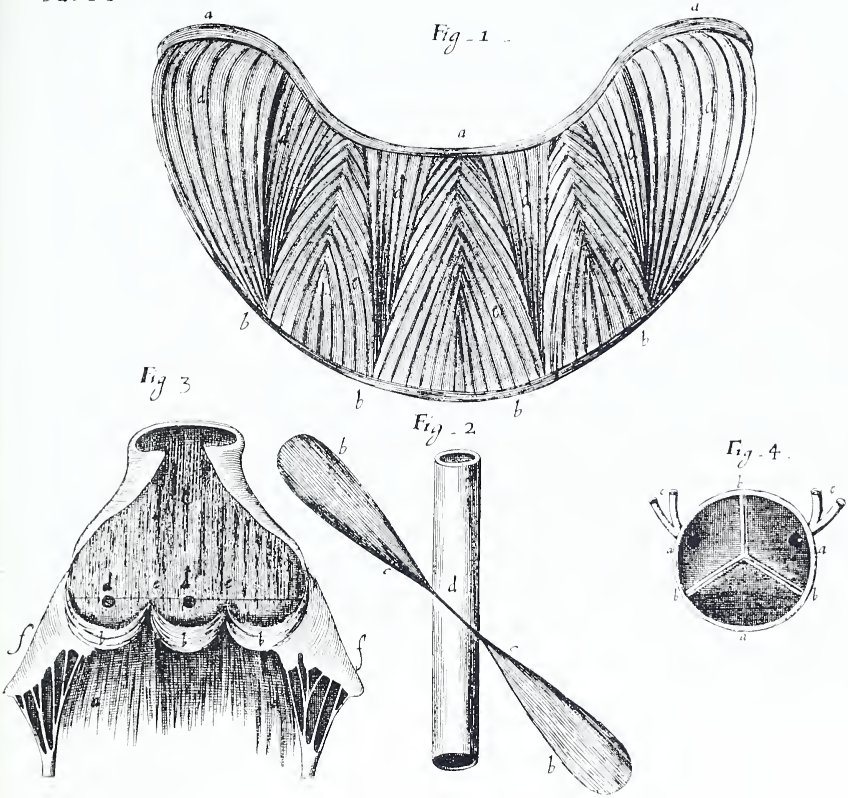

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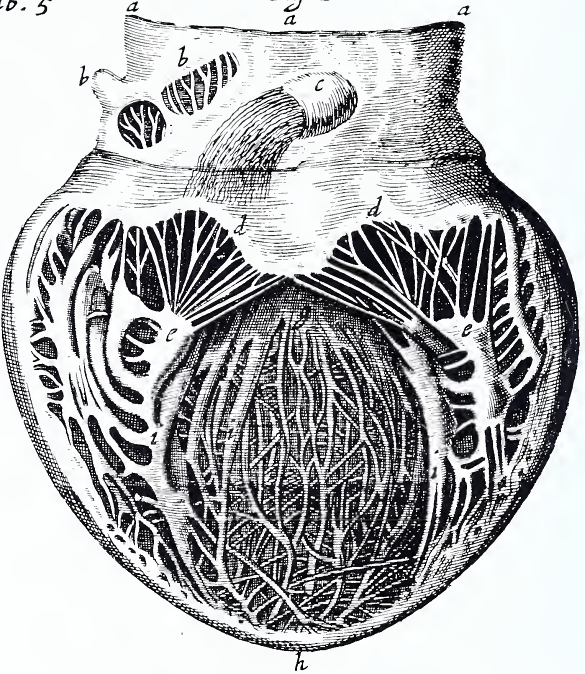

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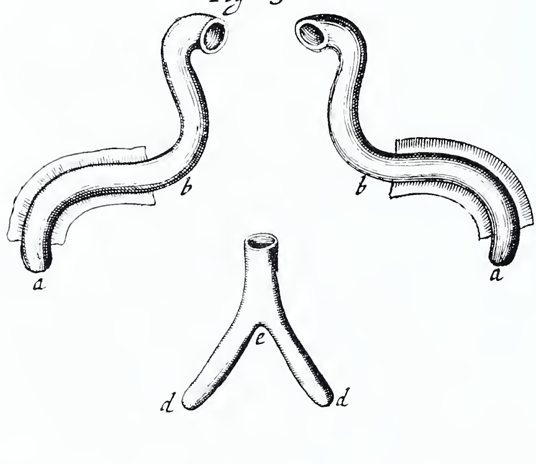

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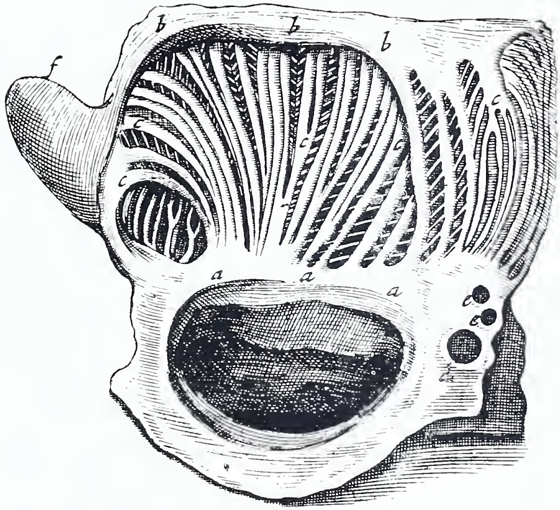

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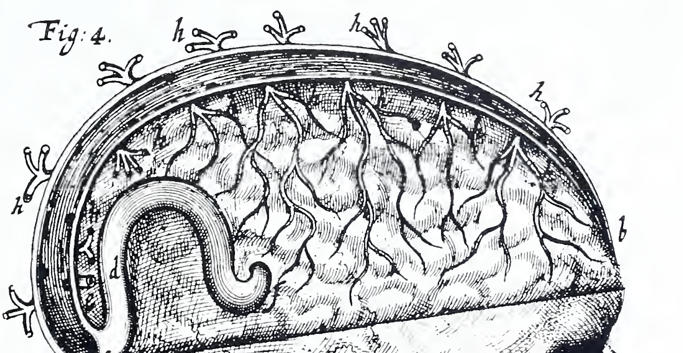

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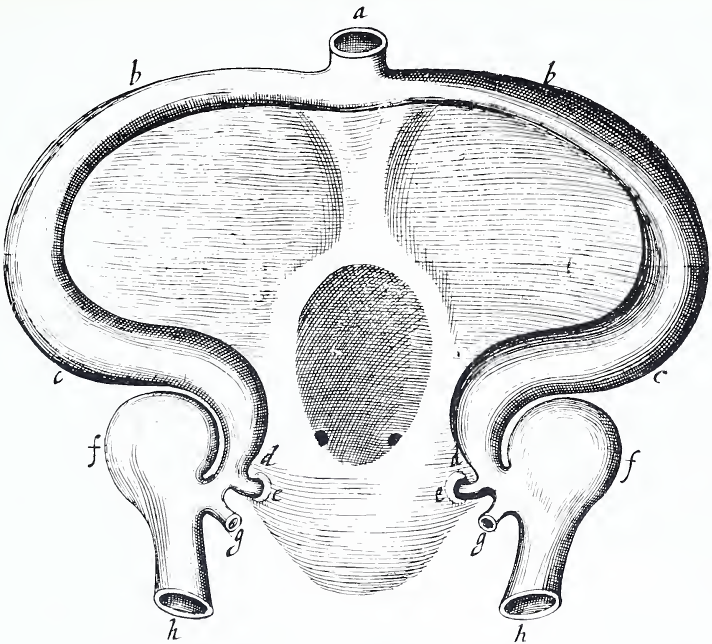

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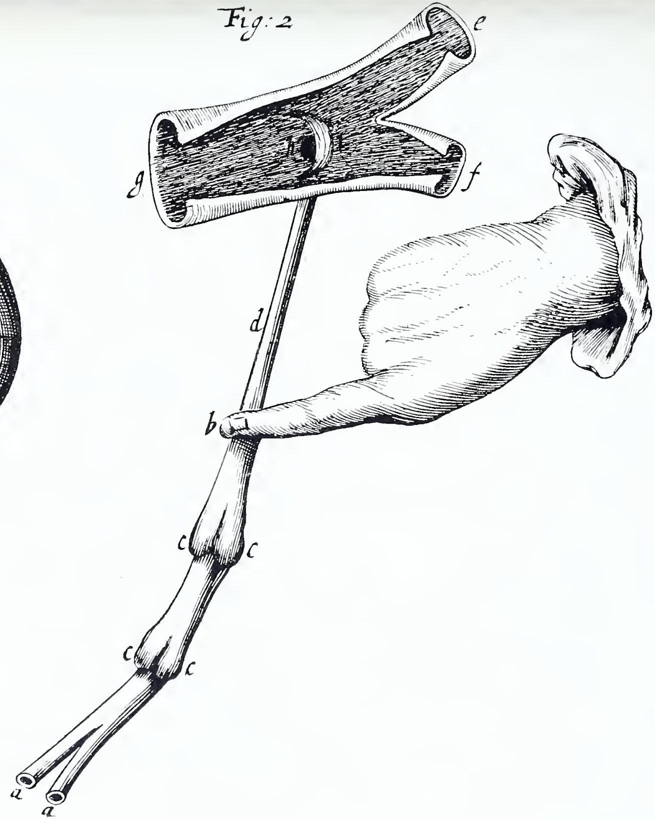

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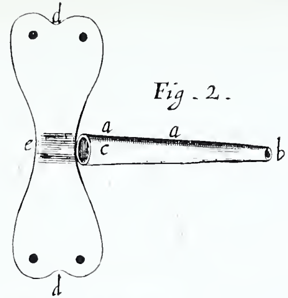

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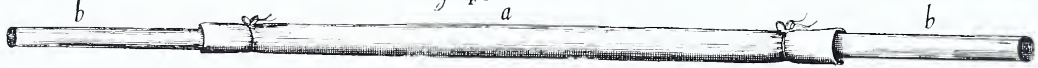

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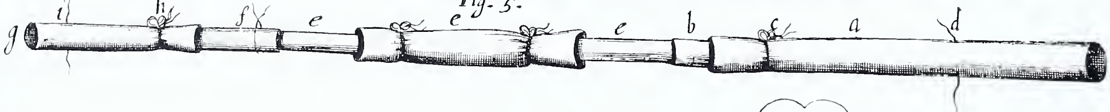

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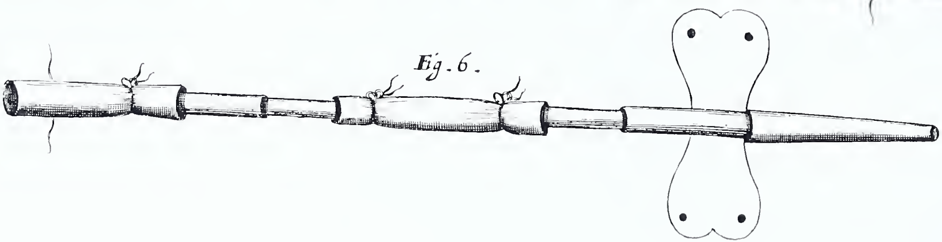

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