A

TREATISE

ON

THE BLOOD,

INFLAMMATION,

AND

GUN-SHOT WOUNDS,

BY THE LATE

JOHN HUNTER.

TO WHICH IS PREFIXED

A SHORT ACCOUNT OF THE AUTHOR's LIFE,

BY HIS BROTHER-IN-LAW,

EVERARD HOME.

IN TWO VOLUMES, FROM THE LONDON QUARTO.

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CHAPTER II.

A SHORT ACCOUNT OF THE LIFE OF THE AUTHOR.

JOHN HUNTER was the ſon of John Agnes Hunter of Kilbride, in the county of Lanerk; he was the youngeſt of ten children, and was born on the fourteenth of July, 1728, at Long-Chalderwood, a ſmall eſtate belonging to the family. His father was deſcended from Hunter of Hunterſton, an old family in Ayrſhire, and his mother was the daughter of Mr. Paul, a very reſpectable man, and treaſurer of the city of Glaſgow.

He had four brothers, John, Andrew, James, and William; and five ſiſters, Elizabeth, Janet, Agnes, Dorothea, and Iſabella; of theſe, John, Andrew, Elizabeth, Agnes, and Iſabella died, while children. James was born in 1715; was brought up to the law, as a writer to the ſignet in Edinburgh, but in the year 1742 went to London on a viſit to his brother William, who was at that time a teacher of anatomy, and ſo much was he captivated by the purſuits in which he found his brother engaged, that he purpoſed to follow them himſelf, and become a practitioner in phyſic. His health however was ſo much impared by his application to anatomy, that he was obliged to return to Long-

Calderwood, where he died of a ſpitting of blood, in the twenty-eighth year of his age*.

William was born on the twenty-third of May, 1718, who became unrivalled as a teacher of anatomy, and it was under his foſtering care that his younger brother John was initiated in theſe purſuits, in which he afterwards became ſo diſtinguiſhed. His hiſtory is already in the hands of the public †.

Janet married Mr. Buchanan of Glaſgow, and died in 1749. Dorothea, who is ſtill alive, married the Rev. Doctor James Baillie, profeſſor of divinity in the univerſity of Glaſgow, by whom ſhe has one ſon, Matthew, doctor of phyſic, ſucceſſor to Dr. Hunter, as a teacher of anatomy and one of the phyſicians to St. George's Hoſpital, and two daughters, Agnes and Joanna.

John Hunter was about ten years old at his father's death, and was left under the direction of his mother, who was particularly indulgent to this her youngeſt ſon.

He was ſent to the grammar-ſchool, but not having a turn for languages, nor being ſufficiently under controul, he neglected his ſtudies, and ſpent the greateſt part of his time in country amuſements. About this time Mr. Buchanan, who had lately come from London to ſettle at Glaſgow as a cabinet-maker, paid his addreſſes to Mr. Hunter's ſiſter

* Mr. James Hunter was a young man of an uncommonly pleaſing addreſs, and of very quick parts. The late Dr. Hunter has been heard to remark, that if he had lived to practice phyſic in London, nothing could have prevented him from riſing to the top of his profeſſion. It would have been a remarkable circumſtance that three brothers ſhould have acquired the firſt reputation in three different branches of the ſame profeſſion.

† Written by Dr. S. Foart. Simmonds, and publiſhed in 1783.

Janet, and having many agreeable qualities, ſhe was induced to marry him, although contrary to the advice of her relations. This marriage gave the family great concern; for the qualities which had rendered Mr. Buchanan agreeable, led him into diſſipation, and made him neglect his buſineſs. Mr. John Hunter, who was now ſeventeen, went to Glaſgow upon a viſit to his ſiſter, for whom he had the greateſt affection, to comfort her in her diſtreſs, and endeavour to aſſiſt her huſband in extricating himſelf from his difficulties; but finding, after ſome time, all his efforts ineffectual, he returned to Long-Calderwood.

Tired of living idle in the country he began to turn his mind to ſome more active employment; and hearing much of the reputation which his brother William had acquired as a teacher of anatomy, he wrote to requeſt that he would allow him to come to London upon a viſit, making at the ſame time an offer to be his aſſiſtant in his anatomical reſearches; or, if that propoſal ſhould not be accepted, expreſſing a wiſh to go into the army. In anſwer to this letter, he received a very kind invitation from his brother, and immediately ſet off for London, accompanied by Mr. Hamilton, a friend of the family who was going upon buſineſs; they rode up together on horſeback.

Mr. Hunter arrived in London in September, 1748, about a fort-night before his brother began his courſes of lectures; and Dr. Hunter, who was very anxious to form ſome opinion of his talents for anatomy, gave him an arm to diſſect for the muſcles with the neceſſary directions how it was to be done; and he found the performance ſuch as greatly exceeded his expectation.

His firſt eſſay in anatomy having thus gained him ſome credit, Mr. Hunter was now employed in a diſſection of a more difficult nature; this was an arm in which all the arteries were injected, and theſe, as well as the muſcles were to be expoſed and preſerved; the manner in which this was performed, gave Dr. Hunter ſo much ſatisfaction, that he did not ſcruple to ſay, that his brother would become a good anatomiſt, and that he ſhould not want for employment.

From this period we may conſider Mr. Hunter as having ſeriouſly engaged in anatomy and under the inſtructions of Dr. Hunter and his aſſiſtant Mr. Symonds, he had every opportunity of Improvement, as all the diſſections at this time carried on in London were confined to that ſchool.

In the ſummer 1749, Mr. Cheſelden, at the requeſt of Dr. Hunter, permitted him to attend at Chelſea Hoſpital, and he there learnt the firſt rudiments of ſurgery.

The following winter he was ſo far advanced in the knowledge of human anatomy, as to inſtruct the pupils in diſſection, to whom Dr. Hunter had very little time to pay attention. This office, therefore, fell almoſt entirely upon him, and was his conſtant employment during the winter ſeaſon.

In the ſummer months of 1750, Mr. Hunter attended the hoſpital at Chelſea; in 1751, he became a pupil at St. Bartholomew's, and in the winter was preſent at operations occaſionally, whenever any thing extraordinary occurred. The following ſummer he went to Scotland, and brought up his ſiſter Dorothea, and in 1753 entered as a gentleman commoner at St. Mary Hall, Oxford. In 1754, he became a ſurgeon's pupil, at St. George's Hoſpital, where he continued during the ſummer months, and in 1756, was appointed houſe-ſurgeon.

In the winter, 1755, Dr. Hunter admitted him to a partnerſhip in his lectures, and a certain portion of the courſe was allotted to him, beſides which, he gave lectures when the doctor was called away to attend his patients.

Making anatomical preparations was at this time a new art, and very little known; every preparation, therefore, that was ſkilfully made, became an object of admiration; many were wanting for the uſe of the lectures, and the doctor having himſelf an enthuſiaſm for the art, left no means untried to infuſe into his brother a love for his favourite purſuits. How well he ſucceeded, the collection afterwards made by Mr. Hunter will ſufficiently evince.

Anatomy ſeems to have been a purſuit for which Mr. Hunter's mind was peculiarly fitted, and he applied to it with an ardor and perſeverance of which there is hardly any example. His labours were ſo uſeful to his brother's collection, and ſo gratifying to his diſpoſition, that although in many other reſpects they did not agree, this ſimple tie kept them together for many years.

Mr. Hunter worked for ten years on human anatomy, during which period he made himſelf maſter of what was already known, as well as made ſome addition to that knowledge *. He traced the ramifications of the olfactory nerves upon the membranes of the noſe, and diſcovered the courſe of ſome of the branches of the fifth pair of nerves. In the gravid uterus, he traced the arteries of the uterus to their termination in the placenta. He was alſo the firſt who diſcovered the exiſtence of the lymphatic veſſels in birds.

Many parts of the human body being ſo complex, that their ſtructure could not be underſtood,

* An account of his injecting the teſtis, his deſcription of the deſcent of that body, with obſervation on the hernia congenita, and his experiments in proof of the veins not being abſorbents, are publiſhed in Dr. Hunter's Medical Commentaries.

nor their uſe aſcertained, Mr. Hunter was led to examine ſimilar parts in other animals, in which the ſtructure was more ſimple, and more within the reach of inveſtigation; this carried him into a wide field, and laid the foundation of his collection in comparative anatomy.

In this new line of purſuit this active inquirer began with the more common animals, and preſerved ſuch parts as appeared by their analogy, or in ſome other way, to elucidate the human œconomy. It was not his intention to make diſſections of particular animals, but to inſtitute an inquiry into the various organizations by which the functions of life are performed, that he might thereby acquire ſome knowledge of general principles. This, I believe, had never been before attempted, or certainly had never been carried far into execution.

So eagerly did Mr. Hunter attach himelf to comparative anatomy, that he ſought by every means in his power the opportunities of proſecuting it with advantage. He applied to the keeper of wild beaſts in the Tower for the bodies of thoſe which died there, and he made ſimilar applications to the men who ſhewed wild beaſts. He purchaſed all rare animals which came in his way; and theſe, with ſuch others as were preſented to him by his friends, he entruſted to the ſhowmen to keep till they died, the better to encourage them to aſſiſt him in his labours.

His health was ſo much impaired by exceſſive attention to his purſuits, that in the year 1760 he was adviſed to go abroad, having complaints in his breaſt, which threatened to be comſumptive. In October of that year, Mr. Adair, inſpector-general of hoſpitals, appointed him a ſurgeon on the ſtaff; and in the following ſpring he went with the army to Belliſle, leaving Mr. Hewſon to aſſiſt his brother during his abſence.

Mr. Hunter ſerved, while the war continued, as ſenior ſurgeon on the ſtaff, both in Belliſle and Portugal, till the year 1763; and in that period acquired his knowledge of gun-ſhot wounds; a ſubject which makes no inconſiderable part of the preſent work.

On his return to England he ſettled in London; where not finding the emoluments from his half-pay and private practice ſufficient to ſupport him, he taught practical anatomy and operative ſurgery for ſeveral winters. He returned alſo with unabated ardour to comparative anatomy, and his experiments could not be carried on in a large town, he purchaſed, for that purpoſe, about two miles from London, a piece of ground near Brompton, at a place called Earl's Court, on which he built a houſe.

In the courſe of his inquiries this excellent anatomiſt aſcertained the changes which animal and vegetable ſubſtances undergo in the ſtomach when acted on by the gaſtric juice; he diſcovered, by means of feeding young animals with madder, (which tinges growing bones red) the mode in which a bone retains its ſhape during its growth; and explained the proceſs of exfoliation by which a dead piece of bone is ſeparated from the living.

His fondneſs for animals made him keep ſeveral of different kinds in his houſe which by attention he rendered familiar with him, and amuſed himſelf by obſerving their peculiar habits, and inſtincts; but this familiarity was attended with conſiderable riſk, and ſometimes led him into ſituations of danger, of which the following is a remarkable inſtance.

Two leopards, which were kept chained in an out-houſe, had broken from their confinement, and got into the yard among ſome dogs, which they immediately attacked; the howling this produced, alarmed the whole neighbourhood; Mr. Hunter ran into the yard to fee what was the matter, and found one of them getting up the wall to make his efcape, the other furrounded by the dogs; he immediately laid hold of them both, and carried them back to their den; but as foon as they were fecured, and he had time to reflect upon the rifk of his own fituation, he was fo much agitated that he was in danger of fainting.

On the fifth of February, 1767, he was chofen a Fellow of the Royal Society. His defire for improvement in thofe branches of knowledge which might affift in his refearches led him at this time to propofe to Dr. George Fordyce and Mr. Cumming an eminent mechanic, that they fhould adjourn from the meetings of the Royal Society, to fome coffee-houfe, and difcufs fuch fubjects as were connected with fcience. This plan was no fooner eftablifhed, than they found their numbers increafed; they were joined by Sir Jofeph Banks, Dr. Solander, Dr. Mafkelyne, Sir George Shuckburgh, Sir Harry Englefield, Sir Charles Blagden, Dr. Noothe, Mr. Ramfden, Mr. Watt of Birmingham, and many others. At thefe meetings difcoveries and improvements in different branches of philofophy were the objects of their confideration; and the works of the members were read over and criticifed, before they were given to the public.

It was in this year that by an exertion in dancing, after the mufcles of the leg were fatigued, he broke his tendo achillis. This accident and the confinement in confequence of it, led him to pay attention to the fubject of broken tendons, and to make a feries of experiments to afcertain the mode of their union. He did not, according to the common practice, confine himfelf to his bed, but by compreffing the mufcles, and raifing the heel, he was enabled, with the knee being kept ftraight, to walk about the third day after receiving the accident. He divided the tendo achillis of ſeveral dogs, by introducing a couching needle through the ſkin at ſome diſtance from it, and with the edge cut through the tendon; in this way the orifice in the ſkin healed up, and made it ſimilar to a broken tendon. The dogs were killed at different periods to ſhow the progreſs of union, which was exactly ſimilar to that of a fractured bone when there is no wound in the ſkin.

In the year 1768, Dr. Hunter having completed the houſe in Wind-mill-ſtreet, in which his collection is at preſent depoſited, and where he afterwards carried on his anatomical lectures, he gave up to Mr. Hunter the leaſe of his houſe in Jermyn-ſtreet, which was commodious and well ſituated for private practice. In this houſe Mr. Hunter lived ten years; the ſame year too he became a member of the corporation of ſurgeons; and in the year following, through his brother's intereſt, he was elected one of the ſurgeons of St. George's Hoſpital.

As he was always engaged in the improvement of his profeſſion, young gentlemen who came to London to finiſh their education were very deſirous of living in his houſe, and ſeveral gentlemen, very eminent in practice in different parts of the country, received part of their education as his houſe-pupils. Dr. Edward Jenner of Berkley, Mr. William Guy of Chicheſter, and Mr. John Kingſton, boarded in his houſe in 1770 and 1771, and lived in habits of intimacy with him till his death.

In May 1771, his Treatiſe on the natural Hiſtory of the teeth was publiſhed; and in July of the ſame year he was married to Miſs Home, the eldeſt daughter of Mr. Home, ſurgeon to Burgoyne's regiment of light horſe. The expence of his purſuits had been ſo great, that it was not till ſeveral years after his firſt engagement with this lady, that his affairs could be ſufficiently arranged to admit of his marrying.

In June 1772, his ſon John was born, who is now an officer in the army *. In the autumn of the ſame year I came to him as an apprentice.

While he was paying his addreſſes to my ſiſter Miſs Home, I was a boy at Weſtminſter-ſchool. During the holidays I came home, and Mr. Hunter who was frequently there, always ſhewed me particular kindneſs; he made my father an offer to bring me up to his profeſſion; a propoſal which I readily accepted. I was ſtruck with the novelty, and extent of his reſearches, had the higheſt reſpect and admiration for his talents, and was ambitious to tread the paths of ſcience under ſo able a maſter. It is a tribute which I owe to his memory to declare, that an intimate knowledge of him for one-and-twenty years has increaſed my admiration of his uncommon exertions, and my reſpect for his abilities..

After finiſhing my education at Weſtminſter-ſchool as a king's ſcholar, and being elected off to Trinity College, Cambridge, I found that no advantages which could have been derived from a ſcholarſhip in the Univerſity would compenſate for the time I muſt have given up in keeping my terms, to the diſadvantage of my chirurgical education; I therefore thought it prudent to forego my claims upon the Univerſiry as a king's ſcholar, and inſtead of going down to Cambridge, though elected, went immediately to Mr. Hunter.

* He had another ſon who died an infant, and two daughters, of which Mary Anne died while very young; and Agnes, who is ſtill alive, is married to Capt. James Campbell, eldeſt ſon of Sir James, brother of the late Sir Archibald Campbell.

At this time his private practice and his professional character were advancing very faft, and his family had begun to increafe, but ftill no fmall part of his time was devoted to his collection, which, as it daily became larger, was alfo attended with greater expence. The whole fuite of the beft rooms in his houfe were occupied by his preparations; and he dedicated his mornings, from fun-rife to eight o'clock, (the hour for breakfaft) entirely to his purfuits. To thefe he added fuch parts of the day as were not engaged in attending his patients.

The knowledge he derived from his favourite ftudies he conftantly applied to the improvement of the art of furgery, and omitted no opportunity of examining morbid bodies, from which he made a collection of facts which are invaluable, as they tend to explain the real caufes of fymptoms, which, during life could not be exactly afcertained, the judgment of the practioner being too frequently mifled by theoretical opinions, and delufive fenfations of the patients.

In the practice of furgery, where cafes occured in which the operations proved inadequate to their intention, he always inveftigated with uncommon attention the caufes of that want of fuccefs, and in this way detected many fallacies, as well as made fome important difcoveries in the healing art.

He detected the caufe of failure, common to all the operations in ufe for the radical cure of the hydrocele, and was enabled to propofe a mode of operating, in which that event can with certainty be avoided. He afcertained, by experiments and obfervations, that expofure to atmofpherical air, fimply, can neither produce nor increafe inflammation. He difcovered in the blood fo many phænomena connected with life, and not to be referred to any other caufe, that he confidered it as alive in its fluid ſtate. This opinion ſeems to be advanced in the Old Teſtament *, and, what is very extraornary, in the Alcoran † of Mahommed, it alſo appears to have been entertained by the celebrated Harvey ‡; but the mode in which this ſubject is conſidered in the following work will ſufficiently ſhew that in Mr. Hunter's mind this was not an opinion adopted, but one which aroſe from his own inveſtigation of the properties of the blood.

He improved the operation for the fiſtula lacrymalis, by removing a circular portion of the os unguis inſtead of breaking it down with the point of a trochar. He alſo diſcovered that the gaſtric juice had a power when the ſtomach was dead of diſſolving it, and gave to the Royal Society a

* "Ye ſhall eat the blood of no manner of fleſh, for "the life of all fleſh is the blood thereof."

Liviticus, chap. xvii, verſe 14.

† Alcoran, chap. xxiii. intitled, "The true Believer's revealed at Mecca."

"We formally created man of a finer ſort of clay; afterwards we placed him in the form of a ſeed in a ſure reſceptacle; afterwards we made the ſeed coagulated blood; and we formed the coagulated blood into a piece of fleſh; then we formed the piece of fleſh into bones, and we cloathed thoſe bones with fleſh; then we produced the ſame by another creation, wherefore, bleſſed be God, the moſt excellent Creator."

Chap. xcvi. intitled "Congealed Blood revealed at "Mecca."

"Read in the name of thy Lord, who hath created all things, who hath created man of congealed blood."

‡ Quinimo ex varioipſius motu, in celeritate aut tarditate vehementia aut debilitate et cætera, eum et irritantis injuriam et foventis commodum perſenticere manifeſtum eſt. Ideoque concludimus ſanguinem per ſe vivere et nutriri;

Gueliemi Harveii,
Operum, tom. ii. Exercitatio 52.

paper on this subject, which is published in the Philosophical Transactions *.

In the winter 1773, he formed a plan of giving a course of lectures on the theory and principles of surgery, with a view of laying before the public his own opinions upon that subject. For two winters he read his lectures gratis to the pupils of St. George's Hospital, and in 1775, gave a course for money upon the same terms as the other teachers in the different branches of medicine and surgery.

Giving lectures was always particularly unpleasant to him; so that the desire of submitting his opinions to the world, and learning their general estimation, were scarcely sufficient to overcome his natural dislike to speaking in public. He never gave the first lecture of his course without taking thirty drops of laudanum to take off the effects of his uneasiness. He was so diffident of himself that he trusted nothing to memory, and made me draw up a short abstract of each lecture, which he read on the following evening as a recapitulation, to connect the subject in the minds of the students.

It is curious that the fundamental doctrines of these lectures, which constitute the principal part of the present work, should be the last of his publications; and that his anxiety to render them complete, should make him patiently revise and correct them for twenty years before he gave them to the press. We learn from these circumstances both his diffidence respecting himself, and the value which he placed upon his future reputation.

Comparative anatomy may be considered as the pursuit in which Mr. Hunter was constantly employed. No opportunity escaped him. In the year

* There are several preparations both in Dr. Hunter's and Mr. Hunter's collection illustrating this fact.

1773, at the requeſt of his friend Mr. Walſh, he diſſected the torpedo, and laid before the Royal Society an account of it's electrical organs.

A young elephant which had been preſented to the Queen by Sir Robert Barker died, and the body was given to Dr. Hunter, which afforded Mr. Hunter an opportunity of examining the ſtructure of that animal by aſſiſting his brother in the diſſection; ſince that time two other elephants died in the Queen's menagerie, both of which came under Mr. Hunter's examination.

In 1774, he publiſhed in the Philoſophical Tranſactions an Account of certain Receptacles of Air in Birds, which communicate with the lungs, and are lodged both among the fleſhy parts and hollow bones of theſe animals; and a paper on the Gillaroo-trout, commonly called in Ireland, the Gizzard-trout.

In 1775, ſeveral animals of that ſpecies, called the gymnotus electricus of Surinam was brought alive to this country, and by their electrical properties excited very much the public attention. Mr. Walſh, deſirous of purſuing his inveſtigations of animal electricity, made a number of experiments on the living animals; and to give his friend Mr. Hunter an opportunity of examining them, purchaſed thoſe that died. Any anatomical account of their electrical organs was drawn up by Mr. Hunter, and publiſhed in the Philoſophical Tranſactions. In the ſame volume there is a paper of his, containing Experiments on Animals and Vegetables reſpecting their power of producing heat.

In the courſe of his purſuits, Mr. Hunter met with many parts of animals where natural appearances could not be preſerved, and others, in which the minuter veſſels could not be diſtinctly ſeen when kept in ſpirits; it was therefore neceſſary to have them drawn, either at the moment, or before they were put into bottles. The expence of employing profeffed draftfmen, the difficulty of procuring them, and the difadvantage which they laboured under in being ignorant of the fubject they were to reprefent, made him defirous of having an able perfon in his houfe entirely for that purpofe.

With this view he engaged an ingenious young artift to live with him for ten years; his time to be wholly employed as a draftfman, and in making anatomical preparations. This gentleman, whofe name was Bell, foon became a very good practical anatomift, and from that knowledge was enabled to give a fpirited and accurate refemblance of the fubjects he drew; fuch as is rarely to be met with in reprefentations of anatomical fubjects. By his labours Mr. Hunter's collection is enriched with a confiderable number of very valuable drawings, and a great variety of curious and delicate anatomical preparations *.

In January 1776, Mr. Hunter was appointed furgeon-extraordinary to his Majefty, and in the fpring he gave to the Royal Society a paper on the beft mode of recovering drowned perfons.

In the autumn he was taken extremely ill, and the nature of his complaints made his friends, as well as himfelf, confider his life to be in danger. When he reflected upon his own fituation, that all his fortune had been expended in his purfuits, and that his family had no provifion but what fhould arife from the fale of his collection, he became very folicitous to give it its full value, by leaving it in a ftate of arrangement.

* The engravings inferted in Mr. Hunter's Treatife on the Venereal Difeafe, in his book upon the Animal Œconomy, and moft of thefe contained in the prefent work, are taken from Mr. Bell's drawings, and will remain as proofs of his abilities in that particular line of drawing.

As ſoon as he was able to leave his room, his firſt object was to make a catalogue of his collection; but his health requiring him to go to Bath, I was was employed, with the aſſiſtance of Mr. Bell, during his abſence, in making deſcriptions of the preparations, leaving blanks for ſuch as I was not acquainted with. His complaints were a good deal relieved, but his impatience to return to town, made him come back before he was well; he continued, however, to amend, and very ſoon recovered.

In 1778, he publiſhed the ſecond part of his Treatiſe on the Teeth, in which their diſeaſes, and the mode of treatment are conſidered. This rendered his work upon that ſubject complete. He publiſhed alſo in the Philoſophical Tranſactions a paper on the Heat of Animals and Vegetables.

I had now lived ſix years with Mr. Hunter, and had compleated my education; his expences had always exceeded his income, I had therefore no emolument to expect from remaining in his houſe, which made it neceſſary for me to take up ſome line for my own ſupport, and Admiral Keppel's action with the French fleet was the means of procuring me a very eligible ſituation.

The newly finiſhed naval hoſpital at Plymouth received the whole of the wounded men from Admiral Keppel's fleet, and Dr. Farquarſon, the firſt commiſſioner of ſick and hurt, at the requeſt of Mr. Adair, the preſent ſurgeon general to the garriſon of Gibraltar, gave me the appointment of aſſiſtant-ſurgeon, with appartments to reſide at the hoſpital. From the circumſtance of my being the only ſurgeon on that eſtabliſhment, who was a member of the corporation, I was authorized by the ſick and hurt board to perform operations, and aſſiſt the ſurgeon in the more important parts of his duty.

In this ſituation many opportunities occured to me of adding to Mr. Hunter's collection; the ſea furniſhing curious fiſh and other marine productions, and the hoſpital practice preparations of morbid parts.

Mr. Hunter was now wholly aſſiſted by Mr. Bell. In 1779, he publiſhed his Account of the Free Martin in the Philoſophical Tranſactions.

In 1780, he laid before the Royal Society an Account of a Woman who had the Small-pox during Pregnancy, where the diſeaſe ſeemed to have been communicated to the fœtus.

In 1781, he was elected a Fellow of the Royal Society of Sciences and Belles Lettres, at Gottenburg.

In 1782, he gave the Royal Society a paper on the Organ of Hearing in Fiſh. Beſides the papers which he preſented to that learned body, he read ſix Croonion lectures upon the ſubject of Muſcular Action, for the years 1776, 1778, 1779, 1780, 1781, and 1782. In theſe lectures he collected all his obſervations upon muſcles, reſpecting their powers and effects, and the ſtimuli by which they are affected; and to theſe he added Comparative Obſervations upon the moving Powers of Plants.

Theſe lectures were not publiſhed in the Philoſophical Tranſactions, for they were withdrawn as ſoon as read, not being conſidered by the author as complete diſſertations, but rather as materials for ſome future publication.

It is much to be regretted that Mr. Hunter was ſo tardy in giving his obſervations to the public; but ſuch was his turn for inveſtigation, and ſo extenſive the ſcale upon which he inſtituted his inquiries, that he always found ſomething more to be accompliſhed, and was unwilling to publiſh any thing which appeared to himſelf unfiniſhed. His obſervations on the Muſcular Action of the Blood-veſſels were laid before the Royal Society in 1780, and yet he delayed publiſhing them till his Obſervations on the Blood and Inflammation were arranged, and they will be found to make a part of the preſent work.

In 1783, he was choſen into the Royal Society of Medicine, and Royal Academy of Surgery in Paris.

In this year the leaſe of his houſe in Jermyn-ſtreet having expired, and his collection being now too large to be contained in his dwelling houſe, he purchaſed the leaſe of a large houſe on the eaſt ſide of Leiceſter-ſquare, and the whole lot of ground extending to Caſtle-ſtreet, on which there was another houſe. In the middle ſpace between the two houſes he erected a building for his collection.

Upon this building he expended above three thouſand pounds, and unfortunately for his family, the leaſe did not extend beyond twenty-four years.

In excuſe for ſo inconſiderate a tranſaction, it can only be ſaid, that the difficulties he had met with in finding ground in an eligible ſituation, had haraſſed his mind, already too much occupied, to ſuch a degree, that he was glad to be relieved from that embarraſſment, and made the intereſt of his family give way to his preſent accommodation.

In the building formed for the collection there was a room fifty-two feet long, by twenty-eight wide, lighted from the top and having a gallery all round, for containing his preparations. Under this were two apartments; one for his lectures, and the other, with no particular deſtination at firſt, but afterwards made uſe of for weekly meetings of medical friends during the winter. To this building the houſe in Caſtle-ſtreet was entirely ſubſervient; and the rooms in it were uſed for the different branches of human and comparative anatomy.

During the execution of this extenſive plan I returned to England from Jamaica, where at the cloſe of the war I had been appointed ſtaff ſurgeon. Sir Archibald Campbell, the governor, coming home, gave me leave of abſence on account of my health, and allowed me to attend him. We arrived in Auguſt 1784, and I was permitted to exchange upon half pay.

I found Mr. Hunter now advanced to a very conſiderable ſhare of private practice, and a ſtill greater ſhare of the public confidence. His collection had increaſed with his income. In this he was materially aſſiſted by the friendſhip of Sir Joſeph Banks, who not only allowed him to take any of his own ſpecimens, but procured him every curious animal production in his power, and afterwards divided between him and the Britiſh Muſeum all the ſpecimens of animals he had collected in his voyage round the world. To his friends the honourable Mr. Charles Greville and Mr. Walſh, he was alſo under particular obligations.

Drawing materials from ſuch ample ſources, ſtanding alone in this branch of ſcience, and high in the public eſtimation, he had ſo much attention paid to him, that no new animal was brought to this country which was not ſhewn to him; many were given to him; and of thoſe that were for ſale he commonly had the refuſal: under theſe circumſtances, his collection made a progreſs, which would otherwiſe have been impoſſible.

In April 1785, the new room was compleated, and I devoted the whole of this ſummer to the object of aſſiſting him in moving his preparations, and arranging them in their proper order. Mr. Bell and Mr. Andre, a gentleman who had been the greater part of his life engaged in anatomical purſuits, were conſtantly employed in this buſineſs.

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At this period Mr. Hunter may be confidered as at the height of his chirurgical career; his mind and body were both in their full vigor. His hands were capable of performing whatever was fuggefted by his mind; and his judgment was matured by former experience. Some inftances of his extraordinary fkill may very properly be mentioned.

He removed a tumor from the fide of the head and neck of a patient at St. George's Hofpital, as large as the head to which it was attached; and by bringing the cut edges of the fkin together, the whole was nearly healed by the firft intention.

He diffected out a tumor on the neck which one of the beft operating furgeons in this country had declared, rather too ftrongly, that no one but a fool or madman would attempt; and the patient got perfectly well.

He difcovered a new mode of performing the operation for the popliteal aneurifm, by taking up the femoral artery on the anterior part of the thigh, without doing any thing to the tumor in the ham. The fafety and efficacy of this mode have been confirmed by many fubfequent trials; and it muft be allowed to ftand very high among the modern improvements in furgery*

I believe Mr. Hunter was one of the firft who taught, that cutting out the part was the only mode of preventing the hydrophobia; and he extended the time in which that might be done with every probability of fuccefs, beyond the period generally believed. This doctrine, in favour of cutting out the part, met with the ftrongeft confirmation by two melancholy cafes, in which, from the nature of the parts and numberlefs fcratches on the fkin, it was impoffible to remove them. Though cauftic

* An account of this operation is publifhed in the Tranfactions of a Society for improving Medical and Chirurgical Knowledge.

was applied to every part that had a viſible mark, and every other precaution that could be thought of was uſed, the wounds in both inſtances proved fatal.

If we conſider Mr. Hunter at this period of his life, it will afford us a ſtrong picture of the turn of his mind, of his deſire to acquire knowledge, and his unremitting aſſiduity in proſecuting whatever was the object of his attention.

He was engaged in a very extenſive private practice; he was ſurgeon to St. George's Hoſpital; he was giving a very long courſe of lectures in the winter; he was carrying on his enquiries in comparative anatomy; had a ſchool of practical human anatomy in his houſe; and was always employed in ſome experiments reſpecting the animal œconomy.

He was always ſolicitous for ſome improvement in medical education; and, with the aſſiſtance of Dr. Fordyce, inſtituted a medical ſociety, which he allowed to meet in his lecture-rooms, and of which he was choſen one of the patrons. This ſociety, called the Lyceum Medicum Londinenſe, under his auſpices and thoſe of Dr. Fordyce, has acquired conſiderable reputation, both from the numbers and merits of its members.

In the year 1786, in conſequence of the death of Mr. Middleton, Mr. Hunter was appointed deputy ſurgeon-general to the army. He now publiſhed his work upon the Venereal Diſeaſe, which had been long expected by the public; and, if we may judge from the rapid ſale of the firſt edition, theſe expectations have not been diſappointed. He alſo publiſhed a work entitled, Obſervations on certain Parts of the Animal Œconomy. In this work he has collected ſeveral of his papers inſerted in the Philoſophical Tranſactions, which related to that ſubject, having permiſſion from the preſident and council of the Royal Society to reprint them; there are alſo Obſervations upon fome other Parts of the Animal Œconomy, which had not before been publifhed. This work met with a ready fale. It is to be confidered among the peculiarities of his character, that he chofe to have his works printed and publifhed in his own houfe, where they were alfo fold; but finding this meafure to bear hard upon the bookfellers, in a way which had not been explained, and which was not intended, the fecond edition was fold by Mr. Johnfon in St. Paul's Church-yard, and Mr. Nicol in Pall-mall.

In the fpring of this year he had a very fevere illnefs, which confined him to his bed, and rendered him incapable of attending to any kind of bufinefs. In this ftate I was obliged to take upon myfelf the charge of his patients, as well as of his other affairs, and thefe were fo extenfive that my refidence in his houfe became abfolutely neceffary. His recovery was very flow; and his health received fo fevere a fhock that he was never afterwards entirely free from complaint, or capable of his ufual bodily exertions.

After his recovery from this illnefs, he was fubject to affections of his heart, upon every occafion which agitated his mind, or required any fudden exertion of the body. In this infirm ftate he was unable to attend his patients upon fudden calls in the night, or to perform operations without affiftance; and for thefe reafons I continued to live with him till within a year of his death, and then took a houfe within a few doors, which in no refpect detatched me from his purfuits, or prevented me taking a part in his private practice.

In the year 1787, he gave a paper to the Royal Society, containing an Experiment to determine the Effect of extirpating one Ovarium on the Number of Young; a paper in which the Wolfe, Jackall and Dog, are proved to be of the fame Species;

and a third upon the anatomy of the Whale Tribe. Thefe papers procured him the honour of receiving Sir John Copley's annual gold medal, given as a mark of diftinguifhed abilities.

Thefe labours fhew that the decline of his health, although it diminifhed his exertions, by no means abated his ardour for the inquiries in which he was always engaged.

In July, he was chofen a member of the American Philofophical Society. He now applied to the Governors of St. George's Hofpital, to be allowed on account of his health, an affiftant-furgeon, which they very readily granted, and I was appointed to that office.

His collection, which had been the great object of his life, both as a purfuit and an amufement, was now brought into a ftate of arrangement; and gave him at length the fatisfaction of fhewing to the public a feries of anatomical facts formed into a fyftem, by which the œconomy of animal life was illuftrated. He fhewed it to his friends and acquaintances twice a year, in October to medical gentlemen, and in May to noblemen and gentlemen, who were only in town during the fpring. This cuftom he continued to his death.

Several of his friends had long been defirous of having an engraving of him, and requefted him to fit for a picture to fome painter of eminence whom they would employ. This he always declined, not choofing that it fhould be done at the expence of others; and thinking the price too high for himfelf to pay. His fcruples were, however, at length furmounted, by a defire to oblige Mr. Sharp, the engraver, of whofe works he was an admirer. This artift made a requeft that he would fit to Sir Jofhua Reynolds, who had promifed to take unufual pains with the picture; as the engraving was propofed more as a teſt of the artiſt's abilities upon which he might eſtabliſh a character, than as a print for ſale.

This picture, which is one of the very laſt works of that eminent painter, and one of his beſt, remains in the poſſeſſion of Mr. Hunter's ſon; and the print which Mr. Sharp engraved from it, is conſidered as one of the moſt ſpirited heads and fineſt engravings, which have been produced in this country.

In the year 1789, Mr. Bell, who was become a very ſkillfull anatomiſt, and a good practical ſurgeon, received an appointment as aſſiſtant-ſurgeon to the Iſland of Sumatra, in the ſervice of the Honourable Eaſt India Company. This appointment, procured by the friendſhip of Sir Joſeph Banks, he accepted with a double view, the one to improve his fortune, the other to collect ſpecimens in natural hiſtory. In both of theſe purſuits he was ſucceſsful beyond his moſt ſanguine expectations; he ſent home ſome very rare ſpecimens of animals and corals, and two papers, ſince printed in the Philoſophical Tranſactions, one on the double horned Rhinoceros, the other giving a deſcription of an uncommonly formed Fiſh; but, unfortunately for ſcience, he died of a fever, very much regretted by his friends, in the year 1792.

In the year 1792, Mr. Hunter found that his courſe of lectures took up ſo much of his time, that he was unable to correct his other papers. He therefore gave it up to me. As a previous ſtep to this arrangement I had given it the two preceeding ſummers. Mr. Hunter now began to prepare the preſent work for the preſs, and intended as ſoon as it was in the hands of the public, to give a courſe of practical lectures in ſurgery, for which he had been many years collecting materials; theſe were ſo far advanced, that another winter, had he lived, would have finiſhed them. The materials of theſe lectures having come into my hands; that they may not be entirely loſt to the public, I mean to avail myſelf of them, and am preparing my arrangements for that purpoſe.

Upon the death of Mr. Adair, which happened in this year, Mr. Hunter was appointed inſpector-general of hoſpitals, and ſurgeon-general of the army. He was alſo elected a member of the Royal College of Surgeons in Ireland.

In the year 1791, he was ſo much engaged in the duties of his office, as ſurgeon-general to the army, and his private practice, that he had little time to beſtow upon his ſcientifical objects; but his leiſure time, ſmall as it was, he wholly devoted to them.

In 1792, he was elected an honorary member of the Chirurgo Phiſical ſociety of Edinburgh, and was choſen one of the vice-preſidents of the Veterinary college, then firſt eſtabliſhed in London. He publiſhed in the Tranſactions of the Society for the improvement of medical and chirurgical Knowledge, of which ſociety he was one of the original members and a zealous promoter, three papers, on the following ſubjects: upon the treatment of inflamed Veins, on Introſuſception, and on a mode of conveying Food into the Stomach, in Caſes of Paralyſis of the Œſophagus.

He finiſhed his obſervations on the Œconomy of the Bees, and preſented them to the Royal Society. Theſe obſervations were made at Earl's court, and had engaged his attention for many years; every inquiry into the œconomy of theſe inſects had been attended by almoſt inſurmountable difficulties; but theſe proved to him only an incitement, and the contrivances he made uſe of to bring the different operations of theſe indefatigable animals to view were almoſt without end.

Earl's Court to Mr. Hunter was a retirement from the fatigues of his profeſſion; but in no reſpect a retreat from his labours; there, on the contrary, they were carried on with leſs interruption, and with an unwearied perſeverence. From the year 1772 till his death, he made it his cuſtom to ſleep there during the autumn months, coming to town only during the hours of buſineſs in the forenoon, and returning to dinner.

It was there he carried on his experiments on digeſtion, on exfoliation, on the tranſplanting teeth into the combs of cocks, and all his other inveſtigations on the animal œconomy, as well in health as in diſeaſe. The common bee was not alone the ſubject of his obſervation, but the waſp, hornet, and the leſs known kind of bees were alſo objects of his attention. It was there he made the ſeries of preparations of the external and internal changes of the ſilk-worm; alſo a ſeries of the incubation of the egg, with a very valuable ſet of drawings of the whole ſeries. The growth of vegetables was alſo a favourite ſubject of inquiry, and one on which he was always engaged in making experiments.

In this retreat he had collected many kinds of animals and birds, and it was to him a favourite amuſement in his walks to attend to their actions and their habits, and to make them familiar with him. The fiercer animals were thoſe to which he was moſt partial, and he had ſeveral of the bull kind from different parts of the world. Among theſe was a beautiful ſmall bull he had received from the Queen, with which he uſed to wreſtle in play, and entertain himſelf with its exertions in its own defence. In one of theſe conteſts the bull overpowered him, and got him down, and had not one of the ſervants accidentally come by and frightened the animal away, this frolic would probably have coſt him his life.

The collection of comparative anatomy which Mr. Hunter has left, and which may be confidered as the great object of his life, muft be allowed to be a proof of talents, affiduity, and labour, which cannot be contemplated without furprize and admiration.

It remains an unequivocal teft of his perfeverance and abilities, and an honour to the country in whofe fchools he was educated, and by the patronage of which he was enabled on fo extenfive a fcale to carry on his purfuits.

In this collection we find an attempt to expofe to view the gradations of nature, from the moft fimple ftate in which life is found to exift, up to the moft perfect and moft complex of the animal creation—man himfelf.

By the powers of this art, this collector has been enabled fo to expofe, and preferve in fpirits or in a dried ftate, the different parts of animal bodies intended for fimilar ufes, that the various links of the chain of perfection are readily followed and may be clearly underftood.

This collection of anatomical facts is arranged according to the fubjects they are intended to illuftrate, which are placed in the following order: Firft, parts conftructed for motion. Secondly, parts effential to animals refpecting their own internal œconomy. Thirdly, parts fuperadded for purpofes connected with external objects. Fourthly, parts for the propagation of the fpecies and maintenance or fupport of the young.

The firft clafs exhibits the fap of vegetables and blood of animals, for which fluids all the different parts of the vegetable and animal creation are formed, fupported, and increafed.

Thefe fluids being more and more compounded, as the vegetables and animals become more perfect, are coagulated and form a regular series. The sap of many plants does not coagulate spontaneously but is made to undergo this change by adding the extract of Gowlard, in this respect differing from water: the sap of such plants is considered as the most simple: in the onion there is a spontanious coagulation: in insects the blood coagulates, but is without colour: in the amphibia, colour is superadded. The moving powers of animals from the simple straight muscle, to the most complicated structure of that organ, with the different applications of elastic ligaments, form a second series. The growth of bone, horn, and shell, come next in order; and the joints which admit of their moving readily on one another, finish this subject.

The second class begins with those animals of the hydatid kind, which receive nourishment, like vegetables, from their external surface, having no mouth. Then follow those which are simply a bag or stomach, with one opening, as the polypus, having no organs of generation, as every part of the bag is endowed with that power; but in the leech the structure becomes more complex, for although the animal is composed of a bag with only one opening, the organs of generation, brain, and nerves, are superadded, and thence a gradual series is continued to those animals in which the stomach forms only a distinct part of the animal, for the purpose of digestion. The stomachs themselves are also arranged in the order of their simplicity. First, the true membranous digesting stomach, then those with the addition of crops, and other bags, to prepare the food for digestion, as in the ruminating tribe, and, lastly, those with gizzards. Annexed to the stomach, is a very complete and extensive series of teeth, which are varied according to the kind of food and stomach.

After the stomachs, are the different appearances of the inteſtinal canal, which exhibit almoſt an infinite variety in the ſtructure of their internal ſurface from which the aliment is abſorbed. The quantity of ſurface is increaſed in ſome by tranſverſe folds, in ſome by ſpiral or longitudinal ones, and in others puts on a loculated appearance, as in the whale.

To theſe are added the glands, connected with the inteſtines, as the liver, pancreas, and ſpleen, which may properly be conſidered as appendages.

After digeſtion, follows the ſyſtem of abſorbing veſſels, the ſimpleſt being the roots of plants, after which are lymphatic and lacteal veſſels of different animals. Theſe in the human ſubject and the elephant are ſmall, and in the turtle large and more numerous; but in the ſpermaceti whale, where they are employed for conveying the ſpermaceti, of a ſize infinitely beyond what is met with in any other animal. To theſe are annexed the thoracic ducts in different animals.

The natural order, in following the courſe of the aliment from the ſtomach as a guide, leans from the abſorbents to the heart, which in the caterpillar is a ſimple canal or artery running along the middle of the back of the animal, admitting of undulation of the blood; from this ſimple ſtructure it becomes, in different animals, by ſmall additions, more and more complex, till it arrives at the degree of perfection which is diſplayed in the organization of the human heart. Theſe are followed by the different ſtructures of valves in the arteries and veins, and the coats of theſe veſſels. Then the lungs are ſhown in all their gradations from the ſimple vaſcular lining of the eggſhell, which ſerves as lungs for the chicken, to thoſe of the more perfect animals. In one inſtance, viz. that of the ſyren, both gills and lungs are ſeen in the ſame animal. The windpipe and larynx are then ſhown, under all their different forms. The kidnies, which ſeparate the ſuperfluous fluids from the circulation, make the laſt part of this ſubject.

The third claſs takes up the moſt ſimple ſtate of the brain, which is in the leech a ſingle nerve with ramifications. In the ſnail, the brain forms a circular nerve, through the middle of which paſſes the œſophagus, from which circle there are branches going to every part of the ſkin of the animal. In the inſect, the brain has a more compact form, is larger in fiſh, but ſtill more ſo in birds, gradually increaſing in ſize as the animal is endowed with a greater degree of ſagacity, till at laſt it becomes the large complex organ found in the elephant and in the human ſubject. The coverings of the brain, and the ganglions and peculiarities of the nerves are annexed. The organs of ſenſe are arranged in the order of their ſimplicity, beginning with that of touch, which is only a villous vaſcular ſurface, the villi very ſhort where the impreſſion is to be made through a thin cuticle, as in the human finger; very long where the covering is thick, as the hoof of the horſe. The organ of taſte is only a modification of touch, and therefore nothing in the organization is different, but the varieties in ſtructure adapting the tongue for different purpoſes are numerous; in many animals it anſwers the poſe of a hand, to bring the food to the mouth, as in many ſhell-fiſh, the ant-bear, woodpecker, and camelion. Connected with the tongue are the fauces which in many animals have peculiarities; in the electric eel, they have a curious carrunculated irregular appearance; but they are yet more extraordinary in the camel, which has an apparatus to moiſten the parts, ſo as to prevent the painful ſenſation of thirſt, thus adapting the animal to the ſandy deſarts which it is deſtined to inhabit; this apparatus conſiſts of a large bag hanging down ſeveral inches in the fauces, and attached to the palate, which the animals can at pleafure move up and down, and lubricate the fauces.. The organ of fmell is varioufly conftructed, and is more complicated in many animals than in man, as in the lion, and fea-cow. The organ of hearing in fifh confifts of three femicircular canals; but is much more complex in land animals. The organ of feeing is different in thofe animals which are formed to fee in water, and in thofe which fee in air; it differs again in thofe which are to fee with little or with much light; all thofe peculiarities are illuftrated by preparations. The pigmentum of the eye in fome fifh refembles polifh'd filver; in ruminating animals at the bottom of the eye it has a greenifh hue, in the lion and cat kind, a portion of the bottom is white; but, as a general principle, the colour of the pigmentum is the fame as the rete mufcofum of the fkin of the animal, being white in white animals and black in very dark ones.

After the brain and fenfes are arranged the cellular membrane and animal oils, which are followed by the external coverings. Thefe are divided into the different kinds, as hair, feathers, fcales, etc. with the rete mufcofum, or that membrane which is interpofed between the true fkin and the fcarf-fkin for the purpofe of giving the peculiar colour. Added to thefe are the parts peculiar to different animals, for offence and defence, as fpurs, hoofs, horns, ftings, and alfo electric organs. There follow next fuch peculiar ftructures as occur in certain tribes of animals, as the air-bladders in fifh, etc.

The fourth clafs begins with thofe animals which have no diftinct parts allotted for generation, that power being diffufed over the whole animal. In thefe the young grow out of the old, as in the coral and polypi; and next in order come the hermaphrodite organs both of plants, and of animals. The male organs are then taking up as a diftinct fubject, firſt in plants and then in animals, both at the times in which they do not breed, and in the breeding ſeaſon, to ſhow their different ſtates; to theſe are added a number of parts which anſwer ſecondary purpoſes in generation, and may be conſidered as appendages.

The female organs are firſt exhibited in the maiden ſtate, in every claſs of animals, demonſtrating the ſhape and length of the oviducts, the form of the uterus, the length of its horns, with the varieties in their ſtructure, and the inſtances in which theſe horns are entirely wanting, as in ſome monkeys; to which are added, the peculiarities reſpecting the hymen. They are then exemplied in the impregnated ſtate, beginning with the ſeeds of vegetables and thoſe which have both ſeeds and young ſhoots, as the onion. The eggs of inſects follow next, with their changes, particularly of the ſilk worm. The ſpawn of fiſh, are next ſhown, firſt in thoſe which have eggs, and then in thoſe which have their eggs hatched in the oviducts, as the dog-fiſh.

The arrangement then proceeds to the formation and incubation of the egg in the fowl, and the proceſs of fœtation in the quadruped, with their peculiarities and the different ſtructures and appearances of the afterbirth. Added to theſe are the peculiaarties of the fœtus, and the different modes by which the mother gives nouriſhment to her young.

In this collection, beſides the preparations of the parts of themſelves in ſpirits, in a dried ſtate or corroded, ſo as to give the moſt accurate ideas of their ſtructure, there is a conſiderable number of very valuable drawings to ſhow the progreſs of different proceſſes in the animal œconomy, together with ſuch appearances as were not capable of being preſerved.

This ſketch will give an idea, but a very inadequate one, of the ſyſtem which is comprehended in

Mr. Hunter's collection. It alſo includes a very large ſeries of whole animals in ſpirits arranged according to their internal ſtructure, and many of the moſt rare ſpecimens of preſerved animals in this country, as the camelopardus, guanica, hippopotamus, tapir, argus-pheaſant, etc.

There is alſo a ſeries of ſkulls of different animals to ſhew their peculiarities, and ſkeletons of almoſt every known genius of animals. There is a large collection of ſhells and inſects; a prodigious number of calculi of different ſorts from the urinary and gall-bladders, the ſtomach, and inteſtinal canal; there are likewiſe the moſt uncommon deviations from the natural ſtructure, both in man and in other animals, preſerved in ſpirits or in a dried ſtate; the moſt extraordinary ſpecimens of this kind are a double human uterus, one of the parts pregnant, and a double human ſkull perfectly formed, the one upon the top of the other. To make this collection more complete in every ſubject connected with comparative anatomy, is added one of the largeſt and moſt ſelect collections of extraneous foſſils that can be ſeen in this country.

The ſymptons of Mr. Hunter's complaint, for the laſt twenty years of his life, may be conſidered as thoſe of the angina pectoris; and form one of the moſt complete hiſtories of that diſeaſe upon record. I have choſen to give this account a place by itſelf diſtinct from the general hiſtory of his life, of which it forms an important part, more eſpecially when prefixed to a medical work.

Each ſymptom was deſcribed at the time it occurred, and either noted by himſelf, or dictated to me, when Mr. Hunter was too ill to write; they will therefore be found more accurately detailed than in ordinary cafes *.

Mr. Hunter was a very healthy man for the firft forty years of his life; and, if we except an inflammation of his lungs in the year 1759, occafioned moft probably by his attention to anatomical purfuits, he had no complaint of any confequence during that period. In the fpring of 1769, in his forty-firft year, he had a regular fit of the gout, which returned the three following fprings, but not the fourth; and in the fpring of 1773, having met with fomething which very forcibly affected his mind, he was attacked at ten o'clock in the forenoon with a pain in the ftomach, about the pylorus; it was the fenfation peculiar to thofe parts, and became fo violent that he tried change of pofition to procure eafe, he fat down, then walked, laid himfelf down on the carpet, then upon chairs, but could find no relief; he took a fpoonful of tincture of rhubarb, with thirty drops of laudanum, without the fmalleft benefit. While he was walking about the room he caft his eyes on the looking-glafs, and obferved his countenance to be pale, his lips white, giving the appearance of a dead man, this alarmed him, and led him to feel for his pulfe, but he found none in either arm; he now thought his complaint ferious; feveral phyficians of his acquaintance were then fent for, Dr. William Hunter, Sir George Baker, Dr.

* As the ftatement of the following cafe is made up from detached notes which were not written with a view to publication, it will appear in point of language extremely deficient; it was, however, thought better to leave it in its prefent form, leaft, by altering the language, the effect of fome of the expreffions might be diminifhed, or mifunderftood; it was alfo believed, that an account, however crude, coming directly from the author, would be more acceptable to the public, than one a little more finifhed from any other hand.

Huck Saunders, and Sir William Fordyce, all came but could find no pulſe; the pain ſtill continued, and he found himſelf at times not breathing. Being afraid of death ſoon taking place if he did not breathe, he produced the voluntary act of breathing, by working his lungs by the power of the will; the ſenſative principle, with all its effects on the machine not being in the leaſt affected by the complaint. In this ſtate he continued for three quarters of an hour, in which time frequent attempts were made to feel the pulſe, but in vain; however, at laſt, the pain leſſened, and the pulſe returned, although at firſt but faintly, and the involuntary breathing began to take place; while in this ſtate, he took Madeira, brandy, ginger, etc. but did not believe them of any ſervice, as the return of health was very gradual; in two hours he was perfectly recovered.

In this attack there was a ſuſpenſion of the moſt material involuntary actions, even involuntary breathing was ſtopped, while ſenſation with its conſequences, as thinking and acting with the will, were perfect, and all the voluntary actions were as ſtrong as before.

Quere. What would have been the conſequence of his not having breathed by means of the voluntary muſcles? It ſtruck him at the time that he would have died; but we cannot ſuppoſe that would have been the conſequence, as breathing moſt probably is only neceſſary for the blood while circulating, and as the circulation was ſtopped, no good could have ariſen from breathing.

From this caſe it appears that, the involuntary actions of the body are not a regular ſeries of actions depending abſolutely on one another, but each part can and often does act independently, or leaves off acting while other actions are going on; but although there is not an abfolute dependence, there is a neceffary connexion among them, without which their actions cannot long continue. The ftomach was probably the feat, or origin of this ceffation of action; as we know that affections of the ftomach have the greateft influence on every part of the body, and that affections of every part, have the power of influencing the ftomach.

Mr. Hunter never had any return of thefe affections of the ftomach, though frequently troubled with flight complaints both in the ftomach and bowels, which were readily removed by fmall dofes of rhubarb. In other refpects he enjoyed his health till the year 1776. Towards the end of the fpring he was feized with a very fevere and dangerous illnefs, in confequence of anxiety of mind from being obliged to pay a large fum of money for a friend, for whom he had been fecurity, and which his circumftances made extremely inconvenient.

At two o'clock in the forenoon he eat fome cold chicken and ham, and drank a little weak punch; immediately after this he went eight miles in a poftchaife. While he was on the journey he had the feel of having drank too much, but paffed the remainder of the day tolerably well; at twelve o'clock at night his ftomach was a little difordered, for which he took fome caraways, and went to bed; he had no fooner lain down than he felt as if fufpended in the air, and foon after the room appeared to go round; the quicknefs of this motion feemed to increafe, and at laft was very rapid; it continued for fome time, then became flower and flower till the whole was at reft; this was fucceeded by vomiting, which was encouraged and gave him a good night's reft; next day he was tolerably well, but fatigued: the morning after, thinking himfelf quite recovered, he went out before breakfaft, drank fome tea and eat fome bread and butter, which he was not accuſtomed to do. At eleven o'clock, he felt his ſtomach much in the ſame ſtate as before; in about half an hour, the ſenſation of the room appearing to turn, recommenced, and continued for ſome time, but not with ſuch violence as in the laſt attack; he became ſick and vomited; the ſenſation of himſelf and every thing elſe going round continued for ſome time, but not with ſuch violence as in the laſt attack; he became ſick and vomited; the ſenſation of himſelf and every thing elſe going round, went off, but that of being ſuſpended in the air continued, with a giddineſs; he now could hardly move his head from an horizontal poſition, and about two o'clock was brought home in his carriage, the motion of which was very diſagreeable, giving the ſenſation of going down, or ſinking *.

After he went to bed, the giddineſs and the idea of being ſuſpended in the air increaſed, and the leaſt motion of the head upon the pillow appeared to be ſo great that he hardly durſt attempt it; if he but moved his head half round, it appeared to be moving to ſome diſtance with great velocity; the idea he had of his own ſize was that of being only two feet long, and when he drew up his foot, or puſhed it down, it appeared to him to be moving a vaſt way. His ſenſations became extremely acute or heightened; he could not bear the leaſt light, ſo that although the window-blinds were ſhut, a curtain and blanket were obliged to be hung up againſt it, the fire to have a ſcreen before it, and the bed curtains to be drawn; he kept his eyelids cloſed, yet if a lighted can-

* It is very curious that, the ſenſation of ſinking is very uneaſy to moſt animals. When a perſon is toſſed in a blanket, the uncomfortable part is falling down; take any animal in the hand and raiſe it up, it is very quiet, but bring it down and it will exert all its powers of reſiſtance, every muſcle in the body is in action; this is the caſe even with a child as early as its birth.

dle came acroſs the room, he could not bear it; his his hearing was alſo painfully acute, but not ſo much increaſed, as his ſight; the ſmell and taſte were alſo acute, every thing he put into his mouth being much higher flavoured than common, by which means he reliſhed what he eat; his appetite at firſt was very indifferent, but ſoon became good; his pulſe was generally about ſixty, and weak, and a ſmall degree of heat on the ſkin, eſpecially on the hands and feet; he remained in this ſtate for about ten days, and was obliged to be fed as he lay; by this time he was rather better; that is, he could move his head more freely.

When he was at firſt attacked, the pulſe was full and eight ounces of blood were taken away, but this did not appear to be of ſervice; the day following he was cupped between the ſhoulders, and had a large bliſter applied upon the part; he took an emetic, and ſeveral times purging medicines, and bathed his feet in warm water, but nothing appeared to be of the leaſt uſe. The purging and vomiting diſtreſſed him greatly, for both the ſtomach and inteſtines were ſo irritable, that leſs than half the uſual quantity had the deſired effect. He took ſome James's powder, and drank ſome white wine whey on account of the heat in the ſkin, eſpecially in the feet and hands, which took it off, and gave him for the firſt time a comfortable feel. At the end of ten days all his ideas of his preſent ſtate became more natural, the ſtrange deception concerning his own ſize was in part corrected, and the idea of ſuſpenſion in the air became leſs; but for ſome time after, the fire appeared of a deep purple red. When he got ſo well as to be able to ſtand without being giddy, he was unable to walk without ſupport, for his own feelings did not give him information reſpecting his centre of gravity, ſo that he was unable to ballance his body, and prevent himſelf from falling.

He gradually recovered from this ſtate, and as ſoon as he was able went to Bath, where he ſtaid ſome time and drank the waters, which were thought to be of ſervice to him; but did not ſtay long enough to give them a fair trial; he returned to town much better, and in a few weeks got quite well. From this period to 1785, he had no particular indiſpoſition, but certainly did not enjoy perfect health, for in 1785, he appeared much altered in his looks, and gave the idea of having grown much older than could be accounted for from the number of years which had elapſed.

About the beginning of April 1785, he was attacked with a ſpaſmodic complaint, which at firſt was ſlight, but became afterwards very violent, and terminated in a fit of the gout in the ball of the great toe; this, like his other attacks, was brought on by anxiety of mind; the firſt ſymptom was a ſenſation of the muſcles of the noſe being in action, but whether they really were, or not, he was never able to determine; this ſenſation returned at intervals for about a fortnight, attended with an unpleaſant ſenſation in the left ſide of the face, lower jaw, and throat which ſeemed to extend into the head on that ſide, and down the left arm, as low as the ball of the thumb, where it terminated all at once; theſe ſenſations were not conſtant, but returned at irregular times; they became ſoon more violent, attacking the head, face, and both ſides of the lower jaw, giving the idea that the face was ſwelled, particularly the cheeks, and ſometimes ſlightly affected the right arm. After they had continued for a fortnight they extended to the ſternum, producing the ſame diſagreeable ſenſations there, and giving the feel of the ſternum being drawn backwards toward the ſpine, as well as that of oppreſſion in breathing, although the action of breathing was attended with no real difficulty; at these times the heart seemed to miss a stroke, and upon feeling the pulse, the artery was very much contracted, often hardly to be felt, and every now and then the pulse was entirely stopt; he was afterwards attacked with a pain in the back, about that part where the œsophagus passes through the diaphragm, the sensation being that of something scalding hot passing down the œsophagus; he was next seized with a pain in the region of the heart itself, and last of all with a sensation in the left side, nearly in the seat of the great end of the stomach, attended with considerable eructations of wind from that viscus; these seemed to be rather spasmodic than a simple discharge of wind, a kind of mixture of hiccough and eructation, which last symptoms did not accompany the former, but came on by themselves. In every attack there was a raw sore feel, as if the fauces were excoriated. All these succeeding symptoms (those in the stomach and nose only excepted) where, in addition to the first, for every attack began with the first symptoms. The complaint appeared to be in the vascular system, for the larger arteries were sensibly contracted, and sore to the touch, as far as they could be touched, principally in the left arm; the urine at those times was in general very pale.

These symptoms increased in violence at every return, and the attack which was the most violent, came on one morning about the end of April, and lasted above two hours; it began as the others had done, but having continued about an hour, the pain became excruciating at the apex of the heart; the throat was so sore as not to allow of an attempt to swallow any thing, and the left arm could not bear to be touched, the least pressure upon it giving pain, the sensation at the apex of the heat was that of burning or scorching, which, by its violence, quite exhausted him, and he sunk into a swoon or doze, which lasted about ten minutes, after which he started up, without the least recollection of what had passed, or of his preceeding illness. I was with him during the whole of this attack, and never saw any thing equal to the agonies he suffered; and when he fainted away, I thought him dead, as the pain did not seem to abate, but to carry him off, having first completely exhausted him.

He then fell asleep for half an hour, and awoke with a confusion in his head, and a faint recollection of something like a delirium; this went off in a few days.

The affections above-described were, in the beginning, readily brought on by exercise, and he even conceived that if he had continued at rest, they would not have come on; but they at last seized him when lying in bed, and in his sleep, so as to awaken him; affections of the mind also brought them on; but coolly thinking or reasoning did not appear to have that effect. While these complaints were upon him, his face was pale, and had a contracted appearance, making him look thinner than ordinary; and after they went off his colour returned, and his face recovered its natural appearance. On the commencement of the complaint, he suspected it to be rheumatism, and applied electricity to his arm, which took it off for the time only; he then, for two or three nights successively, took three grains of James's powder, without any abatement of the symptoms; he next had recourse to the camphorated julep, both at the commencement of the spasm, and while it was upon him, but obtained no relief; he tried Hoffman's anodyne liquor, in the dose of a tea-spoonful, and and not finding it to answer alone, joined to it the camphorated julep, but the spasms seemed to be more violent; one night he took twenty drops of thebaic tincture, which made his head confufed all the following day, but did not at all abate the fpafms; the following day he took two tea-fpoonfuls of the bark, which heated him, and gave him a head-ach, thirft, and drynefs of his month, which prevented his continuing it. At the defire of Dr. David Pitcairn, he took the powder of valerian, an ounce a day, which feemed for the firft two days to remove his fpafms, but they returned on the third with more violence than ufual, efpecially one evening at the Royal Society, which induced him to leave off the valerian, and he bathed his feet on going to bed in warm water, mixed with half a pound of flour of muftard, and took a tea-fpoonful of tincture of rhubarb in ginger-tea; alfo wore worfted ftockings all night.

On Friday morning, the twentieth of May, between fix and feven o'clock, he had a violent fpafm, attended with moft violent eructations of wind from the ftomach for nearly a quarter of an hour. Dr. Pitcairn, who was fent for upon this occafion, afked him, if there was any diftrefs upon his mind that had brought on this attack; and he confeffed his mind to have been much harraffed, in confequence of having opened the body of a perfon who died from the bite of a mad dog, about fix weeks before, in doing which he had wounded his hand; and for the laft fortnight his mind had been in continual fufpenfe, conceiving it poffible that he might be feized with fymptoms of hydrophobia. This anxiety preying upon his mind for fo long a time, there is every reafon to believe was the caufe of the prefent attack, and probably had alfo brought on the former ones, which were all after the accident which had impreffed his mind with this horrible idea.

At the deſire of Dr. Pitcairn, he took at two doſes in the forenoon, ten grains of aſafœtida, and three grains of opium, and in the afternoon fifteen of aſafœtida, and one of opium; in the evening he had a head-ach, which was ſuppoſed to be brought on by the opium, his bowels were loaded and oppreſſed with wind, and he endeavoured in vain to procure a motion by laxative clyſters, although repeated, and ten grains of jalap were taken by the mouth; he paſſed a very reſtleſs night. On Saturday morning he was viſited by Sir George Baker, Dr. Warren, and the late Dr. Pitcairn; he repeated the aſafœtida twice in the courſe of the day, and two ſpoonfuls of the following mixture were taken every hour, without producing a motion till about half an hour after the whole was uſed.

Infuſion of ſenna, ſix ounces;
Tincture of ſenna, one drachm and a half;
Soluble tartar, three drachms.
M.

In the afternoon he had another evacuation, ſoon after which, the moſt violent attack of ſpaſm which he experienced, came on; nothing was attempted internally during the attack, which laſted two hours; a bladder of hot water was applied to the heart, and afterwards to the feet, without any effect.

The aſafœtida was now left off, and this evening he began the oleum ſuccini in ſaline draughts fifteen drops every ſix hours. On ſunday morning he continued the oleum ſuccini, but the ſaline draught was changed to cinnamon-water, and a large bliſter was put upon the back cloſe to the neck; he continued pretty free from ſpaſm. On Monday the bliſter was taken off, and the oleum ſuccini continued; but about nine o'clock at night he had threatenings of ſpaſm, with head-ach, and the feel of a load in his bowels; he had a pain in the left ſide and region of the ſtomach, with violent eructations of wind from the ſtomach, which laſted about two hours; he took thebaic tincture, twenty-five drops, in the warm tincture of rhubarb, and afterwards ſome baume de vie, but the eructations continuing, ſinapiſms were applied to the feet, after which they ceaſed, and the ſinapiſms were ſo troubleſome that he had them taken off five hours after they were applied. On Tueſday morning he felt himſelf eaſier, the oleum ſuccini was continued, five drops of laudanum being added to each doſe; in the evening he bathed his feet in warm water, to clean them from the ſinapiſms, and both the great toes appeared a little inflamed, and very tender; they were more painful after being bathed, and were very troubleſome all night. On Wedneſday morning the inflammation and ſwelling in the great toes appeared evidently to be the gout, and the pain continued very acute till Thurſday, when it began to abate; and on Friday was very much diminiſhed: he continued the oleum ſuccini on Wedneſday, and a took a bolus of aromatic ſpecies before each doſe; but on Friday the oleum ſuccini made him ſick, and was left off. On Saturday he began the bark in tincture and decoction with the ſpecies aromaticæ; Sunday continued the bark, and having eructations and flatulencies after his meals, he was ordered every day before dinner, rhubarb fifteen grains, ginger ten grains, in a bolus. He had no ſpaſm after Monday the thirtieth of May; he however had threatenings, or ſlight ſenſations, ſimilar to thoſe which preceded the ſpaſms, and occaſional eructations. Although evidently relieved from the violent attacks of ſpaſm by the gout in his feet, yet he was far from being free from the diſeaſe, for he was ſtill ſubject to the ſpaſms, upon exerciſe or agitation of mind; the exerciſe that generally brought it on, was walking, eſpecially on an aſcent, either of ſtairs or riſing ground, but never on going down either the one or the other; the affections of the mind that brought it on were principally anxiety or anger: it was not the cause of the anxiety, but the quantity that most affected him; the anxiety about the hiving of a swarm of bees brought it on; the anxiety lest an animal should make its escape before he could get a gun to shoot it, brought it on; even the hearing of a story in which the mind became so much engaged as to be interested in the event, although the particulars were of no consequence to him, would bring it on; anger brought on the same complaint and he could conceive it possible for that passion to be carried so far as totally to deprive him of life; but what was very extraordinary, the more tender passions of the mind did not produce it; he could relate a story which called up all the finer feelings, as compassion, admiration for the actions of gratitude in others, so as to make him shed tears, yet the spasm was not excited: it is extraordinary that he eat and slept as well as ever, and his mind was in no degree depressed; the want of exercise made him grow unusually fat.

As he had not drank wine for four or five years he was advised to try it, which he complied with, but found the spasms more easily brought on after using it, than on those days on which he drank none; and they were always more readily produced after eating a hearty meal. He continued very much in the same way till August, when he went to Tunbridge and drank the waters for about a fortnight, without the least benefit, but rather conceived he was worse. From thence he hurried to Bath, the first week in September, and drank the waters for four weeks, twice before breakfast, and once at noon; having drank them for about a fortnight, he began to bathe every other night in the hot-bath, and on the intermediate nights put his feet into the hot-bath waters, and sometimes rode on horseback.

After being there three weeks he did not find the leaſt benefit, but on Monday, the beginning of the fourth week, he found that his walking to the pump-room in a morning did not bring on the ſpaſm as uſual, and found alſo that he could extend his walk very conſiderably on that day; on Tueſday he was not quite ſo well, although when he compared that day with the preceding days, or rather months, he could ſay that he was better; this ſeemed to be a ſtep gained; in this ſtate he left Bath, and continued the ſame through the whole winter. About the beginning of May 1786, he began to believe that the exerciſe he was able to make uſe of affected him leſs; he found that in the months of June, July, Auguſt, and September, he was able to take a long walk ſlowly; he could, however, at any time, bring on the complaint, for upon uſing the leaſt exerciſe he felt as if it was coming on; and often, by forgetting himſelf, he brought it on ſlighty, which made him ſlacken his pace. In the month of October, when the weather became cold, he was obliged conſtantly to uſe his carriage, becauſe he could not walk ſufficiently faſt to keep himſelf warm, although in other reſpects he was not affected by it. What appeared very extraordinary was, that the ſpaſm did not come on equally upon all kinds of exerciſe; he often performed an operation, as cutting for the ſtone, or extirpation of a breaſt, which, from peculiar circumſtances, required a conſiderable deal of fatigue, and laſted near an hour each time, yet the ſpaſm did not come on. He was employed in embalming the Princeſs Amelia for three hours, in which time he was really fatigued, but had no ſpaſm the whole time; yet, by going the length of Cavendiſh-ſquare, and on towards Oxford-road, he was ſeized with a conſiderable ſpaſm; but the fatigue he had undergone acted, probably, as a prediſpoſing cauſe.

Thefe fpafms, although they did not increafe in violence, were uniformly more frequent, and came on upon a greater variety of occafions; but as he became accuftomed to their effects, lefs attention was paid to them. Nothing particular occurred from this period till about the beginning of December 1789, in the evening, when at the houfe of a friend on a vifit, he was attacked with a total lofs of memory; he did not know in what part of the town he was, not even the name of the ftreet when told it nor where his own houfe was; he had not a conception of any place exifting beyond the room he was in, yet was perfectly confcious of the lofs of memory. He was fenfible of impreffions of all kinds from the fenfes, and therefore looked out of the window, although very dark, to fee if he could be made fenfible of the fituation of the houfe; this lofs of memory gradually went off, and in lefs than half an hour his memory was perfectly recovered. About a fortnight after, as he was vifiting his patient one forenoon, he obferved occafionally a little giddinefs in his head, and by three o'clock it was attended with an inclination to vomit. He came home and drank fome warm water, which made him vomit feverely, but nothing came off his ftomach except the water. The giddinefs became fevere, but went off again about feven or eight o'clock; about nine or ten it returned with more feverity, and when going to bed, about eleven o'clock, he had entirely loft the centre of gravity, although he could move his limbs as the will directed; light became offenfive, and every thing had a kind of yellow caft; founds were more acute than natural, objects had loft their true direction; a perpendicular, for inftance, feemed to lean to the left, making, as nearly as he could conjecture, an angle with the horizon of fifty or fixty degrees; objects were alfo fmaller than the natural recollection of them; his idea of his own fize was that of only being four feet high; alſo objects appeared to be at an unuſual diſtance, as if ſeen through a concave glaſs; he had a ſlight ſound in the right ear, at every ſtroke of the pulſe; motion in his head was extremely diſagreeable, he therefore moved with great caution; although coughing and ſneezing did not affect it: during this illneſs Dr. Pitcairn and Dr. Baillie attended him. It is difficult to deſcribe ſenſations, eſpecially when they are not common; the ſenſation which he had in his head was not pain, but rather ſo unnatural as to give him the idea of having no head; with all this, neither the mind nor the reaſoning faculty were affected, which is not the caſe when ſuch effects are produced from liquor. Objects in the mind were very lively, and often diſagreeably ſo; dreams had the ſtrength of reality, ſo much ſo, as to awaken him; the remembrance of them was very perfect. The diſpoſition to ſleep was a good deal gone, an hour or two in the twenty-four being as much as could be obtained; theſe ſymptons were much the ſame for about a week, and began gradually to diminiſh, ſo that in a fortnight he was able to ſit up, and in three weeks went an airing in the carriage; cordial medicines were given, and the body kept open; he felt a pain in the joint of the great toe, which inflamed gently, but ſoon left it; his pulſe was rather increaſed in frequency, the urine at firſt was high coloured, depoſited a ſediment, and was rather diminiſhed in quanity; but the retention in the bladder was very great, as he was not able to make water from ten o'clock in the evening till the ſame time the next evening, the quantity being very conſiderable, although not ſo much as would have been made in the ſame time had he been in health. The urine became of a yellow colour, and afterwards pale; the ſtools were ſolid; the taſte of victuals was not impaired, except tea, for which he had no reliſh. Although he had no particular inclination to eat, yet his appetite was not much diminiſhed. To excite the action of the gout, ſinapiſms were applied to the feet, but had not the deſired effect; in the fourth week the head not recovering ſo faſt as was expected, a bliſter was applied between the ſhoulders, but had no immediate effect, probably did harm, by producing irritation and want of ſleep; one night, not having above an hour's ſleep, he drank a tumbler full of hot water, which ſet him immediately to ſleep, in which ſtate he continued near four hours; he took a hint from this and drank a tumbler full of hot water every night, juſt before he went to bed, which did not fail of putting him ſoon to ſleep, and giving him a good night's reſt*.

The apparent obliquity of objects he accounted for by ſuppoſing that the two correſponding oblique muſcles had an unnatural contraction which moved the two eyes round near thirty or forty degrees; we ſhall ſuppoſe that the obliquus ſuperior of the left eye brought the eye-ball forwards to the noſe, while the obliquus inferior of the right eye contracted equal to the ſuperior of the left; this turned the under part of the right eye inwards towards the noſe, and the upper part outwards, which moved a lateral part of the eye upon the object, and gave it that obliquity.

His recovery from this indiſpoſition was leſs perfect than from any of the others; he never loſt entirely the oblique viſion; his memory was in ſome reſpects evidently impaired, and the ſpaſms became

* He took advantage of this circumſtance, and in all caſes of irritable ſtomachs, from whatever cauſe, preſcribed warm water, which in general gave relief; one remarkable caſe of bleeding from the ſtomach, in conſequence of irritation, was entirely cured by the internal uſe of warm water.

more conſtant; he never went to bed without their being brought on by the act of undreſſing himſelf; they came on in the middle of the night; the leaſt exertion in converſation after dinner was attended by them; he felt therefore obliged to confine himſelf within a certain ſphere of action, and to avoid dining in large companies. Even operations in ſurgery, if attended with any nicety, now produced the ſame effects.

In the autumn 1790, and in the ſpring and autumn 1791, he had more ſevere attacks than during the other periods of the year, but of not more than a few hours duration: in the beginning of October 1792, one, at which I was preſent, was ſo violent that I thought he would have died. On October the 16th, 1793, when in his uſual ſtate of health, he went to St. George's Hoſpital, and meeting with ſome things which irritated his mind, and not being perfectly maſter of the circumſtances, he withheld his ſentiments, in which ſtate of reſtraint he went into the next room, and turning round to Dr. Robertſon, one of the phyſicians of the hoſpital, he gave a deep groan, and dropt down dead.

It is a curious circumſtance that, the firſt attack of theſe complaints was produced by an affection of the mind, and every future return of any conſequence aroſe from the ſame cauſe; and although bodily exerciſe, or diſtention of the ſtomach, brought on ſlighter affections, it ſtill required the mind to be affected to render them ſevere; and as his mind was irritated by trifles, theſe produced the moſt violent effects on the diſeaſe. His coachman being beyond his time, or a ſervant not attending to his directions, brought on the ſpaſms, while a real misfortune produced no effect.

At the time of his death he was in the 65th year of his age, the ſame age at which his brother, the late Dr. Hunter, died.

Upon inſpecting the body after death, the following were the appearances: the ſkin in ſeveral places was mottled, particularly on the ſides and neck, which aroſe from the blood not having been completely coagulated, but remaining nearly fluid.

The contents of the abdomen were in a natural ſtate, but the coats of the ſtomach and inteſtines were unuſually loaded with blood, giving them a fleſhy appearance, and a dark reddiſh colour; thoſe parts, which had a depending ſituation, as in the bottom of the pelvis, and upon the loins, had this in a greater degree than the others; this evidently aroſe from the fluid ſtate of the blood. The ſtomach was rather relaxed, but the internal ſurface was entirely free from any appearance of diſeaſe; the orifice at the pylorus was uncommonly open. The gall-bladder contained five or ſix ſmall ſtones of a light yellow colour. The liver and the other viſcera exhibited nothing unuſual in their appearance.

The cartilages of the ribs had in many places become bone, requiring a ſaw to divide them. There was no water in the cavity, of the cheſt, and the lungs of the right ſide were uncommonly healthy; but thoſe of the left had very ſtrong adheſions to the pleura, extending over a conſiderable ſurface, more eſpecially towards the ſternum.

The pericardium was very unuſually thickened, which did not allow it to collapſe upon being opened; the quantity of water contained in it was ſcarcely more than is frequently met with, although it might probably exceed that which occurs in the moſt healthy ſtate of theſe parts.

The heart itſelf was very ſmall, appearing too little for the cavity in which it lay, and did not give the idea of its being the effect of an unuſual degree of contraction, but more of its having ſhrunk in its ſize. Upon the under ſurface of the left auricle and ventricle, there were two ſpaces nearly an inch and an half ſquare, which were of a white colour, with an opaque appearance, and entirely diſtinct from the general ſurface of the heart: theſe two ſpaces were covered by an exudation of coagulating lymph, which at ſome former period had been the reſult of inflammation there. The muſcular ſtructure of the heart was paler and looſer in its texture than the other muſcles in the body. There were no coagula in any of its cavities. The coronary arteries had their branches which ramify through the ſubſtance of the heart in the ſtate of bony tubes, which were with difficulty divided by the knife, and their tranſverſe ſections did not collapſe, but remained open. The valvulæ mitrales, where they come off from the lower edge of the auricle, were in many places oſſified, forming an imperfectly bony margin of different thickneſſes, and in one ſpot ſo thick as to form a knob; but theſe oſſifications were not continued down upon the valve towards the chordæ tendineæ.

The ſemilunar valves of the aorta had loſt their natural pliancy, the previous ſtage to becoming bone, and in ſeveral ſpots there were evident oſſifications.

The aorta immediately beyond the ſemilunar valves had its cavity larger than uſual, putting on the appearance of an incipient aneuriſm; this unuſual dilatation extended for ſome way along the aſcending aorta, but did not reach ſo far as the common trunk of the axillary and carotid artery. The increaſe of capacity of the artery might be about one-third of its natural area; and the internal membrane of this part had loſt entirely the natural poliſh, and was ſtudded over with opaque white ſpots, raiſed higher than the general ſurface.

On inſpecting the head, the cranium and dura matter were found in a natural ſtate. The pia mater had the veſſels upon the ſurface of the two hemiſpheres of the brain turged with blood, which is commonly found to be the caſe after ſudden death.

The internal ſtructure of the brain was very carefully examined, and the different parts both of the cerebrum and cerebellum were found in the moſt natural and healthy ſtate; but the internal carotid arteries as they paſs by the ſides of the cella turſica were oſſified, and ſeveral of the ramifications which go off from them had become opaque and unhealthy in their appearance. The vertebral arteries lying upon the medulla oblongata had alſo become bony, and the baſillary artery, which is formed by them, had opaque white ſpots very generally along its coats.

From this account of the appearances obſerved after death, it is reaſonable to attribute the principal ſymptoms of the diſeaſe to an organic affection of the heart. That organ was rendered unable to carry on its functions, whenever the actions were diſturbed, either in conſequence of bodily exertion, or affections of the mind.

The ſtoppage of the pulſe aroſe from a ſpaſm upon the heart, and in this ſtate the nerves were probably preſſed againſt the oſſified arteries, which may account for the excruciating pain he felt at thoſe times.

The other ſymptoms may be explained from the defect in the valves and the dilatation of the aorta, which had loſt its elaſticity.

In the laſt attack the ſpaſm upon the heart was either too violent in the degree of contraction, or too long continued to admit of relaxation, ſo that death immediately enſued.

His remains were interred in a vault under the pariſh church of St. Martin in the Fields, attended by a few of his oldeſt medical friends.

Mr. Hunter was of a ſhort ſtature, uncommonly ſtrong and active, very compactly made, and capable of great bodily exertion. His countenance was animated, open, and in the latter part of his life deeply impreſſed with thoughtfulneſs. When his print was ſhewn to Lavator, he ſaid, "That man thinks for himſelf." In his youth he was cheerful in his diſpoſition, and entered into youthful follies like others of the ſame age: but wine never agreed with his ſtomach, ſo that after ſome time he left it off altogether, and for the laſt twenty years drank nothing but water.

His temper was very warm and impatient, readily provoked, and when irritated, not eaſily ſoothed. His diſpoſition was candid, and free from reſerve, even to a fault. He hated deceit, and as he was above every kind of artifice, he deteſted it in others, and too openly avowed his ſentiments. His mind was uncommonly active; it was naturally formed for inveſtigation, and that turn diſplayed itſelf on the moſt trivial occaſions, and always with mathematical exactneſs. What is curious, it fatigued him to be long in a mixed company which did not admit of connected converſation; more particularly during the laſt ten years of his life.

He required leſs relaxation than moſt other men; ſeldom ſleeping more than four hours in the night, but almoſt always nearly an hour after dinner; this, probably, aroſe from the natural turn of his mind being ſo much adapted to his own occupations, that they were in reality his amuſement, and therefore did not fatigue.

To his own abilities alone was he indebted for the eminence which he acquired in his profeſſion; for although his medical education, his ſituation as ſurgeon to St. George's Hoſpital, and above all, his brother's recommendation entitled him to notice, yet the increaſe of his private practice was at firſt but ſlow. The natural independence of his mind, led him rather to indulge in his own purſuits, than to cultivate the means of enlarging the ſphere of his buſineſs; but the proofs which he afterwards gave of his talents commanded the attention of the public and procured him a very liberal income.

In the firſt eleven years of his practice, from 1763 to 1774, his income never amounted to a thouſand pounds a year; in the year 1778 it exceeded that ſum; for ſeveral years before his death it had increaſed to five, and at that period was above ſix thouſand pounds.

In private practice he was liberal, ſcrupulouſly honeſt in ſaying what was really his opinion of the caſe, and ready upon all occaſions to acknowledge his ignorance whenever there was any thing which he did not underſtand.

In converſation he ſpoke too freely, and ſometimes harſhly of his cotemporaries; but if he did not do juſtice to their undoubted merits, it aroſe not from envy, but from his thorough conviction that ſurgery was as yet in its infancy, and he himſelf a novice in his own art; and his anxiety to have it carried to perfection, made him think meanly and ill of every one whoſe exertions in that reſpect did not equal his own.

Public-ſpirited to an extreme, he valued money no farther than as it enabled him to proſecute and extend his various, and nearly univerſal reſearches; and hurried on by the ambition of benefiting mankind at large, he paid too little attention to his own and his family's intereſts. But imprudence almoſt always goes hand in hand with genius; if it deſerves a harſher name, let it be remembered, that his immediate relatives alone, and not the public, have a right to complain; for viewed in a profeſſional light, and as a man of ſcience, his zeal for the improvement of ſurgery in particular, and for the advancement of knowledge in general, to both of which he himſelf materially contributed, entitles him at leaſt to the gratitude, if not to the veneration of poſterity.

INTRODUCTION.

THE following pages, treating of inflammation, were first arranged in the year 1762, at Bellisle, after the complete reduction of that place. They were compiled from notes, and memorandums of observations, made in the course of twelve years residence in London. During this space, my time was occupied partly in my education under the late Dr. Hunter, and partly in assisting him. In the winter season I was principally employed in the dissecting-room, where I taught the practical part of anatomy; in the summer I attended the hospitals. The truth of these observations was, during the siege of Bellisle, in some degree put to the test, by comparing them with many cases of wounds, which were attended with inflammation. From the frequency of gun-shot wounds at that place, I was naturally led to arrange my thoughts upon the subject, and was induced to select them more particularly, for the illustration of my opinions on inflammation. About the year 1770, when I began my lectures on the principles of disease, inflammation was the subject of a considerable part of them; and, from that time till this, though I have been extending and correcting the materials, my principles remain the same. To distinguish the different species of inflammation*, and to express my own ideas the better, I was naturally led to substitute such terms as appeared to me more expressive of what was meant, than those usually employed. The best test of the propriety of these terms is, that they have been adopted by many medical writers since that period; and indeed my principles have undergone the same kind of test. In this some medical writers have been very liberal, for, not contented with taking hints, they have even laid hold of

* In the course of this work I very often make use of the word species or specific, by which I only mean peculiarities or distinctions; and probably the term is much too loose in its application; for as we are not entirely acquainted with the specific differences in disease, we may call that a species which more properly ranks as a genus, class, &c. Of morbid poisons we can make a correct arrangement; but, with regard to disease arising from peculiarities in the constitution, we have no such absolute guides.

large portions of my lectures, ſcreening themſelves under the very honourable protection of their not being in print; and, at the ſame time, quoting authors to ſhow their reading and their *candour*. It would appear that they conſider the diſcoveries and opinions of a lecturer, found probably in a manuſcript, as fair game; though their delicate attention to the rights of another would, no doubt, have prevented them from adopting the ſame doctrines, had they been actually in print. Such freedoms have made me anxious to publiſh, not only becauſe the public intereſts itſelf in the origin of every diſcovery or opinion, but becauſe I wiſh to preſerve my right, and alſo to give in a more perfect form, what was thought worthy of the public, even in a mutilated ſtate. My reſpect for that public, however, has withheld me hitherto from publiſhing, that I might firſt be able to complete my ſubject, as far as time and other circumſtances would allow me. I hope this publication will, at leaſt, have equal good effects with thoſe I have before produced, not only enabling perſons to write on the ſame ſubject, who could not otherwiſe have done it, but even to become critics in matters of which, till then, they were entirely ignorant.

I have endeavoured, as far as my other purſuits would permit, to form this work into a regular ſyſtem, one part exactly depending on another; how far I have ſucceeded the world muſt judge; but at the ſame time it ought to be conſidered as a new figure compoſed from rough materials, in which proceſs little or no aſſiſtance could be had from any quarter, wherein the author is conſcious of many imperfections, more of which he is perſuaded he ſhall himſelf obſerve at every ſucceſſive review.

There are many opinions reſpecting the animal œconomy peculiar to myſelf, which are introduced, or frequently referred to, in the courſe of this work. It is therefore neceſſary to premiſe a ſhort explanation of ſome of them, that the ideas and terms which are employed may be better underſtood. To others of them, however, this method cannot be applied, as they belong eſſentially to the body of the work, or are ſo immediately connected with it, as to be beſt underſtood when treated in connection with that part.

I ſhall carry my ideas of life further than has commonly been done: life I believe to exiſt in every part of an animal body, and to render it ſuſceptible of impreſſions which excite action; there is no part which has not more or leſs of this principle, and consequently no part which does not act according to the nature of the principle itself, and the impressions thence arising, producing thereby infinite variety, both in all natural and diseased acts. How far every part has an equal quantity of life, or of the powers of life, is not easily ascertained; but if we were to estimate them by the powers of action, we should judge tolerably well. Disease would seem to give some intelligence with regard to this matter; but how far resistance to disease, and powers of restoration, depend on the powers of life, or simply on the powers of action, I cannot say; but I believe it may be set down as a rule, that those parts that are endowed with most action resist disease most strongly, and in disease restore themselves more readily to a healthy state.

I. OF DISEASED ACTIONS, AS BEING INCOMPATIBLE WITH EACH OTHER.

As I reckon every operation in the body an action, whether universal or partial, it appears to me, beyond a doubt, that no two actions can take place in the same constitution, nor in the same part at one and the same time; the operations of the body are similar in this respect to actions or motions in common matter. It naturally results from this principle, that no two different fevers can exist in the same constitution, nor two local diseases in the same part at the same time. There are many local diseases which have dispositions totally different, but having very similar appearances, have been supposed by some to be one sort of disease, by others to be a different kind, and by others again a compound of two diseases. Thus the venereal disease, when it attacks the skin, is very similar to those diseases which are vulgarly called scorbutic, and vice versâ. These, therefore, are often supposed to be mixed, and to exist in the same part Thus we hear of a pocky-scurvy, a pocky-itch, rheumatic-gout, etc. etc. which names, according to my principle, imply a union that cannot possibly exist.

It has been considered as contradictory to this opinion, that a patient might have the scrofula, scurvy, venereal disease, small-pox, etc. at the same time; all this is indeed possible; but then no two of them can exist in the same part of the body at the same time; but before one of them can occupy the place of another, that other muſt be firſt deſtroyed, or it may be ſuperſeded for a time, and may afterwards return.

When a conſtitution is ſuſceptible of any one diſeaſe, this does not hinder it from being alſo ſuſceptible of others. I can conceive it poſſible that a man may be very ſuſceptible of every diſeaſe incident to the human body, although it is not probable; for I ſhould believe that one ſuſceptibility is in ſome degree incompatible with another, in a manner ſimilar to the incompatibility between different actions, though not of ſo ſtrict a kind.

A man may have the lues and the ſmall-pox at the ſame time; that is, parts of his body may be contaminated by the venereal poiſon; the ſmall-pox may at the ſame time take place, and both diſeaſes may appear together, but ſtill not in the ſame part.

In two eruptive diſeaſes, where both are neceſſarily the the conſequence of fever, and where both naturally appear after the fever nearly at the ſame diſtance of time, it would be impoſſible for the two to have their reſpective eruptions, even in different parts, becauſe it is impoſſible that the two preceding fevers ſhould be co-exiſtent.

From this principle I think I may fairly put the following queries:—Does not the failure of inoculation, and the power of reſiſting many infections, ariſe from the exiſtence of ſome other diſeaſe at that time in the body, which is therefore incapable of another action?

Does not the great difference in the time, from the application of the cauſe to the appearance of the diſeaſe, in many caſes, depend upon the ſame principle? For inſtance, a perſon is inoculated, and the puncture does not inflame for fourteen days, caſes of which I have ſeen, is not this deviation from the natural progreſs of the diſeaſe to be attributed to another diſeaſe in the conſtitution at the time of inoculation?

Does not the cure of ſome diſeaſes depend upon the ſame principle as the ſuſpenſion or cure of a gonorrhoea by a fever?

Let me illuſtrate this principle ſtill further, by one of many caſes which have come under my own obſervation. On Thurſday, the ſixteenth of May, one thouſand ſeven hundred and ſeventy-five, I inoculated a gentleman's child, and it was obſerved that I made pretty large punctures. On the Sunday following, viz. the nineteenth, he appeared to have received the infection, a ſmall inflammation or redneſs appearing round each puncture, and a ſmall tumor. On the twentieth and the twenty-firſt the child was feveriſh; but I declared that it was not the variolous fever, as the inflammation had not at all advanced ſince the nineteenth. On the twenty-ſecond a conſiderable eruption appeared, which was evidently the meaſles, and the ſores on the arms appeared to go back, becoming leſs inflamed.

On the twenty-third he was very full of the meaſles; but the punctures on the arm were in the ſame ſtate as on the preceding day.

On the twenty-fifth the meaſles began to diſappear. On the twenty-ſixth and twenty-ſeventh the punctures began again to look a little red. On the twenty-ninth the inflammation increaſed, and there was a little matter formed. On the thirtieth he was ſeized with fever. The ſmall-pox appeared at the regular time, went through its uſual courſe, and terminated favourably.

II. OF PARTS SUSCEPTIBLE OF PARTICULAR DISEASES.

There are ſome parts much more ſuſceptible of ſpecific diſeaſes than others. Poiſons take their different ſeats in the body as if they were allotted to them. Thus the ſkin is attacked by what are vulgarly called ſcorbutic-eruptions, as well as many other diſeaſes; it is alſo the ſeat of the ſmall-pox and the meaſles; the throat is the ſeat of action in the hydrophobia and the hooping cough. The abſorbent ſyſtem, eſpecially the glands, are more ſuſceptible of ſcrofula than moſt other parts of the body. The breaſts, teſticles, and the conglomerate glands, are moſt commonly the ſeat of cancer. The ſkin, throat, and noſe, are more readily affected by the lues venerea, than the bones and perioſteum, which however ſuffer ſooner than many other parts, particularly the vital parts, which perhaps are not at all ſuſceptible of this diſeaſe. Theſe differences may ariſe from the nature of the parts themſelves, or from ſome regular circumſtances, which muſt act as an exiſting cauſe.

III. OF SYMPATHY.

It is unneceſſary to give a definition of ſympathy, for it is generally very well underſtood when applied to the mind, and alſo by medical men when applied to the body. In the mind its reference is external, it depends upon the ſtate of others, and one of its chief uſes is to excite an active intereſt in favour of the diſtreſſed, the mind of the ſpectators taking on nearly the ſame action with that of the ſufferers, and diſpoſing them to give relief or conſolation; it is, therefore, one of the firſt of the ſocial feelings, and by many uſeful operations, incline mankind to union. In the body, ſympathy has only a reference internally to the body itſelf, and is not ſo evident as the ſympathy of the mind; although in ſome caſes we ſee its effects. It is either natural or diſeaſed; but it is the diſeaſed only that I propoſe at preſent to conſider. I ſhall divide the ſympathy of the body into two kinds, univerſal and partial.

By the univerſal ſympathy is meant, where the whole conſtitution ſympathizes with ſome ſenſation or action of a part. By partial ſympathy is meant, when one or more diſtinct parts ſympathize with ſome local ſenſation or action. The univerſal ſympathies are various in different diſeaſes; but thoſe which ariſe in conſequence of local violence, are principally three, viz. the ſymptomatic, the nervous, and the hectic fever. The ſymptomatic fever is an immediate effect of ſome local injury, and therefore is an univerſal ſympathy ariſing from a local cauſe; the nervous has no determined form nor ſtages of the diſeaſe from the firſt cauſe, as delirium, ſpaſm, almoſt of all kinds and in all parts, locked-jaw, etc. The hectic fever is alſo an univerſal ſympathy, attended with a local diſeaſe, which the conſtitution is not able to overcome. Moſt of theſe will be more fully treated when I have occaſion to deſcribe their cauſes.

I divide partial ſympathy into three kinds; the remote, the contiguous, and the continuous.

The remote ſympathy is where there appears no viſible connection of parts that can account for ſuch effects. In theſe caſes there is commonly a ſenſation in the ſympathizer which appear to be deluſive, and produces a wrong reference of the mind to the ſeat of the diſeaſe, ſuch as the pain of the ſhoulder in an inflammation of the liver.

The contiguous ſympathy is that which appears to have no other connection than ariſes from the contact of ſeparate parts. An inſtance of which we have in contained parts ſympathizing with the containing; ſuch as the ſtomach and inteſtines ſympathizing with the integuments of the abdomen, the lungs with the cheſt, the brain with the ſcalp, and the teſticles with the ſcrotum.

The continuous ſympathy is where there is no interruption of parts, and the ſympathy runs, or is continued along from the irritating point as from a centre, ſo as to be gradually loſt in the ſurrounding parts, in proportion to the diſtance; and this is the moſt common of all the ſympathies; an example of it we have in the ſpreading of inflammation, which will be often mentioned in this treatiſe.

IV. OF MORTIFICATION.

MORTIFICATION is of two kinds, the one without inflammation, and the other preceded by it; but as the caſes of mortification, which will be mentioned in this work, are all of the ſecond kind, I ſhall confine my obſervations to that ſpecies.

I conſider inflammation as an increaſed action of that power which a part naturally poſſeſſes; and, in healthy inflammations at leaſt, it is probably attended with an increaſe of power; but in inflammations which terminate in mortification, there is no increaſe of power; but, on the contrary, a diminution of it. This, when joined to an increaſed action, becomes a cauſe of mortification, by deſtroying the balance which ought to ſubſiſt between the power and action of every part. There are beſides, caſes of mortification preceded by inflammation, which do not ariſe wholly from that, as a cauſe, but rather ſeem to have ſomething in their nature; of this kind is the carbuncle, and the ſlough formed in the ſmall-pox puſtule.

If this account of mortifications, ariſing from no ſpecific nature, be juſt, we ſhall find it no difficult matter to eſtabliſh a rational mode of cure; but, before we attempt this, let us take a view of the treatment which has been hitherto recommended, and ſee how far it agrees with our theory. It is plain, from the common practice, that the weakneſs has been attended to; but it is plain that the increaſed action has been overlooked; and, therefore, the whole aim has been to increaſe the action in order to remove the weakneſs. The Peruvian bark, confectio cardiaca, ſerpentaria, etc. have been given in large quantities, as the caſe appeared to require, or the conſtitution could bear; by which means an artificial or temporary appearance of ſtrength has been produced, while it was only an increafed action. Cordials and wine, upon the principle on which they have been given, are rationally adminiftered; but there are ftrong reafons for not recommending them, arifing from the general effect which they poffefs, of increafing the action without giving real ftrength. The powers of the body are, by this treatment, funk afterwards in the fame proportion as they had been raifed, by which nothing can be gained, but a great deal may be loft; for, in all cafes, if the powers are allowed to fink below a certain point, they are irrecoverable.

The local treatment has been as abfurd as the conftitutional; fcarifications have been made down to the living parts, that ftimulating and antifeptic medicines might be applied to them, as turpentines, the warmer balfams, and fometimes the effential oils; warm fomentations have been alfo applied, as being congenial to life; but warmth always increafes action, and, therefore, fhould be well adjufted to the cafe; for, on the other hand, cold debilitates, or leffens powers when carried too far, but at firft leffens action. Stimulants likewife are improper where the actions are already too violent.

Upon the principles here laid down, the bark is the principal medicine, as yet known, that we depend upon, as it increafes the powers and leffens the degree of action. Upon many occafions opium will be of fingular fervice, by leffening the action; although it does not give real ftrength. I have feen good effects from it, both when given internally in large dofes, and when applied to the part. It is proper alfo to keep the parts cool, and all the applications fhould be cold.

PART I.

CHAPTER I.

GENERAL PRINCIPLES OF THE BLOOD.

AS the blood is allowed by all to have a conſiderable ſhare in inflammation, or at leaſt to be particularly affected by it, becoming, by its appearances, one of the ſigns or ſymptoms of its exiſtence; and, as the blood is a material object with me in the theory of inflammation, I ſhall begin my treatiſe with its natural hiſtory, a previous knowledge of which is the more requiſite, becauſe the accounts of this fluid, hitherto given, will hardly explain any of its uſes in the machine in health, or of its changes in diſeaſe.

The heart and veſſels are very active in inflammations; and as their ſtructures and actions have not hitherto been underſtood, I have ſubjoined to the natural hiſtory of the blood an account of the ſtructure of the heart and veſſels, together with their actions in the machine; to which I have added one uſe of the abſorbents not hitherto known.

As every natural action of the body depends, for its perfection, on a number of circumſtances, we are lead to conclude, that all the various combining actions are eſtabliſhed while the body is in health, and well-diſpoſed; but this does not take place in diſeaſed actions, for diſeaſe, on the contrary, conſiſts in the want of this very combination; and diſeaſed actions, therefore, vary according to many natural circumſtances, of which I propoſe to point out a few of the moſt ſtriking inſtances.

Inflammation muſt have ſome exciting cauſe, and the ſame cauſe will produce an effect under one circumſtance, which it will not under another. I have, therefore, begun with the ſuppoſition of an injury, attended with ſuch circumſtances as do not excite inflammation, which will form a ſtrong contraſt to thoſe which do, the oppoſite effects mutually illuſtrating each other; but as inflammation is a very general action of the veſſels in diſeaſe, and is of various kinds, I have previouſly given a ſhort account of ſeveral of the moſt common ſorts of inflammation, which will explain the reſt.

The whole material world has been very properly divided into ſolids and fluids; theſe being the only eſſentially different ſtates of matter we are able to obſerve. From one of theſe ſtates, to the other, matter appears to be continually paſſing, but with theſe reſtrictions, that no ſpecies of matter can aſſume a ſolid form, without having firſt been in a fluid ſtate; nor can any change take place in a ſolid till it be firſt formed into, or ſuſpended in a fluid. The living animal body is obedient to theſe general laws, for all ſolid and animal matter has firſt been fluid, and having paſſed into this ſolid form, becomes a recipient for other fluids, out of which the ſolids may themſelves be renovated and increaſed.

The ſolids of an animal, although compoſed of one ſpecies of matter, yet admit of great variety in their appearance, and this variety takes place in ſome animals more than in others. But the fluid part of an animal body, in its natural ſtate, has but one appearance, which is that of blood. There are certain parts of animals which, though hardly ſolid in their own nature, are yet to be conſidered as ſolids, from their being fixed in their ſituation, and appropriated to local actions; ſome of them acting on the fluids (which are, to a certain degree, paſſive in all animals) and diſpoſing of them for particular purpoſes in the animal œconomy, in the ſame manner as is done by thoſe which are uſually called the ſolids in animals; of this ſort are the gelatinous parts in many of the inferior orders of ſea animals, as the Meduſa, the vitrious humour of the eye, etc. There appears to be a ſympathetic intercourſe between the ſolid and the fluid parts of an animal, deſigned by nature for their mutual ſupport. In diſeaſe, when the machine cannot be furniſhed in the common way, the ſolids of the body ſupply the defects, and the perſon becomes lean; and the fluids would appear from this, to be more an object of attention in the machine than even the ſolids.

This fluid part of an animal is called the blood, and in the animals with which we are moſt acquainted, it is of a red colour. The nature and appearances of the blood have been more attended to in diſeaſes, eſpecially of the inflammatory kind, than in full health, as it is more expreſſive of diſeaſe, when removed from the body, than any of the ſolids, and undergoes changes which the ſolids do not. Some of theſe changes are produced by the ſeparation of parts from one another; but as the body is ſeldom in perfect health, we can hardly procure the blood in the ſame ſtate twice from one perſon, although it may not be ſenſibly diſeaſed. In a hiſtory of the blood theſe varieties muſt be mentioned, although they are often ſlighter appearances of what we find in diſeaſe; for diſeaſe certainly throws great light on the natural hiſtory of the blood, and the apparent changes which it undergoes muſt have unavoidably called medical men to conſider it with attention.

The only knowledge, however, we have of any difference in the blood, ariſes from theſe varieties in its ſpontaneous changes when extravaſated; nor do theſe differences appear always to affect the real nature of the blood, as the animals often continue in health while they are going on.

Blood is moſt probably as much alike in all animals, as the muſcle of one animal is like that of another; only with this difference, that ſome animals have not that part which gives it the red colour; but the other parts, as the lymph and ſerum, are, as far as I yet know, the ſame in all.

Transfuſion of the blood of one animal into the veſſels of another, proves, to a certain degree, the uniform nature of the blood; for, as far as theſe experiments have been urged, no alteration has been obſerved.

Concerning natural objects, we uſually acquire a groſs knowledge, from the frequency with which they are obſerved, and it often requires little more than common attention to have a tolerable conception of their general principles. This is the caſe with the blood.

Blood is known to be of a red colour in a great number of animals, and to be altogether a fluid while circulating in the living body. It is known to ſeparate into parts when out of the body, and a portion of it to become ſolid; it is likewiſe known, that, when deprived of a certain proportion of it, an animal dies; it has, therefore, been held in particular veneration, as conſtituting the life of the animal. Like other things which are diſcovered to be of great uſe, the blood has frequently attracted the attention of mankind, as an object of curioſity only, from which ſome have proceeded to a more critical enquiry into its nature and properties, and to more extenſive elucidation of the ſubject at large. To this, practitioners in phyſic have a great deal contributed, from a conviction, that this knowledge would be of much uſe to them in their profeſſion; and the teachers of the art have been ſtill more induſtrious in their inveſtigations; but the frequeut recourſe which is had to the lancet in diſeaſes, has afforded the moſt ample opportunities of obſervation, almoſt ſufficient to explain every principle in the blood, without the aid of further experiment.

In animals poſſeſſed of red blood, two modes of inveſtigation may be adopted. One of theſe reſpects the blood while in its circulating, when the colour makes its motion viſible, and gives an idea of the circulation in the ſmaller veſſels. Accidents, operations, and anatomical knowledge of the veſſels in which the blood is contained, have at the ſame time aſſiſted us to form more perfect ideas of its motion in the larger veſſels. The other mode, which is that of examining the blood when out of the body, enables us to obſerve whatever relates to its ſpontaneous changes and ſeparation, together with the apparent properties of each component part. Its chemical properties become known likewiſe by this ſecond mode, though without throwing much light on the nature of the fluid itſelf.

The blood is called a fluid becauſe it is always found in a fluid ſtate in the veſſels of a living animal, while under the influence of the circulation: yet it is not, under all circumſtances naturally ſo; for of one part of it, when not circulating, ſolidity is a neceſſary and eſſential property; fluidity being only neceſſary at the time of circulation for its motion, diſtribution, and the eaſy ſeparation of its parts.

Without being fluid, it could not be propelled through flexible tubes, and diſtributed to all parts of the body. It could not be divided into portions, as the veſſels branch off; it could not paſs through the ſmaller veſſels, nor admit of the various ſeparations of its parts, which are to produce the increaſe and repairs of the whole body; neither could it be adapted for furniſhing the various ſecretions; nor could it be brought back to the heart*.

* The diſtribution of water from the ſea, is ſimilar to the arterial ſyſtem; and the rivers returning to it have an analogy to the veins; but their effects are different; becauſe the globe works entirely upon its own materials. The waters are conti-

The red colour of the blood is produced merely by ſome red matter diffuſed through it, but not common to all animals. The blood exhibits a greater variety of changes, and admits of more experiments to determine its nature and properties than the ſolids. This, in ſome degree, ariſes from its fluidity, in which form it has not yet attained its ultimate ſtate, and is only the ſubſtance that furniſhes materials, out of which the ſolids are produced or augmented.

The heat in the animal body, principally in thoſe which are called warm animals, has been commonly conſidered as depending principally on the blood, or at leaſt as being connected with it, as much as with any other portion of the body†: as I ſhall have occaſion to take notice of the increaſed heat of inflamed parts, it might be expected, that I ſhould endeavour to explain this principle in the hiſtory of the blood. I profeſs, however, not thoroughly to underſtand it, and the theories hitherto brought forward, do not in the leaſt ſatisfy me; as I think that none of them accord perfectly with every circumſtance obſervable in theſe caſes.

I. OF THE MASS OF BLOOD, AS COMPOSED OF DIFFERENT PARTS.

THE blood, while circulating in the veſſels, appears to the eye to be a homogeneous maſs; but when it is paſſing in veſſels ſo ſmall as almoſt to ſeparate its viſible parts, and is viewed in a microſcope, there is no appearance but that of globules moving in the veſſels.

In ſuch a ſituation the other parts called the coagulable lymph, and the ſerum, are not diſtinguiſhable, on account

nually carrying away the land from one ſituation, and depoſiting it in another; taking down continents, and leaving the ocean in their place; while at the ſame time they are raiſing continents out of the ſea. But animals work upon foreign matter, introduced from time to time into the ſyſtem.

† From whence the expreſſion, warm blooded, or cold blooded animals; but the expreſſion ſhould rather be, the animals of a permanent heat in all atmoſpheres, and animals of a heat variable with every atmoſphere.

of their being tranfparent, and the globules do not, ftrictly fpeaking, conftitute a part of the fluid, but are only diffufed through it. Thefe globules being red, give this colour to the blood, and are called the red part, but are not always of the fame rednefs when collected in a mafs; this is probably owing to each globule being changed in its tint of colouring. The blood of fome animals has no fuch globules, but is perfectly tranfparent, indeed more fo than the moft tranfparent parts of the red blood, to which it is analogeous. A red colour is therefore not effential to conftitute true blood; and I believe the flight tinge of colour there is in the blood, independent of the globules, arifes from the folution of various fubftances in the ferum. The blood has a peculiar tafte, being faltifh, but of a peculiar flavour: we can always diftinguifh by the tafte when there is blood in the mouth.

Thefe are the principal obfervations we can make on the blood when circulating, or in its fluid ftate; but as one part of it under certain circumftances changes into a folid, or as it is commonly termed, coagulates, more of its parts are thus expofed; in this procefs the blood feparates into two diftinct fubftances, a coagulating part, and another which feparates from it and remains fluid; but the coagulum entangles the red part, and this alone fhews the blood to be formed of thefe component parts. The parts of the blood fo feparated, have been named according to their apparent properties; the one, the coagulable lymph; the other, the ferum; and the red part has been called the red globules; but upon a more intimate knowledge of the different parts of this fluid, we fhall find that thofe terms are not expreffive of all their properties.

The term *coagulable* lymph, is not expreffive of this property, as one which is inherent in the lymph itfelf; for many fubftances are capable of being coagulated, though not fpontaneoufly, yet by chemical means. For inftance; heat coagulates the farinaceous part of vegetables, and thus forms pafte; and alfo mucus. Spirits of wine coagulates many animal fubftances; acid coagulates milk, &c. the term, therefore, to be ufed refpecting this property of the blood, fhould be fuch as expreffes its inherent power of felf-coagulation: perhaps *coagulating* might be better applied to what is called *coagulable* lymph; and the epithet coagulable might be referved for thofe fluids which require a chemical procefs to produce that effect. Of this kind is the ferum, for I have discovered this fluid to be composed of two parts, which is ascertained by means of the different causes of coagulation. To discover all the various properties and uses of the component parts of the blood in the machine, may be impossible; and to determine whether they will act, or are employed conjunctively to produce the effect, is not easy: but there are some properties, discoverable which would incline us to believe, that particular parts of the blood are employed to compose particular solid parts, which are found to possess properties similar to different parts of the blood.

II. OF COAGULATION, AND ITS EFFECTS.

As coagulation is the first change which the blood undergoes, when out of the vessels, and as it even coagulates while in them, under certain circumstances, we shall consider this process first. Though fluidity is necessary to enable the blood to circulate, yet coagulation is no less necessary, when it is to be disposed of out of the circulation, even within the body, and therefore deserves to be considered with no less attention. There is, I think, more to be learned of the use of blood in the animal œconomy, from its coagulation, than from its fluidity. The coagulation of the blood, when out of the circulation, would seem to be unconnected with life, yet life could not go on without it; for as all the solid parts of the body are formed from the blood, this could not take place, if there did not exist in it the power of coagulating. Many diseases exhibit the blood coagulated in the living body, even in the vessels themselves, but more frequently when extravasated. Coagulation does not belong to the whole mass of circulating blood; but only to the part I have called coagulating lymph, which during this action commonly detaches itself from the other part, called the serum.

Whether the whole mass of the serum be a distinct part of the blood when circulating, is not easily determined, as we have no mode of separating it from the coagulating lymph, while both are fluid. The serum making a part of the whole mass in the fluid state, the first stage in the coagulation is a species of decomposition, forming a separation of the ferum. But, on the other hand, there are reafons for confidering the coagulating lymph as diftinct from the ferum, even when both are fluid; fince the ferum can be feparated from the lymph, without coagulating, by many actions of the veffels, both natural, preternatural, or difeafed. Thus the liquor of the amnios, and that of dropfies, are formed; and therefore we may conclude, that the feparation of the ferum, when the lymph is coagulated, is not an act neceffary to the coagulation, but an effect of it.

The circumftances attending the coagulation of the lymph are fubject to great varieties. Thefe depend upon or correfpond with the ftate of the body at the time, of which we can beft judge by the readinefs or difficulty with which the blood coagulates, and by the firmnefs or loofnefs of the coagulum. The whole mafs of the blood being a compound, of which the parts are in fome degree feparated: the appearances upon coagulation are attended with ftill more variety than the lymph alone could exhibit, or than could occur in thofe animals which are not poffeffed of red blood, as the red part brings to view many of the changes in the lymph, by the difference of its colour, as well as of its fpecific gravity.

The three fubftances which become vifibly diftinct when the lymph coagulates, differ as to gravity; the ferum is the lighteft, and remaining fluid fwims upon the top; the red globules which undergo no change, are the heavieft, and fink more or lefs in the lymph; but being entangled in it, add to its weight fo as to make it fink deeper in the ferum.

Blood when extravafated coagulates fooner or later, according to the quicknefs or flownefs of its extravafation, and the quantity extravafated: it coagulates late when drawn into a bafon rapidly, and in confiderable quantity; foon, when allowed to flow flowly, and in fmall quantities. This will be better underftood when I treat of the principles of coagulation.

When blood is received into a cup, and thereby expofed, it certainly coagulates more readily than when extravafated in the cellular membrane, or in the veffels; and on the expofed furface it coagulates more readily than any where elfe, except round the edges of the difh in which it is contained. It has been obferved, that the upper furface of the blood coagulates firft, forming a thin pellicle, as milk does, when near boiling; while underneath it ſtill remains fluid; but the whole gradually becoming thicker, and loſing its tranſparency, coagulates in about fifteen or twenty minutes into a ſubſtance of pretty thick conſiſtence. The time required will vary according to the quantity of blood in one maſs, and the diſpoſition of the blood at the time.

We may obſerve the following appearances when the blood is coagulated. The coagulum is generally, but not always, ſwimming in a fluid; for it ſometimes happens that the lymph does not ſqueeze out the ſerum in the act of coagulation, in which there is an act of contraction. The top of the coagulum is tougheſt, or firmeſt; and it becomes leſs and leſs ſo towards the bottom, becauſe there is leſs of the coagulating lymph at the bottom, in proportion as the red globules ſubſide in the lymph before it coagulates. The coagulating lymph has a degree of toughneſs in proportion as it is free from ſerum; for while the ſerum is mixed within it, though there may be red globules, it is not very tough; but when preſſed between the finger and thumb, ſo as to ſqueeze out the ſerum, it becomes nearly as tough, and elaſtic, as the coats of an artery, to appearance, becoming fibrous, and even, forming lamina; and indeed appears to be very much the ſame kind of ſubſtance with an artery, which gives us a clear idea how a membrane may be formed, and probably can be varied according to the impreſſion made on it by the ſurrounding parts. This is one reaſon why the lymph, which has the ſtrongeſt diſpoſition for coagulation, is the tougheſt, as it parts with more of its ſerum. The lymph is tranſparent, but whether tinged as the ſerum is found to be, we can hardly ſay, as it is ſeldom poſſible to catch it in a fluid ſtate free from red globules, and never from ſerum, which has itſelf a tinge. When out of the body in a diſh, where it is long in coagulating, and the red globules ſink faſt, we find it tranſparent; but, during coagulation, it becomes more muddy, till at laſt it is opaque, but with a tinge of colour. On being ſteeped in water it is often rendered very white, which would not probably be the caſe if it had a tinge of its own, independent of the ſerum.

Blood uſually requires a conſiderable time for its complete coagulation, or rather contraction; for, if allowed to ſtand ſome days, the coagulated part becomes leſs and leſs, as more and more of the ſerum is ſqueezed out, which cannot arife from the ferum being lighter, and iffuing out fpontaneoufly; for without fome expelling force it would be retained mechanically by the capillary attraction, as in a fponge. The blood which is longeft in coagulating, coagulates moft ftrongly, and produces the moft complete feparation of its parts. In fuch inftances as the coagulating lymph continues longer fluid, it allows the red globules more time to fubfide, and the ferum to be more fqueezed out from the craffimentum. When the coagulation is flow, and of that kind which will be firm when completed, we may fkim off the fluid coagulating lymph, free from the red globules; and the part fo taken will coagulate immediately, while that in the cup remains fluid fome time longer.

Many caufes have been affigned for the coagulation of the lymph, which appear to me to be ill-founded. It frequently happens that when changes take place in matter of which the immediate caufes are unknown, the mind refers them to fome circumftances which accompany thefe changes; although, perhaps, they may have had no concern whatever in producing them, and may be only attendants. This will always be the cafe where thofe changes arife out of the nature of the part itfelf. A feed put into moift ground grows; but the moift ground is only a neceffary attendant, and not the immediate caufe. The life of the feed, ftimulated to action by the moifture, is the immediate caufe of its growth, aud it continues to grow becaufe its action is always excited. All the water in the world would not make a dead feed grow. The fame mode of diftinction is applicable to the coagulation of the lymph.

The firft obfervations on the blood were moft probably made on that of the more perfect animals, whofe heat is commonly greater than the heat of the atmofphere. Such blood when extravafated, was found to coagulate on cooling; it was therefore natural to fuppofe that the coagulation of the lymph arofe from its becoming colder, as happens in jelly*; but cold, fimply, has certainly no effect upon the coagulating lymph.

If we take a fifh out of the fea, the heat of its body,

* This term has been applied to the coagulation of the blood, but I think improperly; for I fhould only call that jelly, which became folid by cold, and fluid again by heat; coagulation is totally different, for it is a new fpecies of combination. The freezing of blood may be called, congelation.

perhaps about 60°, and bring it into an atmofphere of 70°, the blood, on being let out of the veffels, will immediately coagulate. This was afcertained on board of a fhip lying off Bellifle, in the fummer 1761; for immediately upon a fifh being caught, I afcertained its heat, and letting out part of its blood, it immediately coagulated, although the blood difcharged was become warmer than that remaining in the veffels of the fifh; which, however, ftill continued fluid.

Indeed common experience and obfervation fhews us, that cold alone has no power to coagulate the blood. It often happens that particular parts of an animal, fuch as the fingers, face, nofe, ears, &c. are cooled nearly to the freezing point, and frequently are in that ftate for a confiderable time; yet the blood retains its fluidity in thofe parts, as I have experienced in my own fingers; and indeed in thofe parts of an animal where the blood has been frozen, and again thawed, the blood appears as fluid as before, and circulates as ufual. Heat has the power of exciting action in an animal; and we find that heat even increafes the action of coagulation; for, if blood be heated to about 129°, it will coagulate five minutes fooner than when kept at its natural heat, and even fooner than the blood of the fame animal, taken at the fame time and cooled to 50°*. Mr. Hewfon has laboured this point, endeavouring to fhew it is not cold that makes the blood coagulate; and he has laboured no lefs to fhew the real caufe of fuch a change.

He took frefh blood and froze it quickly; on being thawed, it was again fluid, but foon afterwards coagulated: this he conceived to be a fufficient proof, that it was not cold which made the blood coagulate†.

From the above obfervations, and experiments, it muft appear that cold, fimply, has no influence whatever upon the coagulation of the blood.

And in moft of the cafes in which the blood is obferved to coagulate, the air is commonly in contact with it; this was next prefumed to be the caufe of its coagulation‡; but

* Thefe experiments were made on the jugular veins of dogs, by taking a fection of the veins on each fide filled with blood, and immerfing them in water, either warmer, or cooler, or of the natural heat, and obferving the comparative difference.

† Hewfon on the blood, page 21. ‡ Ibid, page 23.

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the air has really no more effect than any other extraneous body, in contact with the blood, that is capable of making an impreſſion upon it; for the blood coagulates more readily in a vacuum than in the open air; nor will either of theſe ſuppoſed cauſes aſſiſt in explaining why it is not found coagulated after many kinds of death, nor in the menſtrual diſcharge. Neither will they account for the very ſpeedy coagulation of the blood which uſually takes place in all the veſſels after death, or when it has been extravaſated into cavities, or cellular membranes, where no air has ever been admitted.

Reſt is another cauſe upon which the coagulation of the blood has been ſaid to depend: and although this opinion be not true in the full extent in which it has been taken, I think that reſt has greater influence in the change than any other circumſtance whatever. But though reſt ſeems greatly to diſpoſe the blood to coagulation, it is the operation of reſt alone, without expoſure, which we are to conſider; as otherwiſe we ſhall be apt to confound it with the two foregoing cauſes, viz. cold, and the contact of air.

Since therefore the blood may coagulate in the veſſels, either of a living, or a dead body, and ſince it coagulates when extravaſated into different parts of a living body, reſt, like cold, or air, might be ſuppoſed to be the ſole cauſe of the coagulation of the blood: yet it is not reſt, conſidered ſimply, but reſt under certain circumſtances, which appears to poſſeſs ſuch a power; for motion given to the blood, out of the veſſels, will not of itſelf prevent its coagulation; nor will it even in the veſſels themſelves, if all the purpoſes of motion are not anſwered by it. Motion ſeems to retard coagulation*; yet we know for certain that blood will in time coagulate, even in the veſſels themſelves, and under certain circumſtances ſooner, perhaps, than any where elſe; as for inſtance, when there is a diſpoſition to mortification. In this caſe we find the blood coagulated even in the larger veſſels.

I have ſeen a mortification come on the foot, and leg, and when it had advanced only to a certain degree, the perſon died. On examining the parts above the mortified part, I found the crural, and iliac arteries, filled completely with ſtrong coagulated blood; we may thence infer,

* This is motion given to it in a veſſel, without any empty ſpace, and having beads put into it, which are ſhaken.

that the tendency to mortification in the veſſels produced this diſpoſition in the blood. If the coagulation ſhould be ſuppoſed to have ariſen from the blood being ſtopped in the large veſſels, at the mortified part, let us reflect, that this cannot account for it; the ſame thing ought then to happen in an amputation, or in any caſe where the larger veſſels are tied up.

In a priapiſm the blood does not coagulate, except it threatens mortification.

The ſeparation of the blood, either from itſelf, that is, when divided into ſmall portions, or ſeparated from the living body, becomes one of the immediate cauſes of the coagulation of the lymph; therefore, the contact of blood with blood, or with living veſſels, in ſome degree retards coagulation: this is the reaſon why blood which comes from the veſſels ſlowly, or falls from ſome height, or runs ſomeway on the ſurface of a diſh, coagulates ſooner than when the contrary circumſtances happen; and upon this principle it is, that blood, when ſhaken in a phial, will coagulate the ~~ſooner, even~~ if ſhaken in a vacuum. A deep maſs of blood is alſo from the ſame cauſe, longer in coagulating than a ſhallow one.

From the above obſervations it muſt appear evident, that neither cold, nor air, nor reſt alone, have any influence on the coagulating power of the blood; there muſt, therefore, be ſome other principle on which this proceſs depends, and, as it retains its fluid ſtate while circulating, and even for a long time when at reſt in the living veſſels, and coagulates when the veſſels or the body dies, it might naturally be ſuppoſed that it was the life of the body or veſſels which kept it fluid; we know, however, that life in the body or veſſels does not hinder the blood from coagulating under certain circumſtances, but often rather excites coagulation; nor does death, in the body or veſſels, in all caſes become a cauſe of coagulation; for we find that in many who die ſuddenly, from a ſtrong impreſſion of the mind, the blood does not coagulate; there is, therefore, ſomething more than the mere ſituation of the blood, ſurrounded with dead parts, that allows of coagulation; and that muſt be a ſomething in the blood itſelf.

From theſe obſervations it muſt be evident, that the fluid ſtate of the blood is connected with the living veſſels, which is its natural ſituation, and with motion; and that where there is a full power of life, the veſſels are capable of keeping the blood in a fluid ſtate: I believe, however, very little motion is required to keep up this fluidity when the other is preſent. A total ſtagnation of the blood, while the body is alive, as in a trance, or where the circulation has been ſtopt for ſeveral hours, as in the caſe of perſons apparently drowned, does not make it coagulate; yet where there are no actions going on, in a part, if the blood ſtagnates for a much ſhorter time than in a trance, it will be found coagulated, as in mortifications; but then this coagulation is to anſwer a good purpoſe, and ariſes from neceſſity*, which appears to act as a ſtimulus in diſpoſing the blood to coagulate.

As a proof that blood will not coagulate in living veſſels, in a perfect and natural ſtate, and ready to act when powers were reſtored to it, I found that the blood of a fiſh, which had the actions of life ſtopped for three days, and was ſuppoſed to be dead, did not coagulate in the veſſels; but, upon being expoſed, or extravaſated, ſoon coagulated.

The blood of a lamprey-eel, which had been dead to appearance ſome days, was found fluid in the veſſels, becauſe the animal was not really dead; there had, however, been no motion in the blood, as the heart had ceaſed acting; but upon its being expoſed, and extravaſated into water, it ſoon coagulated†: yet under certain circumſtances in life, it had been obſerved, that the blood will in a ſmall degree coagulate: this is in the ſtate of torper. It is aſſerted by ſome author, whom I now do not recollect, that

* By action taking place from neceſſity, effects are meant which ariſe in conſequence of ſome unuſual, or unnatural change, going on in the parts, and become a ſtimulus to action. The ſtimuli fromthis cauſe, may vary exceedingly among themſelves; but as we are unable to inveſtigate them, I have included them under this general term, ſtimulus of neceſſity.

† There are ſome circumſtances which hinder the coagulation of blood in living bodies although extravaſated. Two leeches had been applied, and had ſucked till full. Theſe were preſerved for ten weeks, and then had contained conſiderable quantity of blood, which appeared like that recently drawn from a vein, and coagulated when expoſed. I have known, in tapping a hydrocele, that a ſmall veſſel has been wounded, and the blood, as it extravaſated, got into the ſack, and when tapped ſixty-five days after, the blood has come out thickiſh; but when extracted it coagulated, and ſeparated into different parts.

the blood of a bat coagulates when in that ſtate; and Mr. Cornish, ſurgeon, at Totneſs, Devonſhire, to whom I applied for ſome bats in the torpid ſtate, ſent me them, but in the carriage they always died; however, he took opportunities of examining them, and he found that the blood was in a certain degree coagulated; but it ſoon recovered its fluidity on motion and heat.

From theſe remarks I ſhould conclude, that reſt does not of itſelf in the leaſt aſſiſt the coagulation of the blood; but that this effect ariſes from the blood being ſeparated from the living veſſels, and being deprived of motion; and that it happens ſooner, or later, according to other circumſtances. It might be ſuppoſed that theſe are rather negative cauſes of coagulation, than poſitive ones; but it is to be conſidered, that in a living body, the ceſſation of a natural action, the abſence of an uſual impreſſion becomes a cauſe of action, of which innumerable inſtances may be given.

I have now conſidered the circumſtances under which the blood coagulates, and ſhewn that none of them alone, nor all of them combined, induce the blood to coagulate. My opinion is, that it coagulates from an impreſſion: that is, its fluidity under ſuch circumſtances, being improper, or no longer neceſſary, it coagulates to anſwer now the neceſſary purpoſe of ſolidity. This power ſeems to be influenced in a way, in ſome degree ſimilar to muſcular action, though probably not entirely of that kind; for I have reaſon to believe, that blood has the power of action within itſelf, according to the ſtimulus of neceſſity; which neceſſity ariſes out of its ſituation.

I ſhall now conſider the ſimple act of coagulation, abſtracted from cauſes.

Coagulation I conceive to be an operation of life; and I imagine it to proceed exactly upon the ſame principle as the union by the firſt intention; it is particle uniting with particle, by the attraction of coheſion, which, in the blood, forms a ſolid; and it is this coagulum, uniting with the ſurrounding parts, which forms the union by the firſt intention: for union by the firſt intention, is no more than the living parts when ſeparated, whether naturally, or by art, forming a reciprocal attraction of coheſion with the intermediate coagulum, which immediately admits of mutual intercourſe, and as it were, one intereſt.

To produce coagulation of the blood, however, fomething more is required than merely the reverfe of the caufes above-mentioned, as having the power to keep it fluid; for the blood becomes in many cafes inftantaneoufly incapable of coagulation, either in or out of the veffels, even when nothing has been added, or taken away, and muft be therefore under the influence of fome other caufe. This, I believe, muft be fought in fome property inherent in the blood itfelf: befides, fome natural operations deftroy this principle in the blood, when extravafated.

In many modes of deftroying life the blood is deprived of its power of coagulation, as happens in fudden death produced by many kinds of fits; by anger, electricity, or lightening; or by a blow on the ftomach, etc. In thefe cafes we find the blood, after death, not only in as fluid a ftate as in the living veffels, but it does not even coagulate when taken out of them. As in the bodies of fuch perfons as no action of life takes place, the mufcles do not contract. There are partial influences, likewife, which deftroy the power of coagulation, as a blow on a part producing a confiderable extravafation. This forms an ecchymofis, in which we fhall often find the blood not in the leaft coagulated. In healthy menftruation, the blood which is difcharged does not coagulate; in the irregular or unhealthy it does. The healthy menfes, therefore, fhew a peculiar action of the conftitution; and it is moft probably in this action that its falubrious purpofes confift; for if twice the ufual quantity is evacuated with the power of coagulation, even from the fame veffels, the fame benefit is not produced; much lefs when taken from another part by art.

Many fubftances, when mixed with the blood, prevent coagulation; bile has this effect out of the body; but we cannot fuppofe that in a living body it can be taken into the blood in fuch quantity as to produce this effect; for we find in a very fevere jaundice, that the blood is ftill capable of coagulating ftrongly.

That probably every inanimate fluid in nature, which is capable of being rendered folid, produces heat, during that change; and in the contrary change cold is commonly known; it is on that principle Dr. Black has eftablifhed his very ingenuous theory of latent heat. Thus in the freezing of water, heat is produced.

To fee how far the coagulation of the blood was fimilar in this refpect to the fame change in other fubftances, I firft coagulated the white of an egg, by applying to it rectified fpirits of wine: the heat of both was the fame before their union; but I found upon uniting them, that the white of the egg was immediately coagulated, and that the heat of the mixture was increafed four, fometimes five degrees, according as it coagulated, flowly, or quickly.

As the blood in the animals upon which we moft commonly make our experiments is warm, it becomes a difficult matter to afcertain whether it produces heat upon coagulation. In holding the ball of the thermometer in the ftream of blood coming from the arm, I found the heat raifed to ninety-two degrees: I then took a cup of human blood, allowed it to coagulate, and put it up to the brim in water warmed to ninety-two degrees, till the whole mafs was heated to this point. I bled afterwards another perfon to the fame quantity, in a fimilar cup, which was put into the fame water. Having two well regulated thermometers, one in each cup of blood, I obferved which cooled firft, for I did not expect fo much heat to be produced as to make it warmer; but conceived, if any heat was formed, it would retard the cooling of the frefh blood; but it rather cooled fafter, which I imputed to the coagulated blood parting with its heat flower than the fluid blood. Thefe experiments I have repeated feveral times, with nearly the fame effect. I then conceived the experiment would be more conclufive if I could get blood in a fluid ftate, which was naturally of the heat of the atmofphere, for which purpofe I took the blood of turtles.

A healthy turtle was kept in a room all night, the floor of which was about 64°, and the atmofphere 65°. In the morning the heat was nearly the fame. The thermometer was introduced into the anus, and the heat of that part was 64°. The animal being fufpended by the hind legs, the head was cut off at once, and the blood caught in a bafon; the blood while flowing, was 65°, and when collected, was 66°, but fell to 65° while coagulating, which it did very flowly: it remained at 65°, and when coagulated, was ftill 65°. Thefe experiments had been made feveral times, but not with that nice accuracy which was obtained by caufing all the heats to correfpond exactly; yet as they were all known, and marked down, if any heat had been produced upon coagulation, its exact quantity would have been ascertained in each; and, indeed, in some, it seemed to cool, but in none it became warmer. From these experiments I should say, that in the coagulation of the blood, no heat is formed.

Coagulated blood, is an inorganized animal substance. When the blood is thinly spread before coagulation, or oozes out on surfaces, in which act it immediately coagulates, and coagulates in that form, it may then be said to form an inorganized membrane, of which there are many; and organization is seemingly so simple in many (which we know to be constituent parts of the body) that these coagula, more especially the thin ones, cannot easily by their appearances be distinguished from them.

The coagulating lymph of the blood being common, probably to all animals, while the red particles are not, we must suppose it from this alone, to be the most essential part; and as we find it capable of undergoing, in certain circumstances, spontaneous changes, which are necessary to the growth, continuance, and preservation of the animal; while to the other parts we cannot assign any such uses, we have still more reason to suppose it the most essential part of the blood in every animal.

Besides a disposition for coagulation under certain circumstances, as before described, the blood has also a disposition for the separation of the red globules, and probably of all its parts; for I think I have reason to believe that a disposition for coagulation, and a disposition for a separation of the red part, are not the same thing, but arise from two different principles. Indeed, a disposition to coagulation would counteract the effect, and hinder the separation of the red particles from taking place. Thus we see that rest, or slow motion of the blood in the vessels, gives a disposition towards a separation of the red part, as well as when it is extravasated; since the blood in the veins of an animal acquires a disposition to separate its red parts, more than in the arteries, especially if it be retarded in the veins; the nearer, therefore, to the heart in the veins the greater will the disposition for separation be; though it does not seem to retard coagulation. This is always observable in bleeding; for if we tie up an arm, and do not bleed immediately, the first blood that flows from the orifice, or that which has stagnated for some time in the veins, will soonest separate into its three constituent parts: this circumstance expoſes more of the coagulating lymph, at the top, which is ſuppoſed by the ignorant to indicate more inflammation, while the next quantity taken ſuſpends its red parts in the lymph, and gives the idea that the firſt ſmall quantity had been of ſuch ſervice at the time of its flowing, as to have altered for the better the whole maſs of blood. Reſt, therefore, may be regarded as one of the immediate cauſes of the ſeparation.

III. OF THE SERUM.

THE ſerum is the ſecond part of which the whole maſs of blood appears to be compoſed; or is one of thoſe ſubſtances into which the blood ſpontaneouſly ſeparates itſelf. So far it appears as a ſimple fluid, in which light I ſhall firſt conſider it; though we ſhall find hereafter that it is compoſed of two ſubſtances, which, in many of our experiments, ſeparate. Serum, I believe, is common to the blood of all animals; but there is more of it, I think, in thoſe animals which have red blood: perhaps it may bear ſome proportion to the qaantity of red particles in the blood, and may be of uſe to dilute it.

The ſerum is lighter than the other parts of the blood, and therefore ſwims above them when ſeparated. It is commonly ſeparated from the coagulating lymph when that fluid coagulates; and is, therefore, almoſt always found when the blood is taken out of the blood veſſels, and kept together in a conſiderable maſs. When the lymph coagulates ſtrongly, we commonly find more ſerum, becauſe it is then ſqueezed out more forcibly than when the coagulation is formed looſely; it is not, however, neceſſary for the lymph to coagulate, in order to ſeparate the ſerum, for we find that it ſeparates in diſeaſe, as in the dropſy. It is ſeparated alſo from the maſs of blood in uterine-geſtation, being the fluid in which the fœtus is immerſed or ſwims.

I have ſeen it ſeparate from the remaining maſs before the coagulation of the lymph. I obſerved once in the blood of a lady, that a ſeparation between the two fluids almoſt immediately took place, the ſerous part ſwimming on the top, while the lymph remained ſtill fluid. From this appear-

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ance I had pronounced that there would be a great deal of buff, ſuppoſing that the tranſparent fluid at the top was coagulating lymph; but I was miſtaken, for when the lymph was coagulated, there was no buff, and the tranſparent fluid remaining at top, proved to be the ſerum.

In this there could be no deception, as there was no buff, or ſize; for if there had been ſize at the top of the coagulum, it might have been ſuppoſed that this fluid, which appeared ſo ſoon after bleeding, had been the coagulating lymph, and that the ſerum had been ſeparated in the act of coagulation as uſual. The ſerum is commonly of a yellowiſh colour, ſometimes more ſo than at others; and this I ſhould conceive ariſes from the ſubſtances diſſolved in it*, by means of the water it contains; for it probably ſuſpends every ſalt ſoluble in water, many of which are diſſolved in it. If ſerum be not coagulable in itſelf, though it contains a large quantity of coagulable matter, yet I conceive it to be in a more fluid ſtate when circulating. As it is ſeparated from a compound maſs, it appears in this reſpect to be ſomewhat ſimilar to the whey of milk, though not exactly. This fluid undergoes no ſpontaneous changes but what may ariſe from its ſeparation, from the coagulating lymph, except putrifaction. Though not coagulable in itſelf, yet one of its properties out of the body, is to coagulate upon the application of certain ſubſtances. This is the principal change it undergoes, and during the proceſs, it more or leſs ſeparates into two parts; one of which is not coagulable by ſuch means.

The coagulable part, which I now mean to deſcribe, ſeems to be in ſome degree the ſame with that in the white of an egg, ſynovia, etc. and many other ſecretions, but not exactly; for thoſe ſecretions contain, as I conceive, a quantity of the coagulating lymph united to them, which makes them in part, coagulate after ſecretion; and the further coagulation of thoſe ſecretions afterwards, by mixture with other ſubſtances, is owing to this part of the ſerum. Though the ſerum is coagulable under certain circumſtances, and with certain mixtures, yet this power, or effect, may be prevented by other mixtures. Heat, to a certain degree, coagulates this part; and probably this is the only teſt neceſſary to know whether a fluid found any where in the bo-

* The red globules are ſuſpended without being diſſolved in the ſerum, in which they are commonly examined.

dy, not coagulable in itſelf, is this part of the ſerum; but as many ſubſtances do alſo coagulate it, I ſhall mention a few of them, although to me their effects do not ſeem to throw any light on the ſubject. Heat coagulates the ſerum at 160°, or 165°; it ſtood at 150°, for ſome time perfectly fluid. There is a great deal of air contained in the ſerum, which is let looſe by heat; but not from its coagulation, for when it is coagulated by other means, no air is ſeparated. The ſerum, which was a little whitiſh, coagulated in that degree of heat neceſſary for ſeparating its air, which was extricated in very large quantities. This coagulum becomes firſt like the ſynovia, and then thicker. Many ſubſtances which do not coagulate this part of the ſerum, do not, however, hinder its coagulation by heat; ſuch as vinegar, acid of lemon, ſalt of wormwood, nitre, ſea-ſalt.

Serum coagulates with ſpirits of wine, in about equal quantities, into a ſort of curd and whey; which, upon heating, becomes ſomething like a jelly, but the ſpirit ſeems to evaporate.

It coagulates with volatile ſpirits, into a milky fluid, which becomes like a jelly upon heating; it requires a greater proportion of the ſpirit than the ſerum; and the ſpirit ſeems chiefly to evaporate.

When mixed with ſalt of hartſhorn, it does not coagulate with heat, but makes a large effervefcence, till the whole is formed into froth. This again becomes a fluid, by the froth ſubſiding, but at laſt it forms a ſort of coagulum, which is not tough. Being mixed with water, and let to ſtand for twelve hours, it coagulates like pure ſerum upon heating. If this be mixed with ſal. cernu cervi, as above, it rather becomes more fluid, and continues ſo for a long time, with a ſtrong efferveſcence; but it forms at length into a jelly, or paſte, though not a ſolid one.

Here I ſuſpect that the ſalt is evaporated, and likewiſe the water in the paſte, ſo that it is not a true coagulation.

When mixed with common water, it is coagulated by heat; but the water ſeparates with the other ſubſtance, and does not unite with the coagulum.

Upon the coagulation of the ſerum, by heat, I have obſerved that it ſeparates a fluid, which is not coagulable by heat; and, I have reaſon to believe, by none of the other means, viz. ſpirits of wine, etc. though this is not ſo eaſily aſcertained; for the other coagulating ſubſtances, as ſpirits of wine, etc. are applied in a fluid form, and therefore, a fluid may remain after the coagulation of the ſerum, which might be ſuppoſed to be the fluid ſeparated; but from other experiments, it is proved that thoſe ſubſtances coagulate the coagulating part, and unite with the other. It is alſo obſervable in meat, either roaſted, or boiled, or when cut, there flows from it a fluid, more or leſs tinged with the red part, commonly called gravy. I conceived that this muſt be different from the coagulating part of the ſerum, believing that the heat had been ſufficient to coagulate it; but I choſe to try it further, and therefore gave it ſuch heat, as would have produced the effect if it had been coagulable by heat; but I found it did not coagulate. The fluid ſeparated from the coagulable part of the ſerum, I conceived to be the ſame with this. Thus then I ſaw there was in the ſerum a matter coagulable by heat; and a fluid which was not ſo.

Purſuing the above obſervations on dreſſed meat, I obſerved that the older the animal had been, the more of this fluid was contained in the meat. In lamb we have hardly any of it: in young mutton of a year old, but little; but in mutton of three, four, five, or ſix years old, it is in large quantity: in veal alſo we have but little; while we have it in great quantity in beef; but perhaps we know leſs in general of the age of our beef, than of our mutton.*

Poultry is commonly killed young in this country, therefore we have not the comparative trials; but in wild fowl, and what is commonly called game, we find the above obſervations hold good. I likewiſe obſerve that animals who have not had exerciſe, ſuch as houſe-lamb, veal, etc. have leſs of this fluid, than thoſe of the ſame claſs which have been allowed to go at large: nothing can be drier than the Engliſh veal, though kept to a greater age than any where elſe; while it is juicy in every other country, though killed much younger.

In many of the trials reſpecting the coagulation of the ſerum, I obſerved, that it had in ſome caſes much more

* It may be obſerved here that this is very different from the jelly formed in boiling, or roaſting meat; that which forms the jelly, is part of the meat itſelf, diſſolved down in this very fluid, and the water in which it is boiled; and we find that this effect is juſt the reverſe of the above, for in young meat there is the moſt of this jelly.

coagulum than in others; and of courſe a leſs proportion of the fluid part that ſeparated, and vice verſâ: from the above obſervations too, I conceived that a deficiency of this fluid-part beſpoke a greater quantity of coagulating matter in the ſerum; and to aſcertain this, I took the ſerum of perſons of different ages. This fluid, like the ſerum itſelf when united with the coagulating lymph, appears only to be mixed with the ſerum; for it is ſeparated in the living body for many purpoſes of the œconomy; it is not therefore ſerum in another form; but a diſtinct fluid, which, before the coagulation, is mingled with the ſerum, and ſeems to make a part of it.

The following experiments are, perhaps, not perfectly concluſive; for many were obliged to be made on blood taken from thoſe who were not perfectly in health: peculiar diſpoſitions in the body may make a material difference in the ſerum. It is probable, however, that diſeaſe may not have any great effect upon the ſerum; for I found, from experiment, that the ſerum of blood taken from a perſon labouring under an inflammatory complaint, and the ſerum of blood in a caſe not at all inflammatory, were nearly the ſame reſpecting coagulation, and the quantity of matter not coagulable by heat.

The ſerum of a man fifty-ſix years of age, who had met with a ſlight accident, and was of a healthy conſtitution, coagulated by heat, almoſt wholly into a pretty firm coagulum, ſeparating only a ſmall portion of that fluid which is not coagulable by ſuch means.

The ſerum of the blood of a man ſeventy-two years of age, of a healthy conſtitution, hardly coagulated by heat, became only a little thicker, and formed a ſmall coagulum, adhering to the bottom of the veſſel. With ſpirits, it formed but a very ſmall quantity of coagulable matter.

On putting about three-fourths of water to the blood of the perſon aged fifty-ſix, and heating it as above, it coagulated much in the ſame way with the ſerum of ſeventy-two.

The ſerum of a boy fifteen years of age, coagulated wholly; there was hardly any of the fluid part that could be ſqueezed out; at the ſame time I coagulated the ſerum of a man ſixty-three years of age, in which there was but a ſmall quantity of the fluid part.

Conceiving that the whey of milk, made with runnet, was the ſerum of the blood, I made experiments on it, analogous to the above. I heated ſome of the whey, and found it formed a coagulable matter, which floated in flakes in a fluid, which did not coagulate by this means.

As this lefs coagulable fluid is a fubftance hitherto not taken notice of, and makes perhaps as interefting a part as any of the whole mafs of blood, it will be neceffary to be more defcriptive in giving an account of it than of the other parts. As urine does not coagulate by heat; but I had found that it coagulated with the extract of Goulard*; and as I alfo knew that this extract coagulated the whole mafs of the ferum, I conceived that the fluid in queftion might be fimilar to urine, and that the coagulation of the ferum might be owing to the coagulation of this part; I therefore put the fluid to this teft, and found that it was coagulated by the extract, which led to a feries of experiments.

As feveral fluids, apparently different from each other, appear to be thrown out from the blood on many occafions, I wifhed to fee how far they confifted of the common ferum, viz. of a pretty equal quantity of matter coagulable by heat, or principally of that coagulable by Goulard's extract; I therefore collected the feveral kinds, not only thofe which may be called natural, but alfo thofe proceeding from difeafe, which appear more like ferum than the others. Of the natural, I took the aqueous humor of the eye, and firft heated it in a fpoon, to fee what quantity of coagulable matter by heat was in it, and I found it became gently wheyifh; therefore it had a fmall portion of matter coagulable by heat; but, upon adding the extract to it, it coagulated immediately. The fame exactly happened with the water in the ventricles of the brain; and alfo with the tears.

Water was taken from the leg of a dropfical boy, who was extremely reduced by a compound fracture of the oppofite thigh-bone; which water was much clearer than any ferum. Upon heating it in a fpoon over a candle, it be-

* What led me to the above knowledge, was, mixing this extract of Goulard with folutions of gum arabic in water, for injections; when I found that the whole always became a folid mafs; while injections with fachrum faturni, had not that effect. I then tried it upon many other vegetable juices, and found it coagulated every one of them. In fome of thefe experiments, I put fome of the compounds into a veffel where there was fome urine, and I found that when the extract had been in too large a quantity, that the urine was alfo coagulated.

came a little wheyifh, and had a few flakes of coagulum floating in it.

The water from the abdomen of a lady, which was a little wheyifh, coagulated before it gave out its air; but the coagulum was not one half of its quantity.

In another cafe of afcites, the water coagulated wholly, although not to a firm coagulum.

Water drawn from the abdomen of a gentleman, which was pretty clear, when held over a lamp to coagulate, became at firft wheyifh.

The liquor amnii has but little coagulable matter in it.

In coagulating all the above kinds of ferum by heat, and taking the incoagulable parts, and putting extract of Goulard to them, they coagulated immediately.

Whether this fluid is of the fame fpecific gravity with the other, I do not know; for though when part of it is coagulated by the extract of lead it is the heavieft; yet as it is united with the lead, it may acquire its additional weight from this union.

The ufe of the ferum is probably to keep fufpended, and undiffolved, the red globules; for we find it in largeft quantity when thefe globules are moft abundant. It is alfo intended to fufpend, and diffolve any foreign fubftances in the blood, whether they are of ufe to the body, or otherwife, acting upon them as a common folvent.

Thus we fee in a jaundiced perfon, the ferum is yellower than common. When a perfon has taken rhubarb, the fame thing happens. It is probably the folvent of all our fecretions.

I conceive it to be unneceffary to fay how much water enters into the compofition of the blood. In order to conftitute a perfect body or compound, it is neceffary that all its parts fhould be in due proportion; but as the blood in many animals is made up of four diftinct parts, viz. the coagulating lymph; ferum, which we find is compofed of two parts; and the red globules, each muft have its due quantity of water when in a perfect ftate; and I think it is probable that the lymph, and red part, cannot have more water than a certain quantity, but that the ferum may be diluted with any proportion of it; yet as ferum, it can have a certain proportion only; and indeed this was in fome degree proved by the experiment of mixing fome water with

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ſerum, and then coagulating the whole with heat: the water ſeparated and did not make part of the coagulum.

Some of the juices of a living animal, whether circulating, or out of circulation, as thoſe which lubricate ſurfaces, are in a volatile ſtate while the animal is alive; for when the ſcarfskin is taken off, the part ſoon dries; and if the ſkin is removed from a new killed animal, it immediately dries; or if a cavity is opened, the ſurface of the cavity dries quickly; this ſhews that ſome part of the juices muſt have evaporated from the ſurface: but let the animal cool, before it is ſkinned, or the cavity is opened, and then give it the ſame degree of heat that it had when alive, you will find, on taking off the ſkin, no immediate ſenſible evaporation; but the parts ſo expoſed will remain moiſt. This volatility I conceive therefore to be connected with life, and not with the circulation; for that is ſtopped in both caſes before the experiment. Whether it is this volatile part that gives the ſmell that moſt recent killed animals have upon being ſkinned, or opened, I do not know; but it may be obſerved that it follows the ſame rules; for if the animal is allowed to cool, it looſes this ſmell, although warmed to the ſame degree of heat as when alive.

The ſerum of the blood is ſometimes wheyiſh, and then upon ſettling, it often throws up a white ſcum like cream: this was moſt probably firſt obſerved in the human blood; but is not peculiar to it; although theſe appearances pretty often happen, yet few inſtances fall under the obſervation of one man in the common courſe of bleeding. When they have occurred to myſelf, I have made inquiry after the ſtate of health of the patient, as well as examined the nature of this change; and whether there was any variety in it. So far as I have been able to obſerve, it can hardly be ſaid to have any leading cauſe; having found it, however, more frequently in the blood of breeding women, I conceived it might have ſome connection with that ſtate; but I have ſeen it in others, and ſometimes in men: yet it is poſſible that the ſtate of pregnancy may adapt the conſtitution for forming ſuch appearances, as well as for producing other ſymptoms in the blood like thoſe of inflammation; for we often find the ſame effect, or diſeaſe, ariſing from various cauſes, which have no immediate connection with each other. There have been many opinions formed about the nature and cauſe of this appearance of the ſerum.

It has been ſuppoſed to be occaſioned by chyle not yet aſſimilated; but it does not occur frequently enough to be attributed to this fluid. Mr. Hewſon ſuppoſed it to be abſorbed fat, or oil; which certainly is not the caſe; for it is not the ſame in all caſes.

The globules forming this wheyiſh appearance are not of the ſame ſpecific gravity in every caſe; for though they always, I believe, ſwim on the ſerum, and often on water, yet they ſometimes ſink in water. The white cream that ſwims on the top of the ſerum, I believe to be formed after the ſerum is ſeparated from the maſs; for, if it exiſted as ſuch, prior to this, it would be retained in the coagulum, as the red globules are, which is not the fact; and therefore it does not exiſt in the blood while circulating.

I bled a little woman who ſeemed half an ideot, and was big with child, this happened in the afternoon, about three or four hours after her having eat ſome veal-cutlets: the day following I went to ſee the blood, and found the ſerum of a milky white, with a white pellicle ſwiming at the top like cream.

I bled a lady in the arm, who was ſix months gone with child. It was about two o'clock in the forenoon: ſhe had only eaten a dry toaſt, and drank a cup of chocolate for breakfaſt, about ten o'clock, which was four hours before ſhe was bled. On ſeeing the blood the next day, I found it inflamed rather more then is common in women who are pregnant; and I alſo found a thin white ſcum on the top of the ſerum; this ſcum I examined in the microſcope, and found it to be globular: I diluted it with water, and found the globules did not diſſolve, as the red globules do. I put ſome of them in water, and found that they roſe to the top, but not ſo faſt as in the ſerum.

About ſix days after I bled the ſame lady again, after ſhe had eaten the ſame kind of breakfaſt, and about the ſame interval of time from it. The blood was ſtill ſizy, but the ſerum had no white appearance at the top.

I examined the wheyiſh ſerum taken from the blood of a man at St. George's Hoſpital, who had received a ſevere blow on the head, which had ſtunned him, but had produced no bad ſymptoms. In this ſerum, when viewed in the microſcope, I could not obſerve any thing like globules or flakes, although the magnifier was a deep one. The red globules when mixed with it were the fame as in common ferum. It dried uniformly like fize.

Blood was taken away from the arm, being of no particular quality, except in having a wheyifh ferum, and was allowed to ftand quiet in order to fee the fpontaneous changes of this ferum. The white part came to the top like cream, being therefore lighter than the ferum, and was very white when collected. When viewed in a microfcope it was plainly globular, but the globules were fmaller than thofe of red blood. They did not feem to be diffolved when mixed with water, as red globules are.

Thomas Skelton, a publican, forty-feven years of age, being rather lufty, fubject to frequent colds, attended with coughs, hoarfnefs, and a difcharge of matter from the lungs or throat, but otherwife enjoying a good ftate of health, was attacked with a violent cold, together with a difficulty of breathing, and applied to Mr. Wilfon, apothecary, who took twelve ounces of blood from his arm, which relieved him greatly. He had taken fome bread and butter, with fome tea, without milk, about four hours before he was bled. The blood coagulated firmly, and the ferum which feparated, was of a white colour with a yellowifh tinge, appearing like the colour of cream; upon the top of this floated a whiter fcum, like another cream.

On viewing this cream in a microfcope, it had a flaky appearance. It did not coagulate fooner than common ferum.

In fpirits of wine, a white mixture was produced, which, on ftanding fell to the bottom of the glafs; this moft probably arofe from the ferum with which it was mixed, coagulating.

The globules of the white ferum, differ from the red globules in colour; fpecific gravity, fize, and in not diffolving in water.

To fee how far this is chyle, it would be proper to try the chyle in the fame way in ferum, &c.

After dipping a bit of blotting paper into the cream, and abforbing all of it, and alfo dipping a piece of the fame paper into the ferum, and drying them, I burnt them both, to fee if one burnt more brifkly than the other; but there appeared to be no difference.

The white part of the white ferum funk in water.

IV. OF THE RED GLOBULES.

THE red part of the blood I choofe to confider laft, although it has been more the object of attention than the other two, becaufe I believe it to be the leaft important; for it is not an univerfal ingredient in the blood of animals, like the coagulating lymph, and the ferum; neither is it to be found in every part of thofe animals who have it* in the general mafs of their blood.

The blood, as I have already obferved, in thofe animals we are moft acquainted with, appears to the naked eye to be a red mafs of fluid, having a part which coagulates upon being extravafated. The red part, however, may be wafhed out of this coagulum, fo as to leave it white; and this fhews that the blood is not wholly red, but only has a red matter diffufed through its other component parts.

Any further information we receive concerning the red part of the blood, is by means of magnifying glaffes, which appear to give a good deal of information.

They fhew us that the red part is compofed of bodies of a globular form, fwiming in the lymph and ferum of the blood: this circumftance, of the red part having form, probably led anatomifts to pay more attention to it than it deferves; as if they could thence explain any effential principle in the blood, or animal œconomy.

This knowledge is of late date, for fuch examinations of minute bodies could only have taken place fince the invention and application of magnifying glaffes.

Malpighi was probably the firft who employed the microfcope for this purpofe, and he, in 1668, wrote a defcription of the appearance of the globules in the blood-veffels of the omentum, which he miftook, however, for globules of fat. Microfcopical obfervations were purfued with great ardour by Antonius Van Leeuwenhoeck, who

* The blood of the infect-tribe of every kind is free from any red parts, as is probably that of moft animals below them; yet it has been afferted, and fuppofed, that their blood contains globules, although not red. I have examined the blood of the filk worm, lobfter, etc. and with confiderable magnifying powers; but never could difcover any thing, but an uniform tranfparent mafs.

ſaw the red globules, Auguſt the 15th, 1763*. Theſe early obſervers probably imagined more than they ſaw.

When an old opinion is partly exploded, and a new one brought forward, it becomes only neceſſary to ſee how far the new one is juſt; becauſe, if it be not proved, we muſt revert to the old opinion again or to ſome other.

Mr. Hewſon has been at great pains to examine the blood in the microſcope, and has given us figures of the different ſhapes of thoſe globules; but there is reaſon to think he may have been deceived in the manner I have juſt mentioned.

The red globules are always nearly of the ſame ſize in the ſame animal, and when in the ſerum do not run into one another as oil does when divided into ſmall globules in water. This form, therefore, does not ariſe ſimply from their not uniting with the ſerum, but they have really a determined ſhape and ſize. This is ſimilar to what is obſerved of the globules in milk; for milk being oily, its globules are not ſoluble in water; neither do they conſiſt of ſuch pure oil as to run into each other; nor will they diſſolve in oil. I ſuſpect, therefore, that they are regular bodies, ſo that two of them could not unite and form one †.

What this property in the red part is, I do not know, for it has ſomething like the nature of a ſolid body, yet the particles ſeem not to have the properties of a ſolid; for to the touch they yield no feeling of ſolidity; when circulating in the veſſels they may be ſeen to aſſume eliptical forms, adapting themſelves to the ſize of the veſſels; they muſt, therefore, be a fluid, with an attraction to themſelves while in the ſerum, which forms them into round globules, yet without the power of uniting with one another, which may ariſe from their central attraction extending no farther than their own circumference: if they are found, however, of an oval figure in ſome animals, as authors have deſcribed, that circumſtance would rather oppoſe the idea of their being a fluid, having a central attraction; but this is probably an optical deception. Whatever their ſhape is, I ſhould ſuppoſe it to be always the ſame, in the ſame animals, and indeed in all animals, as it muſt depend upon a fixed principle in the globule itſelf.

* Haller's Phyſiology, vol. ii. lib. v. Sangui. ſect. xi. p. 51.

† Milk appears to be oil united with a proportion of mucus.

Hence, the lefs credit is to be given to thofe who have defcribed the globules as being of an oval figure in fome animals; for they have alfo defcribed them as being of different and ftrange fhapes, even in the fame animal*.

* I am led to believe that we may be deceived by the appearances viewed through a magnifying glafs; for although objects, large enough to be feen by the naked eye, are the fame when viewed through a magnifying glafs which can only magnify in a fmall degree, yet as the naked eye, when viewing an object rather too fmall for it, is not to be trufted, it is much lefs to be depended upon, when viewing an object infinitely fmaller, brought to the fame magnitude by a glafs. In fuch a fituation, refpecting our eye, all the relative objects, by which the eye, from habit, judges with more nicety of the object itfelf, are cut off; the eye has likewife a power of varying its form, adapting it to the different diftances of the parts of an object within its compafs, making the object always a whole; but a magnifying glafs has no fuch power: for inftance, in viewing a fpherical body, a magnifying glafs muft be made to vary its pofition, and bring in fucceffion the different parts of the hemifphere into fo many focal points; every part feparate, not having the fame relative effect on our organ of vifion as when they are all feen at the fame time; and the eye, under fuch circumftances, being unable to vary itfelf fufficiently to alter the focal diftance of the glafs, is the reafon why rounded bodies appear of different fhapes, giving the fhape only of the part that is within the focus of the glafs, placed upon an undefined plane; and if it fhould have more focal points than one, then there is an increafe of parts; and this will vary according to the opacity or tranfparency of the body. It may alfo be remarked, that from habit our minds are informed by the neceffary actions of our body, therefore the eye taking in the neceffary actions (as it were inftinctively) adapting itfelf at once to the circumftances of the object, gives an intelligence to the mind, independent of the real impreffion of the object, fo that both the impreffion and the confequent action give information; but this cannot be effected by glaffes for the different focal diftances of the hemifphere do not accord with thofe to which we vary our eyes in adapting them to the diftances of the different parts of a rounded body; we are, therefore, left to the impreffion alone, which is new, and confequently imperfect, the centre being too near for the circumference to be feen at one diftance, and the circumference, when feen, bringing the centre within the focus, fo as to obfcure it: for an eye with a given focus which can vary it in a certain degree when viewing objects alone, yet when looking through a magnifying glafs of any power, muft now vary the diftance of the object, according to the magnifying

The globules of the blood are endowed with a number of properties. They are the only part of the blood which has form or colour; two properties which are ready to catch the eye, and render the maſs more viſible. In the living body, by making it an object of ſight, they give ſome idea of the motion of the blood in the ſmaller veſſels where it is much divided; being there viewed with microſcopes, the red gobules are ſeen moving with different velocities in different parts, and taking retrograde, or lateral motions, according as mechanical obſtructions, or thoſe ariſing from contractions in the veſſels, may happen to retard or change their motion.

They are heavier than the coagulating lymph, and of courſe heavier than the ſerum, which is known by their

power in the glaſs, the eye not being able to vary the focal diſtance of both; and this, probably, in an inverſe degree, to the magnifying power of the glaſs. This may be obſerved to take place in very ſhort-ſighted people, for in them the eye has the leaſt variation reſpecting diſtance. A rounded body may be juſt of ſuch a ſize as ſhall have either of its parts out of the focal diſtance of the eye, and muſt be moved to and fro, alternately, before the centre and circumference can be ſeen; and indeed, it is only having a ſpherical body, of a ſize proportional to the length of focus, to produce the ſame effect in every eye.

The appearance in a tranſparent body, when viewed through a magnifying glaſs, are ſtill more fallacious than of an opaque one; for an opaque body gives only the reflected light, which, however, will vary according as the rays come on the object. The moon, an opaque body, gives us various ſhapes, and therefore ſhews only the light and ſhade ariſing from the irregularity of the ſurface; but a ſemi-tranſparent body, like a red globule, gives both the reflection of the light from the ſurface and alſo the refraction of other rays of lights, which vary according to the direction of the light thrown upon the object reſpecting our eye.

In ſome tranſparent bodies we have ſtill a greater variety, for we have both the reflex and refracted light, and theſe varying according to the diſtance of the object from the eye, or the diſtance of the light.

If the tranſparent body is not perfectly round, or is by any circumſtance broken in the uniformity of ſtructure on which tranſparency depends, which, I conceive happens to the red globules when diluted in the ſerum, then the different reflections and refractions will give to the eye the impreſſion of ſo many ſhapes.

falling to the bottom of the cup when blood is taken out of a blood-veſſel. This allows the coagulating lymph to be ſeen more or leſs at the top, and produces on the ſurface various hues, according as the red globules ſubſide: when they ſubſide much, the buff is then of a yellowiſh colour; when the buff is thin at the top, then we have the red gobules ſhining through it, of various colours, ſuch as blue, purple *, &c. according to the reflection or refraction, which is according to the depths.

In healthy blood, however, the coagulum is commonly formed before the red part has time to ſubſide; but we may always obſerve, that the lower part of the maſs contains more red globules than the top, and will ſink more quickly in water. The red globules do not retain their globular form in every fluid, but are diſſolved and diffuſed through the whole, and this probably happens ſooner in water than in any other fluid, though the red globules are not ſoluble in the ſerum of the blood, yet it is not the only fluid in which they are inſoluble; the urine does not diſſolve them; but urine might be ſuppoſed to be principally ſerum. Water itſelf, however, ceaſes to diſſolve them when ſaturated with many of the neutral ſalts, or with ſome of the acids. The red globules are not ſoluble in water mixed with common ſea-ſalt, ſal-armoniac, Epſom-ſalt, nitre, Glauber-ſalt, ſoluble tartar, Lymington-tartar; nor in the fixed vegetable alkalies, when ſaturated with fixed air. As they do not diſſolve in the ſerum or urine, it might be imagined to ariſe from the neutral ſalts which they contain; but I ſhould believe that neither of theſe fluids have a quantity ſufficient for that purpoſe.

The vitriolic acid does not diſſolve the red globules when diluted ſo low as to have leſs pungency of taſte than common vinegar.

The red globules are ſoluble in common vinegar, but take a longer time to diſſolve than in water; and they alſo diſſolve much ſooner when the vinegar is diluted with water.

In muriatic acid, diluted ſo as to be more pungent to the tongue, and three times ſtronger than the vinegar, the red globules are not diſſolved, but loſe their red colour:

* The blood in the veins, when near the ſkin, gives the ſame hues.

by adding more water to the red globules they diffolve; lemon juice diffolves the red globules: all this, however, throws but little light on this part of the blood.

When the globules are put into water they diffolve, which deftroys their globular form: it is therefore the ferum, and probably the coagulating lymph alfo, when circulating, which confines them to this form; but when the ferum is diluted with water, they diffolve in it; and this appears to take place at once; as quick as water unites with water. I could not obferve that it was like the folution of a folid body, as a falt for inftance; a drop of blood requires about two drops of water added to it to diffolve its globules: if urine alfo be diluted with water, the globules diffolve in it. However, after ftanding fome days, the globules diffolve both in ferum and urine; but I think later in the laft. When the globules are not diffolved in any fluid, the whole looks muddy, not tranfparent; but when diffolved in water the whole is a fine clear red. What are the properties of the ferum, and thofe other fubftances that preferve the red part of the blood in a regular form, I do not know.

The red globules, when dried in the ferum, and moiftened in the fame, do not again refume their regular form; nor do they diffolve in it, as they do in water, but form rather a fort of flakes. As the ferum and folutions of many kind of falts do not diffolve the red globules, I conceived that it might be poffible for them to refume their globular figure (after having been diffolved in water) by adding fuch a quantity of ferum as to make the proportion of water very little; but I could not produce this effect, although the menftruum was fuch as not to diffolve frefh globules.

The red globules not diffolving in the ferum, nor in the coagulating lymph, become feparable from thofe parts, when circulating, and therefore may be prevented from going where the coagulating lymph paffes in a natural ftate; which they certainly do not *; and which alfo is the reafon why they are fo perfectly retained in the coagulum when extravafated. The globules, befides being heavier than the ferum, or the coagulating lymph, appear to have more fubftance, for they do not lofe fo much upon drying, and when dried with ferum, they give a kind of roughnefs to the fur-

* This will be more fully explained, when on the colour of parts from the blood.

face which ſerum has not by itſelf. They appear not to be a natural part of the blood; but as it were, compoſed out of it, or compoſed in it, and not with it; for they ſeem to be formed later in life than either of the other two; thus we ſee, while the chick is in the egg, the heart beating, and it then contains a tranſparent fluid before any red globules are formed, which we may ſuppoſe to be the ſerum, and the lymph. The globules do not appear to be formed in thoſe parts of the blood already produced, but rather to riſe up in the ſurrounding parts *. It would alſo ſeem to be formed with more difficulty, than either of the other two parts. When an animal has loſt a conſiderable quantity of its blood, the other parts ſeem to be ſooner made up than the red globules; the animal looks long pale; but this is only conjecture, for we have no method of knowing the quantity of the other parts.

From the above account it appears, that whatever may be their utility in the machine, the red globules certainly are not of ſuch univerſal uſe as the coagulating lymph, ſince they are not to be found in all animals, nor ſo early in thoſe that have them, nor are they puſhed into the extreme arteries, where we muſt ſuppoſe the coagulating lymph reaches; neither do they appear to be ſo readily formed. This being the caſe, we muſt conclude them not to be the important part of the blood, in contributing to growth, repair, etc. Their uſe would ſeem to be connected with ſtrength; for the ſtronger the animal the more it has of the red globules; and the ſtrength acquired by exerciſe increaſes their proportion; not only in the whole body, but, as we ſhall find, occaſions them to be carried into parts where in either a quiet or debilitated ſtate of the animal they were not allowed to go; the uſe, therefore, of a part, and the quantity of red globules paſſing through it, are probably pretty well proportioned to each other. This effect is ſo well known to feeders of young animals, for the table of the epicure, that bleeding, to leſſen the quantity, is immediately practiſed; as alſo debarring the creature from

* Thus, on ſome of the firſt appearances of the chick we find a zone ſurrounding it, compoſed of dots, which contain red globules, but not in veſſels, and which zone becomes vaſcular afterwards. Vide plate 1.

exercife, in order to prevent their increafing, and being carried fo far from the heart, as they otherwife would be.

Thefe three fubftances are of different fpecific gravities: the ferum or fluid part is the lighteft; the folid part or lymph is the next in order; and the red globules are the heavieft. This is feen in fuch blood as feparates readily into its conftituent parts. The ferum fwims upon the top, and the red globules fall to the bottom, while the lymph would be fufpended between the two, if the red part were not retained in the lymph, from its coagulation; but this conftant effect is no abfolute proof of the difference in the fpecific gravities of the ferum, and coagulating lymph; for we ftill do not know but that the red globules, which are evidently the heavieft, make the coagulating lymph to fink in the ferum. To afcertain this circumftance, I made the following experiment: I took fome blood, which feparated eafily into its conftituent parts; I then fufpended in a portion of ferum a piece of coagulating lymph, which was free from red globules, and it funk to the bottom, but not very quicly; this proves that the lymph, when coagulated, is fomewhat heavier than the ferum.

I then took as much of the bottom of the coagulum, containing the red globules, and put it into the ferum along with the lymph, to fee which of them funk the fafteft, and found that the piece with the red globules funk much more quickly than the other; I fhould think three times as faft. The ferum itfelf is much heavier than common water, for when the parts beforementioned were put into common water, in the fame manner as into the ferum, they both funk much fafter, and there was not that difproportion between the times of their falling, as in the ferum. But if the blood has a ftrong difpofition to coagulate, and is not in large quantity, it will coagulate foon, and involve the red globules; yet there will then be feweft at top, and they will be more and more crowded towards the bottom; though there would appear in fuch blood to be no coagulating lymph at top free from the red globules, yet in moft of it a thin pellicle may be found, which can be pulled off.

I have already obferved that the whole mafs of blood, taken together in a greater variety of claffes of animals, appears of a red colour; and I fhall now further remark, that it is of a much deeper colour in fome claffes of animals than in others, which I believe arifes from a greater number of red globules being contained in a given quantity of lymph and ferum. This, I think, evidently appears to be the cafe when we examine a portion of the blood itfelf, belonging to different claffes of animals. In the clafs called quadruped, I believe it has the deepeft body of colour; I am not, however, certain that it is not nearly as deep in fome birds; and even in the fame clafs of animals it appears to have a much greater body of colour in fome fpecies than in others. Thus it appears to be deeper in the hare than the rabbit.

It is the red part itfelf which makes the difference in depth of colour in different parts of the fame animal; and the common mode of judging is by the colour of the parts in different claffes of animals that have red blood; on thefe we generally form our opinion, for though in fome animals which have white mufcles, the liver, kidney, and heart, may be nearly as red as in others whofe mufcles are univerfally as red; yet, as the mufcles are white, there muft be a deficiency in the red globules on the whole; for if thefe parts which are red in animals, having white mufcles, as the heart, liver, etc. have no more than their due proportion with other animals that are univerfally red, there muft be in fuch animals a deficiency of red globules on the whole. This idea may be gradually carried on, from the animal which has feweft red mufcles, to thofe whofe mufcles are univerfally red, and of a high colour; even in the fame fpecies the colour of all the mufcles is not equally high. What are called different temperaments have their mufcles redder, or paler; the darker the colour of the fkin, hair, etc. of any one fpecies, I believe the blood is in proportion redder. When a part, of whatever kind, is red, it takes place in confequence of its veffels being large enough to carry red blood; and therefore, when we find a mufcle red, fhe know it arifes from the fame caufe. When a part, on the contrary, is white, as a tendon, it is becaufe its veffels are fmall, and have little or none of the red blood paffing along them; although it may probably be as vafcular as the mufcle to which it belongs *; and thofe animals

* Conceiving that the amnion of a calf might have but few veffels, I injected a piece of it with quick filver, firft drying its edges all round, on the edge of a difh, while the middle of it lay in the difh in water; but the whole became one mafs of veffels. The intention of this experiment was to fee, if poffible,

that have no red blood, have white fleſh univerſally*, and this, probably, no leſs vaſcular than the fleſh which receives red blood.

The blood in the ſame animals is not equally deep coloured in every part; that is, every part of the body has not its blood equally loaded with red globules, or, at leaſt, it is not equally red, even in parts of the ſame conſtruction and uſe, ſuch as muſcles: this ariſes from the red globules not being carried into thoſe parts in equal proportion; theſe are the white parts of animals; ſuch muſcles, in animals uſed for food, are called white meat. In animals, which have theſe muſcles, there is commonly not ſo much red blood, as in others where theſe parts are more univerſally red; and perhaps the red part of the blood is not puſhed ſo far in them as in thoſe which have it in a larger proportion: there are ſome animals, however, which have a larger quantity of red globules in the blood, yet have ſome of their muſcles of a lighter colour than others: even in the human ſubject, all the muſcles are not equally red; the muſcular part of the inteſtines, for inſtance, is not equal in redneſs to the heart, and many other muſcles. To what is this owing? Does ariſe from mechanical cauſes? Do the veſſels become ſuddenly ſo ſmall beyond a certain limit as not to allow the red blood to paſs? or are the other parts of the blood leſs tenacious? Is the red part in ſuch not allowed to go ſo far? or is it a ſeparating principle in the veſſels themſelves? Many circumſtances of life either increaſe the quantity of red globules, or make them more univerſal in the muſcles of the ſame animal: thus exercise increaſes the quantity of the red globules, and the red colour of muſcles, while there is the ſame quantity on the whole, or perhaps we ſhould rather ſay, that indolence decreaſes the quantity; this is particularly remarkable in women; and probably the whiteneſs of the muſcles of young animals may ariſe from the ſame cauſe; I ſuſpect, however, ſomething more; I conceive it ariſes from the principle of life, influenced by accidental or mechanical

the communication between the arteries and the veins; but the maſs of veſſels prevented every view of this kind.

* The redneſs of the blood is of great uſe towards the knowledge of diſeaſes; many inflammations are known by it, when on the ſkin, and even the kind of inflammation is diſtinguiſhed by the kind of redneſs: alſo putrid diſeaſes are diſtinguiſhed when the blood is extravaſated. The quantity in the face is a ſign of health or diſeaſe.

caufes; for the mufcles of young animals are increafing in colour till they arrive at the age of maturity, and not afterwards, although they continue to ufe exercife. Difeafes leffen the quantity of red globules, and often render their diftribution unequal.

From the above account we may reafon upon the whole, that the animals which are reddeft, or have the greateft number of red parts, have their blood furnifhed with the greateft proportion of red globules.

One would naturally fuppofe that the red globules were of the fame colour every where in the fame animal; this laft is perhaps the cafe, but now we find that thefe globules are of different hues in the different fyftems of veffels in the fame animal. In the more perfect animals, where there are two fyftems of veffels carrying the blood, viz. arteries and veins, the blood is not of the fame fpecies of red in both of them in the fame animal; one red is the fcarlet, which takes place in the arteries of the body, the other is the modena which takes place in the veins; and as every part of the body poffeffes fuch fyftems of veffels, the parts which are vifited by red blood muft have a mixture of both. As there are two circulations in every animal above the infect, one in the lungs in thofe that breathe air, or in the gills in fifh who breathe water, and the other the general circulation to the body in both, we find the two colours of the globules not correfponding to the fame fyftem of veffels in each. The fcarlet is the venal blood in the lungs, and afterwards becomes the arterial in the body, where it is commonly feen; and hence it is called the arterial blood; the modena is the venal blood of the body, and is the blood alfo of the pulmonary artery; but, as it is commonly feen in the veins only of the body, it is called the venal blood; the fcarlet colour, therefore, is acquired in the lungs, and the modena in the body. There are fo many proofs of this, that it hardly requires any illuftration; yet, many circumftances and experiments may be brought in direct proof of it. I bled a man in the temporal artery, and in the vein of the arm at the fame time, each into a phial. The blood of the artery was of a florid red, and the venal was dark. The arterial kept its colour, and did not feparate its ferum; but this was fingular, for in others it does feparate its ferum and coagulum; the venal feparated into its conftituent parts as ufual.

Although this, however, is a general rule, yet there are many exceptions; for we find in many cafes the fcarlet colour of the blood in the arteries not changed in the veins, and under fome circumftances the modena taking place in the arteries, as well as where blood is extravafated in the body.

It becomes a queftions how the change is produced in each?

More attention has been paid to the mode in which it gets the fcarlet colour, than the modena, (though both probably are of equal importance,) becaufe it was believed that life, in fome degree, depended on this colour. Many fubftances change the colour of the blood from the modena to the fcarlet: refpirable air has this effect, and many of the neutral falts, more efpecially nitre, which occafions the florid colour in meat that has been falted, alfo with fea-falt. But, as the air produces this effect in the living body, and as we find that without air the animal dies, great ftrefs has been laid on this change of colour, whereas, it fhould only be confidered as a fign that the blood has been in contact with the air: but not that it muft be fit for the purpofe of circulation. This effect takes place readily under many circumftanees; it takes place out of the circulation as readily as when in it; as readily when blood is coagulated as before: it takes place in blood whofe coagulating principle has been deftroyed, as by lightning, fudden death, etc. it does not, therefore, depend upon life. It is the caufe only of this change in the colour by refpirable air, which becomes an object of confideration; for if we fuppofe the change of colour in the red globules to be all that refpiration is to perform, we fhall make the red globules the moft effential part of the blood, whereas they are the leaft fo. Moft probably, the effect of air upon the blood is greateft on the coagulating lymph; and this conjecture is rendered more likely, when we confider, that in animals which have no red globules of any kind, refpiration is as effential to their exiftence as in any other; and we find, that the blood may lofe this effect, and yet retain its falutary effects in the conftitution. Thus in the tying up a large artery, when the parts beyond muft be fupplied with blood that fhall have loft its florid colour; and in the chick in the egg, the blood in the arterial fyftem is dark, while in the veins of the temporary lungs it is florid. We are led, by daily experience, to obferve, that the dark blood taken from a vein becomes red on that ſurface which is expoſed to the common atmoſphere; and, that if it be ſhaken in a phial with air, the whole becomes red*. If blood alſo be allowed to ſtand expoſed to the air, and coagulate, its upper ſurface will become of the ſcarlet red, while the bottom remains dark, or even of a darker colour than common venal blood, becauſe it contains a greater quantity of red globules. If the coagulated blood be inverted, and the bottom expoſed to the air, this part will alſo aſſume the ſcarlet red, and become even redder than that expoſed before, becauſe it contains a greater number of red globules, which undergo this change. The red colour will even penetrate to ſome depth, which ſhews that the effect can be produced through a thick ſubſtance. We often find the veſſels of the lungs full of blood, and the whole ſubſtance of the lungs of a dark colour; but, if we inflate the lungs, the cells will become of a florid red, the ſmall veſſels on thoſe cells, both arteries and veins, having the colour of their blood changed by the air in the cells affecting it through their coats: we find the ſame thing on the ſurface of fleſh, or muſcles, liver, etc. We may obſerve in the gills of fiſh, that they retain their florid colour as long as the fiſh is freſh, from being expoſed to the air, for they naturally have the air applied externally in the act of breathing. It is from theſe facts we reaſon, reſpecting the ſcarlet colour which the blood acquires in the lungs, but loſes in the body, and therefore is found of the modena colour in the veins, and of courſe in the right ſide of the heart, and larger trunks of the pulmonary artery. As the blood is florid in the pulmonary veins, as far as we can trace them, we reaſonably ſuppoſe that it acquires this appearance in the ſmall veſſels of the lungs, and as the lungs conſtantly take in freſh air, we conceive that by expoſure to the air (perhaps both in arteries and veins) it acquired the ſcarlet colour; for we ſhall ſee that the air, or the influence of air, is capable of paſſing through animal ſubſtance.

In the living body when the breathing is imperfect, we can plainly ſee the change taking place in the colour of the blood, in proportion as the breathing becomes more perfect, of which the following experiments are proofs:

* This does not ariſe from motion, for fill the phial with blood without air, and put into it glaſs beads, and ſhake them, ſo as to give them motion, the colour will not be altered.

They were made with a view to obſerve the motion of the heart, by producing an artificial breathing, and exhibited a vaſt variety of phenomena, of which the change in the colour of the blood in the lungs was one.

I invented a pair of double bellows, each of which had two openings, but their actions were reverſed; two of the openings were incloſed in one pipe or nozzle, and the other two were on the ſides. The lower chamber had its valve placed exactly ſimilar to that of the common bellows; but it had alſo a valve at the nozzle, which did not allow any air to enter there. The upper half had a valve placed at the nozzle, which allowed the air to enter, but not to eſcape, and the opening on the upper ſide, allowed the air to eſcape, but not to enter; ſo that on dilating the bellows, the upper ſide, or chamber, drew in the air, by the nozzle only, and at the ſame time, the under chamber drew in its air by the ſide only: on cloſing the bellows, or expelling this air, the air drawn in by the nozzle paſſed out at the opening of the upper ſide, and the air that was drawn in by the under ſide, paſſed out by the nozzle. By this means I could, by fixing the nozzle into the trachea, draw the air out of the lungs into the upper chamber of the bellows, and at the ſame time draw freſh air into the lower chamber; on emptying theſe cavities of their air, the pure air in the lower chamber paſſed into the lungs, and that which had been juſt taken from the lungs into the upper chamber paſſed into the open air alternately. The action of theſe bellows, though double, is exactly as ſimple as breathing itſelf; and they appear to me to be ſuperior to any invention made ſince for the ſame purpoſe. I fixed the nozzle of theſe bellows into the trachea of a dog, and immediately began the artificial breathing; I then removed the ſternum and cartilages, and opened the pericardium. While I continued the artificial breathing, I obſerved that the blood in the pulmonary veins, coming from the lungs, the left auricle, the aorta, etc. was florid or dark, juſt as I threw in air or not, into the lungs.

I cut off a piece of the lungs, and found that the colour of the blood which came from the wound correſponded with the above effects: when I threw air into the lungs, ſo as to render the blood florid in the pulmonary veins, two kinds of blood iſſued from the wound; and when I left off blowing, the whole blood which paſſed out by the wound was of the dark colour. If the air is confined in the lungs of a quadruped, it foon lofes its power over the blood, which remains dark, or has the appearance of becoming dark, becaufe dark coloured blood is thrown in, and it undergoes no change; but if the fame experiment is made on an amphibious animal, it is a confiderable time before the whole blood becomes dark, becaufe in fuch animals, the lungs are a refervoir of air, which of courfe continues its influence over the blood the longer.

This experiment I have repeated upon feveral animals, and commonly for half an hour at a time, which was fufficient to allow me to make my obfervations with coolnefs and accuracy: in this part of the experiment it was curious to fee the coronary arteries turn darker and darker, becoming like the veins which run on each fide of them; and on blowing again, refume gradually a brighter colour, till they become of a florid red. As refpiration was generally prevented in the firft part of the experiment, the blood was found at firft wholly of a dark colour, and the heart large, and hardly acting; but on throwing into the lungs frefh air, the heart began to act, upon which both auricles and ventricles became gradually fmaller; then by ftopping the refpiration, they again became larger and larger.

The diminution of the heart's motion upon ftopping refpiration, does not depend upon the immediate impreffion of improper blood on the left auricle and ventricle, as a fedative, but upon the fympathetic connection between the heart and lungs; one action ceafing, the other alfo ceafes; which fympathy is eftablifhed, becaufe, if the heart were to continue acting, it would fend improper blood into the body, by which it can be fupported only a little while. The right auricle and ventricle alfo ceafe acting, although not fo early, and for the fame reafon; becaufe, on the ceffation in the lungs the blood cannot receive any benefit in paffing through them.

Thefe actions and ceffations of actions are all dependent on life, and the connection of one action with another. It is upon the fame principle that the firft effect of recovery is the act of breathing.

The following cafes illuftrate this ftill further:

I bled a gentleman in the temporal artery, while in a fit of apoplexy; he breathed feemingly with great difficulty; the blood flowed very freely, and he continued to bleed longer than we commonly find, from the fame wound, which made me ſuſpect that the artery had loſt ſome of its contracting power. The blood was as dark as venal blood; he became ſomewhat relieved, and his breathing more free; about two hours afterwards we opened the ſame orifice, which ſtill bled freely, but now the blood was become florid as uſual.

Mrs.———, in Norris-ſtreet, Haymarket, fell into an apoplectic fit, in which ſhe was inſenſible, reſpecting ideas: her breathing was very imperfect, attended with a rattling in her throat, and a ſnort; the pulſe was very ſteady, but rather ſlow. I opened the temporal artery, which bled very freely; but I obſerved that when ſhe breathed freely, the blood from the artery became red; and when her breathing was difficult, or when ſhe hardly breathed at all, the blood became dark, and this alternately ſeveral times in the courſe of bleeding; yet all this made but little alteration in the pulſe.

In many diſeaſes of the heart, as well as of the lungs, we may often obſerve the ſame appearance. In many diſeaſes of the heart, producing what is called angina pectoris, (the ſymptoms of which ariſe from a vaſt variety of cauſes, palpitations being commonly one) we ſhall ſee that upon any exertion, the heart acts with great violence, and the breathing is very laborious, or rather imperfect, not correſponding with the violence of the motion of the blood; the face will become of a dark purple colour, the patients will be nearly expiring, and nothing but reſt relieves them; of this the following caſe is a ſtrong inſtance.

A. B. when a boy, could never uſe the ſame exerciſe that other boys did; he could not run up ſtairs, nor aſcend a hill without being out of breath, and had almoſt through his whole life, an irregular pulſe; more eſpecially when he uſed more exerciſe than he could well bear. Upon the leaſt increaſe of motion, he had a palpitation at the heart, which was often ſo ſtrong, as to be heard by thoſe that were near to him; and his becoming ſoon fatigued, was by his acquaintance ſuppoſed to be owing to a want of ſpirit or courage.

With all this he grew to be a well formed and common ſized man, but ſtill he retained thoſe defects, which, indeed, rather increaſed as he extended his views, and with them extended his actions. About the age of thirty, he took to violent exerciſe, ſuch as hunting, and often in the chaſe would be ſeized ſo ill with palpitations, and almoſt a total ſuffocation, that he was obliged to ſtop his horſe, and be held upon the ſaddle. At ſuch times he became black in the face, and continued ſo as long as the fit laſted. It was often ſeveral days before he perfectly recovered his uſual health; and frequently he could not lie down in his bed, but was obliged to ſit up for breath: all theſe ſymptoms gradually increaſed upon him, and at times, without any violence of exerciſe or action, he would feel as if dying, and uſed ſo to expreſs himſelf: but as the cauſe of theſe feelings did not appear to his friends, they rather treated him ſlightly.

At laſt mere anxiety of mind would bring on theſe feelings, palpitations, and ſuffocations in ſome degree.

In the winter 1780, and 1781, he hunted very violently and alſo caught cold, which together brought on the above-mentioned complaints with greater violence than ever.

He conſulted two gentlemen of the profeſſion: the palpitation, the difficulty of breathing, the great oppreſſion, with the blackneſs in the face (I ſuppoſe) they thought either aroſe from ſpaſms, or was nervous, for they ordered cordials, ſuch as ſpirit of lavender, wine, etc.

I was ſent for, to give a name to the diſeaſe. Upon enquiring into all the ſymptoms, my opinion was, that there was ſomething very wrong about the conſtruction of the heart, viz. about the ſource of the circulation; that the blood did not flow at any time freely through the lungs, ſo as to have the proper influence of the air, but much leſs ſo when he was hurried; that a ſtagnation of the blood in any one part about the heart would produce in ſome degree ſuffocation; and want of due influence of the air upon the blood, being the ſame thing, which was the cauſe of the darkneſs of the face at thoſe times: that the means to be practiſed were in ſome degree contrary to what had been adviſed, namely, reſt, gentle bleeding, care to eat moderately, keep the body open, and the mind eaſy; and as he had got the better of former attacks (although thoſe were not ſo violent) I ſaw no abſolute reaſon why he ſhould not get the better, of the preſent. Eight ounces of blood were taken from him that day, which relieved him. The ſymptoms ſtill continuing, though not ſo violently, I ſaw him once more; he loſt about four or five ounces more blood, which alſo relieved him, but ſtill he did not get materially better: at laſt, as an addition to the above ſymptoms, he became yellow, his legs began to ſwell with water, and all his other complaints gradually increaſed, which made me ſuſpect that a depoſit of water was begun in the cheſt. He was now attended by a phyſician; was bliſtered on his legs, which threatened a mortification, and a cauſtic was applied to the pit of his ſtomach, (I ſuppoſe for a pain there): nature was at laſt worn out, and he died. I ſolicited to open him, and was allowed.

On opening the belly there was found in the abdomen a very ſmall quantity of bloody yellowiſh ſerum. Every viſcus appeared to be ſound; the gall-bladder was pretty full of bile, which was thick, but not ropy, as if the thinner parts had been ſtrained off; the ducts were clear both to and from the gall-bladder.

Upon opening the cheſt the lungs did not collapſe, being a good deal œdematous, but otherwiſe appearing ſound.

There was alſo a little bloody ſerum in both ſides of the cheſt. Theſe I conceive were the conſequences of the laſt attack.

The heart was very large, and very full of blood.

Upon opening the right ſide of the heart, I found nothing uncommon, either in the heart or the pulmonary artery.

Upon opening the left ſide, I found the valves of the aorta thicker, and harder than uſual, having at the ſame time the appearance of being very much ſhrivelled. This diſeaſed ſtructure of the valves accounts for every one of what may be called his original ſymptoms, and was ſuch as to render them of very little uſe; the blood, therefore, muſt have fallen back into the cavity of the ventricle again at every ſyſtole of the artery.

Whether this ſhrivelled ſtate of the valves of the aorta was a natural formation, or a diſeaſe, is not eaſily aſcertained; but if it was a diſeaſe, it muſt have begun much earlier in life than ſuch diſeaſes commonly do, as the ſymptoms appeared when he was young*. From this contraction of valve, we muſt ſee that it required the greateſt quiet to allow the motions of the blood from the left ſide of the heart to go on ſufficiently, and that whatever interrupted this, produced a ſtagnation, or an accumulation of the blood almoſt in every part of the body; firſt in the left ventricle, then the left auricle; pulmonary veins, pulmonary arteries; right ventricle, right auricle, and all the veins in

* I have ſeen it at a very early period.

the body; however a fmaller quantity than ufual could get to the veins of the body through the arteries, fo that a kind of circulation went on.

If we confider the effect arifing from this conftruction of valves, fimply on mechanical principles, we cannot account for the darknefs of the arterial blood, which muft have paffed through the lungs, when there was no mechanical obftruction to refpiration; but fince it happens that when the heart either ceafes to act, or cannot get rid of its blood, (which muft have been the cafe in the prefent inftance) refpiration ceafes, or is performed fo imperfectly as to have nearly the fame effect *; the perfon is in reality in a ftate of fuffocation. Suffocation is no more than imperfect refpiration, which is the caufe of imperfect blood paffing to and from the left fide of the heart; and it is therefore immaterial as to confequences, whether a ftoppage to refpiration is the firft caufe, or is an effect, for in either way it is the caufe of imperfect blood being introduced into the arterial fyftem.

It may be difficult to account for the increafed fize of the heart, whether it was a mechanical effect, as the blood would be thrown back into it at every fyftole of the aorta and diaftole of the heart, or whether it arofe from a particular affection of that vifcus. The firft idea is the more natural; but it is not neceffary that the caufe fhould be of this kind; for we fee every day enlarged hearts, where the fymptoms have been fomewhat fimilar, and yet no vifible mechanical caufe exifted; and indeed it is a common effect where there is an impeded circulation.

It is eafy to be conceived, firft, that the circulation could not, in the cafe of this patient, be carried on regularly and perfectly: fecondly, that a ftoppage to the blood's motion in either arteries or veins, but much more a retrograde motion in the blood in any part muft produce a ftagnation, which will be more or lefs extenfive, according to the quantity of blood paffing that way: thirdly, that if it was only in a branch of an artery, or vein, the ftagnation would probably be only partial; but when in an artery, or the veins of the whole body, as the aorta, or vena cava, it muft then be pretty univerfal; and as the retrogade mo-

* In fuch infpirations I conceive that fo little air is taken in as hardly to reach the cells of the lungs, fo as to be able to influence the blood circulating on thofe cells.

tion in the blood began in the aorta, we can eafily trace its effects. We alfo find in imperfect conftructions of the heart, &c. where there is a communication between the right and left fide kept up after birth, that the fame circumftances and appearances take place; cafes of this kind frequently occur, of which the following is a ftrong inftance:

I was feveral times confulted about the ftate of a young gentleman's health, and though it could not be faid anatomically, with precifion, what the real confirmation of the heart was, yet it was imagined that the fymptoms arofe from fome imperfection in that organ. From his infancy, every confiderable exertion produced a feeming tendency to fuffocation; and as fuffocation always arifes from a want of the due effect of air on the blood, while the circulation is going on, the whole body muft change from the fcarlet tinge to the modena or purple; and in thofe parts where the blood gives its colour moft, there will this effect be greateft, which is commonly in the face, and particular parts of the face, at the finger-ends, &c. While very young, nothing but crying brought on thofe fits, but when he was grown fo as to take bodily exercife, as running, &c. then they became more frequent and more violent; and it is to be obferved, that the older he grew, the worfe he was likely to be; for with years approaching to maturity, his actions were likely to increafe: great care, however, was taken to fupprefs fuch actions as were found, from experience, to bring on the fits. No medical advice could be of the leaft fervice, further than to inform him what experience had already taught, unlefs to recommend occafionally, when his friends found that the fits of fuffocation were more eafily excited than ufual, that he fhould lofe a little blood, fo as to leffen the neceffary action of breathing; putting, in this way, the quantity and motion of the blood more upon a par, and at the fame time, not to indulge too much his appetite; but all thefe precautions hardly kept him tolerably well. The heart, in proportion to the difficulty, acted with more violence, and one could rather have wifhed the contrary to have taken place. As he could hardly ufe any exercife of his own, motion was given him, fuch as riding flowly on horfeback, in carriages, &c. He lived to the age of between thirteen and fourteen, and though the diforder did not deftroy him, yet it is moft probable that he could not have lived long, as he was every day arriving more and more at an age of action, but not in the fame proportion acquiring prudence. When he died he was opened by Dr. Poultney, who tranfmitted an account of the appearance of the parts to the College of Phyficians of London, which is publifhed in the third volume of their Medical Tranfactions: fuch parts as are immediately connected with my fubject, I fhall tranfcribe.

" Both lobes of the lungs were remarkably fmall, and fome parts of them flacid to fuch a degree, as to fuggeft an idea of their having been incapable of performing their functions *. The liquor pericardii was in due quantity, and the heart was firm in texture, and of the natural fize†. On examining the ventricles, and the beginning of the aorta, a canal, or paffage was found communicating with both ventricles, fituated in an oblique direction near the bafis of the heart, fo large as to admit the end of the finger from the aorta with equal facility into either ventricle; the feptum of the ventricle appearing to terminate with this canal. On examining the entrance of the pulmonary artery within the ventricle, it was judged that this entrance was much fmaller and more firm than common." It is difficult here to fay what would be the exact effect of this communication on the motion of the two bloods; that is, whether the blood of the right fide was received into the left, or vice versâ; if the oblique direction of this paffage had been further defcribed, it might have explained this doubt, for if the paffage was direct, the blood would moft probably pafs from the left to the right, as the left ventricle acquires the greateft ftrength; the word oblique, however, and the expreffion, that the finger, from the aorta, paffed with equal facility into either ventricle, would make us fuppofe that the obliquity led out of the right ventricle into the aorta; but even with this obliquity, I fhould not think it probable that the blood would pafs from the right to the left, becaufe the left acts with fo much more force: the defcription leaves us to account for the defect in refpiration another way. If the blood paffed from the right to the left, then it would have had the fame effect as the canalis arteriofus, and probably was

* Although I have tranfcribed this, yet I do not lay much ftrefs upon it.

† This fhews there was no difeafe.

the only one in the fœtus. In this caſe too little blood would paſs through the lungs; but I do not conceive that this circumſtance would affect reſpiration, becauſe no ſtagnation would take place in the lungs; but if the blood got from the left to the right, then too much blood would be ſent to the lungs, as it would be found to take its courſe twice. On the other hand, if the lungs be not capable of allowing a full diſtention equal to the actions of the heart, though naturally framed, the ſame thing takes place. In natural deaths the pulſation of the heart commonly ſtops before breathing ceaſes; but in deaths ariſing from a ſtoppage of breath, ſuch as hanging or drowning, the reverſe muſt take place; and in ſuch we ſhall always find dark blood in the left ſide, which plainly took place in the experiment above-mentioned.

It may be ſuppoſed that in the lungs the blood cannot come in contact with the air, but the circumſtances above related, that the florid colour will extend ſome depth into the blood, ſhews that the effect of air can and does pervade animal matter. Not attending to this fact at firſt, I covered the mouths of veſſels filled with venal blood with gold-beater's ſkin, touching the ſurface of the blood, and the blood conſtantly became of a florid red on the ſurface, and even for ſome depth.

I put ſome dark venal blood into a phial, till it was about half full, and ſhook the blood which mixed with the air in this motion, and became immediately of a florid red*.

As the globules are the coarſeſt part of the blood, and they appear to be fully affected by the air in the lungs, we may ſuppoſe that the veſſels of that viſcus do not run into extreme minuteneſs, by which, apparently, no other purpoſe would be anſwered.

The blood of the menſes, when it comes down to the mouth of the vagina, is as dark as venal blood, and as it does not coagulate, it has exactly the appearance of the blood in theſe, where the blood continues fluid. Whether this ariſes from its being venal blood, or from its acquiring that colour after extravaſation, by its ſlow motion, it is not eaſily determined; but upon being expoſed it becomes florid: it is naturally of a dark colour, but rather muddy,

* Theſe experiments I made in the ſummer 1755, when I was houſe ſurgeon at St. George's Hoſpital, and Dr. Hunter taught them ever after at his lectures.

not having that tranſparency which pure blood has. Whether this ariſes from its mixing with the mucus of the vagina, or from the ceſſation of life in it, I will not pretend to ſay. The red globules, however, are not diſſolved, they retain their figure.

Does air in the cellular membrane of an emphyſematous perſon produce, or continue the floridneſs of the blood or not ?*

The ſurface of the blood becoming of a ſcarlet red, whether expoſed immediately to the air, or when only covered by membranes, through which we may ſuppoſe its influence to paſs, is a circumſtance which leads us to ſuppoſe, that it is the pure air which has this effect, and not ſimply an expoſed ſurface †. To aſcertain this I made the following experiment :

I took a phial, and fixed a ſtop cock in its mouth, and then applying an air-pump to the cock, exhauſted the whole air : in this ſtate keeping it ſtopped, I immerſed its mouth in freſh blood flowing from a vein, and then turning the cock allowed the blood to be preſſed up into the phial. When it was about half full I turned the cock back, and now ſhook the phial with the blood, but its colour did not alter as in the former experiments ; and when I allowed the blood to ſtand in this vacuum, its expoſed ſurface was not in the leaſt changed.

The vaſt number of cells into which the lungs are divided, the whole arterial and venal ſyſtem ramifying on the ſurface of thoſe cells and of courſe the whole of the blood paſſing through them in every circulation, together with the loſs of life upon the miſſing three or four breathings in the moſt perfect animals, ſhew the great nicety that is required in preſerving the due properties of the blood for the purpoſes of animal life : the time that we can live without air or breathing, is ſhorter than that in which we die from a defect in any other natural operation ; breathing, therefore, ſeems to render life to the blood, and the blood continues it in every part of the body. This nicety is not nearly ſo great in many of the more imperfect animals.

The amphibia have not this diviſion of lungs, nor does

* Vide Cheſter on Caſes. Caſe firſt, the venal florid. St. George's, a man emphyſematous ; blood very dark.

† I may here obſerve, that fixed air, as alſo inflammable airs, have contrary effects.

the whole of the blood paſs through the lungs in them, and they can live a conſiderable time without breathing. This, at preſent I only mention as a fact, not meaning to give my opinion of the mode of preſerving life, either in the blood or body, by the application of air to it; though, I will ſay, that mere life in both is ſupported by the air, and probably few of the other properties connected with the blood depend ſo much upon air as its life. But we may obſerve, that it was not neceſſary for the blood to undergo this change, to render it fit for every purpoſe in the animal œconomy; for we find that venal blood anſwers ſome purpoſes: thus the blood from the inteſtines, ſpleen, &c. going to the liver, as we ſuppoſe, for the ſecretion of the bile, ſhews that venal blood will do for ſome ſecretions, though probably not abſolutely neceſſary. This application of venal blood is a ſaving of blood, and it is not neceſſary for the formation of bile, that the venous blood ſhould proceed from the parts abovementioned; for in birds, amphibia, &c. other veins, beſides thoſe, enter the liver.

I have ſhewn that ſeveral ſubſtances mixed with dark coloured blood, have the property of rendering it of a florid red; and it muſt have appeared, that by circulating through the body its dark colour is reſtored. As it is capable of being rendered florid, by ſeveral ſubſtances, ſo it may be rendered dark by ſeveral when florid: vital air has the power of rendering it florid; but the other vapours, or gaſſes, which have the name of airs, ſuch as fixed air, inflammable air, &c. render it dark. This change is peculiar to the living body; for if arterial blood is taken away, it retains its florid colour, although not in the leaſt expoſed to the air. As it is found dark in the veins, and as it performs ſome offices in the courſe of the circulation, which perhaps render it unfit for the purpoſes of life, we may conceive, that the loſs of colour, and this unfitneſs are effects of the ſame cauſe: but, upon further obſervations on this fluid it will be found, that it may be rendered unfit for the purpoſes of life without loſing its colour, and may loſe its colour without being rendered unfit for life: ſlowneſs of motion in the blood of the veins, is one circumſtance that cauſes the alteration, but this alone will not produce the effect, for I have obſerved above, that arterial blood put into a phial and allowed to ſtand quiet, does not become dark; but reſt or ſlowneſs of motion in living parts, would appear, from many obfervations, to be a caufe of this change in its colour: we know that the blood begins to move more and more flowly in the arteries: we know its motion in the veins is flow, in comparifon to what it is in the arteries; we fhould, therefore, naturally fuppofe, (confidering this alone) that it was the flownefs of the motion that was the immediate caufe. Reft, or flownefs of motion, in living, and probably healthy parts, certainly allows the blood to change its colour: thus we never fee extravafations of blood, but it is continually dark. I never faw a perfon die of an apoplexy, from extravafation in the brain, but the extravafated blood was dark; even in anuerifm it becomes dark in the anuerifmal fac, alfo when the blood efcapes out of the artery and coagulates in the cellular membrane, we find the fame appearance.

Thefe obfervations refpecting apoplexy, ftruck me much. I conceived at firft, that the extravafations there muft confift of venal blood; but, from reafoning, I could hardly allow myfelf to think fo; for whatever might be the beginning of the difeafe, it was impoffible it could continue afterwards wholly venal; efpecially when the blood was found in a confiderable quantity; becaufe, in many cafes, great mifchief was done to both fyftems of veffels, and the arteries once ruptured would give the greateft quantity of blood; but to afcertain this with more certainty, I made the following experiment:

I wounded the femoral artery of a puppy obliquely; the opening in the fkin was made at fome diftance from the artery, by a couching needle; the blood that came from the fmall orifice in the fkin was florid. The cellular membrane fwelled up very much; about five minutes afterwards, I punctured the tumour, and the blood was fluid. In ten minutes I punctured it again; the blood was thinner, and more ferous, but ftill florid. In fifteen minutes I punctured it again: at firft only ferum iffued; upon fqueezing a little blood came, but ftill florid: the mafs now feemed to be principally coagulated, which prevented further trials. Some days after, when I cut into the fwelled part, I found the blood as dark as common venal blood; fo that here the change had taken place after coagulation.

When I had plafter of Paris applied to my face to make a mould, in the taking it off, it produced a kind of fuction on the fore part of the nofe, which I felt; and when the plafter was removed, on obferving the part, it was red, as if the cells of the ſkin were loaded with extravaſated blood; this was then of a florid red, but it ſoon became of a dark purple, which ſhewed that it was arterial blood, and that by ſtagnating in the cells of the body it became of the colour of venal blood.

Blood may even be rendered dark in the larger arteries, by a ſhort ſtagnation. I laid bare the caroted artery of a dog, for about two inches in length, I then tied a thread round it at each end, leaving a ſpace of two inches in length between each ligature, filled with blood; the external wound was ſtiched looſly up: ſeveral hours after, I opened the ſtiches, and obſerved in this veſſel that the blood was coagulated, and of a dark colour, the ſame as in the vein. Thus I have alſo ſeen when a tourniquet has been applied round the thigh, and the artery divided, that when it was ſlackened the firſt blood came out of a dark colour, but what followed was florid.

This I have ſeen in amputations, when a tourniquet had been applied for a conſiderable time; and, it is commonly obſerved in performing the operation for the anueriſm.

July, 1779, Mr. Bromfield had a patient in St. George's Hoſpital, with an anueriſm in the crural artery, about the middle of the thigh: the artery had been dilated about three inches in length. The operation was performed, in which the artery was tied up above the dilatation, three or more inches, for ſecurity. When this was done, the tourniquet was ſlackened, and a pretty conſiderable bleeding was obſerved, ſeemingly at the lower orifice, leading from the dilated part, which, at firſt, was ſuppoſed, from its colour, to be the venous blood that had ſtagnated in the veins, by means of the tourniquet; but this it could not be; and it was found to flow from the lower orifice of the artery, which was immediately tied: we muſt ſuppoſe, that the motion of the blood, in making this retrograde courſe, was very ſlow, for it had firſt to paſs off into ſmall collateral branches, above where it was tied, then to anaſtomoſe with ſimilar ſmall ones, from the trunk below, and then to enter that trunk; all of which muſt very much retard its motion; and indeed, the manner of its oozing out of the veſſels ſhewed ſuch a retardation. This motion of the blood, though in the arterial ſyſtem, was in ſome reſpects ſimilar to the motion of the blood in both ſyſtems of veſſels.

This laſt circumſtance plainly indicates a communication of the arteries above the aneuriſm with thoſe below, by means of the anaſtomozing branches.

The blood from the lower orifice flowed without any pulſation; which muſt have been owing to its coming into the large artery below by a vaſt number of ſmaller ones at different diſtances, and of courſe, at different times; but probably, the chief cauſe of this want of pulſation in the great artery was, that the power of the heart was loſt in the two ſyſtems of ſmaller arteries above, and below; for the ſecond ſyſtem, or thoſe from below, became in a conſiderable degree ſimilar to veins; and the great artery in the leg, below the aneuriſm was like a conſiderable vein.

A young man, ſervant to Henry Drummond, Eſq. having had a knife run into his thigh, which wounded the crural artery, a conſiderable tumour came on the part, conſiſting chiefly of blood extravaſated, and lodged in the cellular membrane. This in ſome degree ſtopped the flowing of the blood from the cut artery, and on dilating the wound ſo as to get to the artery, I obſerved that the extravaſated blood in the cellular membrane was of the venal colour. On expoſing the artery, which was firſt ſecured from bleeding by a tourniquet above, and then ſlightly ſlackening that inſtrument, the firſt blood which flowed from above, was dark; and even was taken for venous blood by the operator; but he was ſoon convinced that it was arterial, by the florid colour of that which almoſt immediately enſued. I obſerved that the colour of the blood was as dark as that of any venous blood I ever ſaw.

From theſe experiments, and obſervation, we muſt conclude that the colour of the blood is altered, either by reſt, or ſlow motion, in living parts, and even in the arteries; this circumſtance takes place in the veſſels as the motion of the blood decreaſes.

Another obſervation occurs, viz. that the whole of the limbs below the ligature, where the crural artery has been taken up, muſt entirely be ſupplied with ſuch altered blood; and as this leg kept its life, its warmth, and the action of the muſcles, it is evident that the colour of the blood is of little ſervice to any of thoſe properties. It is probably from this cauſe, that granulations on the lower part of the lower extremity look dark when the perſon ſtands erect; as well as in very indolent ſores, however ſituated.

Another obfervation ftrongly in favour of the fuppofition, that reft is a caufe of the change of blood from the fcarlet colour to the dark, or modena, is taken from the common operation of bleeding; for we generally find the blood of a dark colour at its firft coming out, but it becomes lighter and lighter towards the laft. Some reafons may be given for this, firft, it has ftagnated in the veins, while the vein was filling, and the orifice making, which occupies fome time, and may render it darker than it otherwife might have been in the fame vein: fecondly, when there is a free orifice, the blood may pafs more readily into the veins from the arteries, and therefore may be fomewhat in the ftate of arterial blood, which may occafion the laft blood to be rather lighter. What amounts almoft to a proof of this, is, that although a ligature is tied fo as to ftop the paffage of the blood to the heart, and therefore it might be fuppofed not to have fo free a paffage from the arteries as in common, yet from the following obfervations, it appears that it certainly has a much freer; for if the orifice be large in a full fized vein, the arm beyond the orifice will be much paler than the natural colour, and the blood will become more florid; but if on the contrary the vein be fmall and little blood paffes, it will retain its dark colour; this, however, would appear not always to be the cafe.

I bled a lady whofe blood, at firft was of a dark colour; but fhe fainted, and while fhe continued in the fit, the colour of the blood that came from the vein, was a fine fcarlet.

The circulation was then very languid.

We may obferve that venal blood in the moft healthy, is commonly, if not always, the darkeft; and when the body is the leaft out of order, it is then not fo much changed from the florid to the very dark purple. This I have often obferved, and particularly recollect a ftriking inftance of it in a gentleman who had a flight fever; his venal blood was quite florid, like arterial blood. This could not arife from the increafe of the blood's motion, or from being kept up in the veins by the fever, for it was light*.

* I believe the blood does not become dark by ftanding in an inflamed part. I have feen cafes of apoplexy, where the perfon died fome days after the attack. I have found the piamater inflamed in feveral places, even to the length of inflammatory transfufion; forming dots, all of which were of a florid red colour, while the other parts of the fame membrane, the blood in

The blood will change its colour from the ſcarlet to the modena in different ſituations, according to the mode of circulation. In animals who have lungs, and a complete double circulation, the darkeſt blood will be where it *comes* (if I may be allowed the expreſſion) to get anew its bright colour; for inſtance, in the arteries of the lungs, and of courſe the brighteſt in the veins of the ſame part, which will be continued more or leſs into the arteries of the other circulation, where again it will begin to change, except in one ſtage of life of ſome animals who do not uſe their lungs, ſuch as fœtuſes; but in ſuch fœtuſes as convert animal-matter into nouriſhment, therefore, moſt probably, muſt have it influenced by the air, ſuch as the chick in the egg, although not by means of the lungs of the chick, we find the blood in the veins of their temporary lungs of a florid colour while it is dark in the arteries; therefore has become of a dark colour, in its paſſage to and from the heart; but in the more perfect animals the blood, I believe, becomes darker and darker, as it proceeds from the heart, till it returns to the heart again; but this change is very little in the arterial ſyſtem, more eſpecially in veſſels near the heart, as the coronary arteries. The change of colour is more rapid in the veins, but it is not equally made through the whole venous ſyſtem; for it will be produced more quickly in the lower parts of the lower extremities, than in the veins near the heart: it begins, moſt probably, where the motion firſt has a tendency to become languid; and this uſually takes place in the very ſmall arteries; for in bleeding in the foot, or on the back of the hand, I have obſerved, in general, that the blood is of a more florid red than in the bend of the arm.

V. OF THE QUANTITY OF BLOOD, AND COURSE OF ITS CIRCULATION.

It appears to me impoſſible to aſcertain the quantity of blood in the body; and the knowledge of it would probably give very little aſſiſtance towards better underſtanding the œconomy of the animal. The quantity of blood is

the larger veſſels, and alſo the extravaſated blood, were of the uſual dark colour.

probably as permanent a circumftance as any, and not depending on immediate action: we have not one hour lefs and another hour more; nothing but accident or difeafe can leffen the quantity; the firft, probably, immediately, the other flowly: but even then, although under par, it is fo flowly made up as not to conftitute fudden variations; yet when we come to confider the varieties in the pulfe, we fhould imagine there would be great varieties in the quantity of blood. The quantity I think muft be confiderable, when we reflect on the ufe of this fluid; the quantity of fupply, or food, neceffary to keep it up; that it fupports the body and life, every where; and, that it forms the pabulum of many fecretions. All thefe cannot depend on a very fmall quantity of this fluid, without conceiving at the fame time an extremely quick change. There feems to be two modes of judging, both of which are evidently liable to objections in point of accuracy, and they differ fo much, as to fhew that neither can be right. One is to calculate how much may be in an animal from the quantity it will lofe in a fhort time. I have feen feveral quarts thrown up from the ftomach in a few hours, even by a very thin, puny perfon: and, on the other hand, if we had not this proof, we fhould fuppofe there could be but very little, when a few ounces will make a perfon faint: I have an idea, however, that people can bear to lofe more by the ftomach, than in any other way. Befides, it becomes a matter almoft of furprife, how little is commonly found in the dead body: but I believe in difeafe it in fome degree diminifhes with the body; for more is to be found in thofe who die fuddenly, or of accute difeafes; and even in fome who die of lingering difeafes, as a dropfy, we have a confiderable quantity of blood. The only way of accounting for this is, that in a common lingering illnefs there is lefs blood; and in a dropfy, it coagulates lefs; for the ftrong coagulation fqueezes out the ferum, which, I imagine, tranfudes after death, and is not obfervable.

It would appear upon the whole, that the quantity of blood in an animal is proportioned to the ufes of that blood in the machine, which, probably, may be reckoned three in number: the firft is fimply the fupport of the whole, which includes the growth, or increafe of parts, the keeping the parts already formed to their neceffary ftandard, and alfo the fupply of wafte in the parts. The fecond is the fupport of action, fuch as the action of the brain, and mufcles, in which is produced uncommon wafte; and thirdly, fecretion; all of which will fluctuate except the fimple fupport; but more particularly the fupport of action. I have already obferved that the anaftomofing of veffels gives greater fpace for blood. Probably a paralytic limb would give the neceffary quantity for fimple fupport.

There is nothing in the veins particular, fo as to give an idea that they were intended to increafe the quantity of blood; they hold, however, more than the arteries, which certainly adds to the quantity: but the increafe of fize leffens the velofity. They form plexufes, and what are called certain bodies, as the plexus retiformis in the female; the carpora carvernofa, and fpongiofa in the male. We fee how little blood fupports a part in an aneurifm; and, probably, flownefs of motion is fuitable to little blood.

It muft have appeared in the account of the different colours, of the different parts of the body, arifing from the proportion of red blood, that fome parts muft have much more blood than others, and we have now to mention, that fome parts have much larger veffels going to them, than others. This idea is confirmed, by the blood being the moving material of life, and taking a part in every action of it: its quantity is to be found in proportion to thofe actions; and fince the body is a compound of parts, or rather of actions, whofe ufes are known to vary confiderably, we find blood directed to thofe parts in proportion to their actions; and this we judge of by the fize of the veffel, and rednefs of the part, in thofe animals which have red blood, and we may fuppofe the fame in thofe which have not this part of the blood. The brain has confiderable veffels, etc. going to it, yet its fubftance is white, which is in fome degree owing to its opacity. The tongue is vafcular. The thyroid gland is vafcular. The lungs allow of the paffage of the whole blood in moft animals, and therefore have always a current of blood through them equal to the whole.

The liver is extremely vafcular, which is known from its proportion of veffels, as well as its colour; and as there is in this vifcus a peculiar circulation, the very great quantity of blood paffing through it, adds to the quantity in the whole body.

The fpleen is extremely vafcular, as are likewife the kidnies. The ftomach, and inteftines, have confiderable

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veſſels going to them, and the muſcles in general, more eſpecially thoſe of labouring people; for labour increaſes the quantity of blood in the whole, beyond ſimple nouriſhment in the full grown, or beyond the mere growth in the young.

In tracing the courſe of this nouriſhment in animals, which conſiſts ultimately in the blood; from the moſt ſimple to the moſt complicated, there is a pretty regular ſeries; but this regularity is interrupted whenever there is a variety in the circumſtances which are to be taken into the account; but the whole of this forms too extenſive a ſubject for our preſent conſideration.

If I were to begin at the formation of the blood, I ſhould firſt treat of digeſtion in thoſe animals which have ſtomachs; but this is a diſtinct ſubject: we may, however, begin with its immediate conſequences, as it produces the firſt and moſt eſſential change, viz. the converſion of the blood into a fluid called chyle. The chyle is the immediate effect or product of digeſtion, and is the ſeed, which, as it were, grows into blood, or may be ſaid to be the blood not yet made perfect. The chyle, to appearance, varies in different animals. In the quadruped, and in the crocodile, it is white; but in moſt other animals it is tranſparent: where it is white its parts are more conſpicuous than where it is tranſparent. In this reſpect it is ſimilar to the red blood, and is found to conſiſt of a coagulating matter, a ſerum, and white globules, which render it of a white colour, and in ſome degree reſembles milk. Theſe globules are ſmaller than the red globules of the blood, and about the ſize of thoſe in the pancreatic juice; they retain their figure in water, and therefore are not ſimilar to the red globules: they retain, alſo, their round form in the ſerum.

They are ſpecifically heavier than their own lymph, and ſerum.

One would naturally ſuppoſe from obſerving the chyle to have globular particles in certain animals, that they formed the red globules in the blood; but when we conſider that the chyle in fowls has no globules, and yet that they have red blood, we muſt conclude that they do not anſwer this purpoſe.

The firſt motion of the nouriſhment in moſt animals is by the abſorption of this fluid from the appendages of the ſtomach; and in many, this alone appears to be the whole, as they have no ſuch organ or viſcus, as a heart, to which it may be carried; and in ſuch it may be ſuppoſed to be in its mode of diſtinction ſomewhat ſimilar to the meſenteric veins and vena-portarum: the parts, therefore, aſſimilate, and diſpoſe of it themſelves; but this ſtructure belongs only to the moſt ſimple, or the firſt claſs of animals. In thoſe which are more perfect, where parts are formed for each particular purpoſe, the chyle is brought to one organ, called the heart, having firſt joined the venous blood, which now requires a ſimilar proceſs, and both are ſent to the lungs, where, moſt probably, the chyle receives its finiſhing proceſs, and from thence it comes back to the heart again, to be ſent to every part of the body *.

In thoſe animals that have hearts, we are to take into the account a number of particulars: firſt, the blood's motion in conſequence of that organ: ſecondly, the firſt intention of that motion, viz. to be prepared in the lungs, which introduces breathing: thirdly, the variety in the kinds of lungs: fourthly, the different kinds of ſubſtance animals are obliged to breathe for the purpoſe of matter, employed in the preparation of this fluid.

In this inveſtigation we ſhall find there is not an exact or regular correſpondence in all the parts ſo employed.

This irregularity ariſes from animals breathing different ſubſtances; ſuch as ſome breathing the common atmoſphere, in which is included the reſpirable air; others water, in which air is included, as fiſh.

Some breathe both air and water, while there are others which breathe air in their perfect ſtate, but water in their firſt periods, or imperfect ſtate of life †.

If we were to take a view of all theſe ſyſtems, each ſhould be conſidered apart, with all its peculiarities or connections; together with the different ſyſtems, as they gradually creep into one another, ſome being perfectly diſtinct, while others partake more or leſs of both.

The complete ſyſtem is always to be conſidered as the moſt perfect, although it may belong, in other reſpects, to a more imperfect order of animals.

It has been ſuppoſed by phyſiologiſts, that as the blood is found to conſiſt of different parts, or rather properties, that certain parts or properties were determined to certain

* The circulation in fiſh is an exception to this.

† In this account I do not include animals in embryo, and ſome others, which do not breathe at all.

parts of the body, for particular purpofes; but from the frequent anaftomofis of arteries, the great variety in their number, origin, and the different courfes which they take in different bodies, it is very evident, that there can be no particular blood fent to any part of the body where the whole blood can circulate. Many unnatural fituations of parts fhew this. For inftance, the kidneys fometimes have one artery only on one fide, and two, three, or four on the other. On one fide they arife from the aorta as high as near the fuperior mefenteric, on the other as low almoft as the divifion into the two iliacs: and in fome cafes a kidney has been formed in the pelvis, and the artery has arifen from the iliac; the fpermatic arteries too, fometimes, arife on one fide from the aorta, and on the other from the emulgents or the arteria capfulæ renalis. If there was a particular blood fent to every gland, we fhould expect to find urine fecreted in the tefticle, when its artery arofe from the emulgent: but as the blood vifibly confifts of different parts in thofe animals we are moft acquainted with, and whofe phyfiology is probably beft known to us, and as one part of the blood can be traced in the veffels, we can determine with fufficient accuracy the proportions of blood fent, as well as the different kinds. Thus, the red part of the blood informs us, how far it is carried; and we find that our coloured injections nearly correfpond with this information. I may here firft remind the reader, that the red globules are the groffer part of the blood, and therefore, whenever they are moft in quantity, we have the blood with all its parts in due proportion and unfeparated; but the conftruction in many parts of an animal is fuch, that the red blood is excluded, and this alfo excludes every coloured powder we can inject; the vafcularity, therefore, of fuch parts is not known, as has been mentioned.

Through them the coagulating lymph only can pafs, and probably the ferum, for the fimple nourifhment of the parts. Of this nature are tendons, or tendinous parts, ligaments, elaftic ligaments, cartilages, efpecially thofe of joints, the cornia, &c. Even the brain and nerves, have not the red blood pufhed fo far into their fubftance as many other parts have; we fee, therefore, that the whole blood is not conveyed to all parts alike, and this we may fuppofe to anfwer fome good purpofe; yet, upon a more particular veiw of this fubject, we may find it difficult to affign caufes for this felection of the blood; for in many animals we find parts fimilar in conftruction and ufe, fuch as mufcles, which are furnifhed, fome with the whole blood, others with the coagulating lymph only, with all the gradations; fome animals having both red and white mufcles; others having them wholly red, and others wholly white, as will be more fully explained. Even venous blood can be rendered ufeful, when it is not to anfwer the purpofe of nourifhment; for we find the blood of the inteftine and fpleen going to the liver, we may prefume for the fecretion of the bile, as has been already obferved.

The idea of particular kinds of blood being fent to parts having particular ufes, more efpecially where the part is employed folely in difpofing of this fluid, fuch as glands, is now, I believe, pretty well exploded; and, it is fuppofed, therefore, that the whole mafs of blood is fuch as to be fitted for all the purpofes of the machine. This idea gives to the parts themfelves, full power over the blood fo compofed, and makes us confider the circulation or motion of the blood fimply.

As the blood is compofed of different parts, it might be fuppofed, that if any particular part had been expended in any procefs, the remainder, as returned by the veins, would fhew this by its different appearance or qualities. The only vifible difference that I could conceive to take place, was in the appearance, or the quantity of coagulating lymph. To afcertain this, however, I made the following experiments:

I opened the right fide of the thorax in a living dog, and tied a ligature round the vena-cava inferior, above the diaphragm. I then applied my hand upon the opening, which allowed him to breathe, that the circulation might go on and fill the larger veins. When the inferior vena-cava became turgid, I killed him. On the day following I examined the blood in the different veins, and found a coagulum in the emulgent, mefenteric, vena-cava inferior, fplenic, and in the venæ-cavæ hepaticæ, of fizes proportional to the fizes of the veffels; nor was there any difference in any other way.

Experiment the fecond. Some blood was taken from the mefenteric vein of a living dog, and fimilar quantities from the fplenic vein, the emulgent vein, and the vena-cava inferior, below the openings of the emulgents.

Theſe four quantities were taken in four ſeparate cups. They all ſoon coagulated: if there was any one later of coagulating than another, it was that from the meſenteric veins. On ſtanding twenty-four hours the coagula were all of the ſame firmneſs.

VI. OF THE LIVING PRINCIPLE OF THE BLOOD.

SO far I have conſidered the blood, and in the common way; but all this will explain nothing in the animal œconomy, unleſs we can refer it to ſome principle which may ſhew the nature of its connection with the living ſolids in which it moves, and which it both forms and ſupports. If we ſhould find this principle to be ſimilar to life in the ſolids, then we ſhall ſee the harmony that is ſupported between the two, and we ſhall call it, the living principle of the blood. Without ſome ſuch principle, all we have been examining is like diſſecting a dead body without having any reference to the living, or even knowing it had ever been alive. But, from the account I have given of the blood, it muſt have appeared, that I have ſtill in reſerve a property not hitherto explained; for in treating of the coagulation of the coagulating lymph, I have not been ſo full in my account as I might have been. As many phœnomena, reſpecting the coagulating or not coagulating of the blood, develope this principle, I have choſen in part to reſerve it for this place; nor ſhall I be ſo full upon the preſent occaſion as I ſhould otherwiſe be, were I writing on this ſubject expreſsly. My intention being rather to explain many appearances in the animal œconomy, and particularly the diſeaſes I am to treat of, than to diſcuſs this ſingle principle. I reſerve the illuſtration of my doctrine for ſuch parts of the treatiſe as ſhall be employed on theſe ſubjects; the explanations and illuſtrations, therefore, will be interſperſed through the work, by which means they will come more forcibly on the mind: from many circumſtances attending this fluid, it would ſeem to be the moſt ſimple body we know of, endowed with the principle of life. That the blood has life, is an opinion I have ſtarted for above thirty years, and have taught it, for near twenty of that time in my lectures; it does not, therefore, come out at present as a new doctrine; but has had time to meet with considerable opposition, and also acquire its advocates. To conceive that blood is endowed with life while circulating, is perhaps carrying the imagination as far as it well can go; but the difficulty arises merely from its being fluid, the mind not being accustomed to the idea of a living fluid*. It may therefore be obscure at first, and it will be the more necessary that I should be pretty full in my account of it; yet the illustration of it in my account of inflammation, will, perhaps, do more to produce conviction than any other attempt, although strongly supported by facts. It is to me somewhat astonishing, that this idea did not early strike the medical enquirers, considering the stress which they have laid on the appearances of this fluid in diseases; since it is probably more expressive of disease than any other part of the animal œconomy: and yet all this, according to them, must have arisen from, what shall I call it? a dead animal fluid, on which a disease in the solids must have had such an effect. This, I think, is giving too much to the solids, and too little to the fluids. When all the circumstances attending this fluid are fully considered, the idea, that it has life within itself, may not appear so difficult to comprehend; and indeed, when once conceived, I do not see how it is possible we should think it to be otherwise; when we consider that every part is formed from the blood, that we grow out of it, and if it has not life previous to this operation, it

* It is just as difficult for a man born in the West Indies, to conceive water becoming a solid. I recollect a gentleman from Barbadoes, walking out with me one frosty morning, when there was ice on the gutters, and I, without having any thing else in my mind than just common observation, said, "it "has been a frost in the night." He immediately caught at the word frost, and asked me, "How I knew that?" Without thinking particularly of the cause of his question, I said, "because I see the ice on the gutters." He immediately said, "where?" and I answered, "there." Having been told that ice was a solid, he put his fingers down upon it, but with such caution as bespoke a mind that did not know what it was to meet; and upon feeling the resistance it gave, he gently pulled his hand back, and looked at the ice, and then became more bold, broke it, and examined it.

muſt then acquire it in the act of forming; for we all give our aſſent to the exiſtence of life in the parts when once formed. Our ideas of life have been ſo much connected with organic bodies, and principally thoſe endowed with viſible action, that it requires a new bend to the mind, to make it conceive that theſe circumſtances are not inſeparable. It is within theſe fifty years only, that the callus of bones has been allowed to be alive*; but, I ſhall endeavour to ſhow, that organization and life, do not depend in the leaſt on each other; that organization may ariſe out of living parts and produce action, but that life can never riſe out of, or depend on organization. An organ is a peculiar conformation of matter, (let that matter be what it may) to anſwer ſome purpoſe, the operation of which is mechanical; but, mere organization can do nothing, even in mechanics, it muſt ſtill have ſomething correſponding to a living principle; namely, ſome power. I had long ſuſpected that the principle of life was not wholly confined to animals, or animal ſubſtances endowed with viſible organization and ſpontaneous motion: I conceived that the ſame principle exiſted in animal ſubſtances devoid of apparent organization and motion, where there exiſted ſimply the power of preſervation.

I was led to this notion about the years 55, or 56, when I was making drawings of the growth of the chick, in the proceſs of incubation. I then obſerved, that whenever an egg was hatched, the yolk, (which is not diminiſhed in the time of incubation) was always perfectly ſweet to the very laſt; and that part of the albumen, which is not expended on the growth of the animal, ſome days before hatching, was alſo ſweet, although both were kept in a heat of 103° in the hen's egg for three weeks, and in the ducks for four. I obſerved, however, that if an egg did not hatch, it became putrid in nearly the ſame time with any other dead animal matter; an egg, therefore, muſt have the power of ſelf-preſervation, or in other words, the ſimple principle of life. To determine how far eggs would ſtand other teſts, to prove a living principle, I made the following experiments†:

* Dr. Hunter was the firſt who ſhowed callus to be endowed with the principle of life, as much as bone.

† Philos. Tranſact. vol. 4[?], part [?] page 28, 9; as alſo Obſervations on certain Parts of the Animal Oeconomy, page 106, firſt edition.

Having put a new laid egg into a cold about 0, which froze it, I then allowed it to thaw; from this process I imagined that the preserving powers of the egg might be destroyed.*

I next put this egg into the cold mixture, and with it one newly laid; the difference in freezing was seven minutes and a half; the fresh egg taking so much longer time in freezing.

A new laid egg was put into a cold atmosphere, fluctuating between 17° and 15°; it took about half an hour to freeze; but when thawed, and put into an atmosphere at 25°, viz. nine degrees warmer, it froze in half the time: this experiment was repeated several times with nearly the same result.

To determine the comparative heat between a living and a dead egg, and also to determine whether a living egg be subject to the same laws with the more imperfect animals, I made the following experiments: A fresh egg, and one which had been frozen and thawed, were put into the cold mixture 15°; the thawed one soon came down to 32° and began to swell and congeal; the fresh one sunk first to 29° and a half, and in twenty-five minutes after the dead one, it rose to 32°, and began to swell and freeze. The result of this experiment upon the fresh egg was similar to what was observed in the like experiments upon frogs, eels, snails, &c. where life allowed the heat to be diminished two or three degrees below the freezing point, and resisted all further decrease; but in both the powers of life were expended by this exertion, and then the parts froze like any other dead animal matter.

This is not a principle peculiar to life, but is common in many other cases: it has been observed that water could be so circumstanced as to be brought below the freezing point, without freezing; but just as it began to freeze it rose to 32°. In my experiments on the heat of vegetables, I observed that the sap of a tree would freeze at 32°, when taken out of the vessels of the tree; but I found the trees often so low as 15°, and the sap not frozen.

* However, this was at first not so certain, but the result of the experiment proved it was so. To be more certain of killing a part by freezing it, I believe it should be froze very slowly, for simple freezing does not kill.

From these experiments, it appears that a fresh egg has the power of resisting heat, cold, and putrefaction, in a degree equal to many of the more imperfect animals, which exhibit exactly the same phœnomena under the same experiments; and it is more than probable that this power arises from the same principle in both. Similar experiments have been made on the blood: after a portion of blood had been frozen and then thawed, it has again been frozen with a similar quantity of fresh blood, drawn from the same person, and that which had undergone this process froze again much faster than the fresh blood*.

As all the experiments I had made upon the freezing of animals, with a view to see whether it was possible to restore the actions of life, when they were again thawed, were made upon whole animals; and as I never saw life return by thawing, I wished to ascertain how far parts were in this respect, similar to the whole, especially since it was asserted, and with some authority, that parts of a man may be frozen, and may afterwards recover; for this purpose I made the following experiments upon an animal of the same order with ourselves.

In January 1777, I mixed salt and ice till the cold was about 0; and on the side of the vessel containing them was a hole, through which I introduced the ear of a rabbit. To carry off the heat as fast as possible, the ear was held between two flat pieces of iron, that sunk further into the mixture than the ear; the ear remained in the mixture nearly an hour, in which time the part projecting into the vessel became stiff, when taken out and cut into, did not bleed, and a part being cut off by a pair of scissars, flew from between the blades like a hard chip. It soon after thawed and began to bleed, and became very flaccid, so as to double upon itself, having lost its natural elasticity. When it had been out of the mixture nearly an hour, it became warm, and this warmth increased to a considerable degree; it also began to thicken in consequence of inflammation; while the other ear continued of its usual temperature. On the day following, the frozen ear was still warm, and it retained its heat and thickness for many days after. About a week after this, the mixture in the vessel, being the same as in the former experiment, I introduced both ears of the same rabbit thrugh the hole and froze

* Vide Corrie on the Vitality of the Blood, page 45.

them both; the found one however froze firft, probably from its being confiderably colder at the beginning, and probably too from its powers not being fo eafily excited as thofe of the other: when withdrawn they both foon thawed and became warm, and the frefh ear thickened as the other had done before. Thefe changes in the parts do not always fo quickly take place, for on repeating thefe experiments on the ear of another rabbit, till it became as hard as a board, it was longer in thawing than in the former experiment; and much longer before it became warm; in about two hours, however, it became a little warm, and the following day it was very warm and thickened. In the fpring, 1776, I obferved that the cocks I had in the country had their combs fmooth with an even edge, and not fo broad as formerly, appearing as if nearly one half of them had been cut off. Having enquired into the caufe of this, my fervant told me, that it had been common in that winter, during the hard froft. He obferved, that the combs had become in part dead, and, at laft, had dropt off; and, that the comb of one cock had dropped off entirely; this I did not fee, as the cock by accident had burnt himfelf to death. I naturally imputed this effect to the combs having been frozen in the time of the fevere froft, and having, confequently, loft their life by this operation. I endeavoured to try the folidity of this reafoning by experiment. I attempted to freeze the comb of a very large young cock, (being of a confiderable breadth) but could only freeze the ferrated edges, (which proceffes were fully half an inch long); for the comb itfelf being very thick and warm refifted the cold. The frozen parts became white and hard; and when I cut off a little bit it did not bleed, neither did the animal fhow any figns of pain. I next introduced into the cold mixture one of the cock's wattles, which was very broad and thin; it froze very readily, and, upon thawing both the frozen parts of the comb and wattle they became warm, but were of a purple colour, having loft the tranfparency which remained in the other parts of the comb and in the other wattle: the wound in the comb now bled freely: both comb and wattle recovered perfectly in about a month: the natural colour returned firft next to the found parts, and increafed gradually till the whole had acquired a healthy appearance. Finding that freezing both the folids, and the blood, did not deftroy the life in either, nor the future actions depending on oganization; and, that it alfo did not prevent the blood from recovering its fluidity, I conceived the life of every part of the body to be fimilar: what will affect, therefore, the life of any one part, will affect alfo that of another, though probably not in an equal degree; for in thefe experiments, the blood was under the fame circumftances with the folids, and it retained its life; that is to fay, when the folids and blood were frozen and afterwards thawed, they were both capable of carrying on their functions.

The following experiments were made in the fame manner on living mufcles, to fee how far the contractions of living mufcles after having been frozen, correfpond with the coagulation of the blood.

A mufcle was removed from a frog's leg, with a portion of its tendon, was immediately placed between two pieces of lead, and expofed to a cold about ten degrees below 0. In five minutes it was taken out, when it was quite hard and white; on being gradually thawed it became fhorter and thicker than while frozen; but on being irritated did not contract; yet if at all elongated by force, it contracted again, and the tendinous expanfion covering the mufcle was thrown into wrinkles: when the ftimulus of death took place, it became ftill fhorter.

From a ftraight mufcle in a bullock's neck, a portion, three inches in length, was taken out immediately after the animal had been knocked down, and was expofed between two pieces of lead, to a cold below 0, for fourteen minutes; at the end of this time it was found to be frozen exceedingly hard, was become white, and was now only two inches long: it was thawed gradually, and in about fix hours after thawing, it contracted fo as only to meafure one inch in length, but irritation did not produce any fenfible motion in the fibres. Here then were the juices of mufcles frozen fo as to prevent all power of contraction in their fibres, without deftroying their life; for when thawed they fhowed the fame life which they had before: this is exactly fimilar to the freezing of blood too faft for its coagulation; which, when thawed, does afterwards coagulate, as it depends in each on the life of the part not being deftroyed. I took notice in the hiftory of the coagulation of the lymph, that heat of 120° excited this action in that fluid: to fee how far mufcular contraction was ſimilar in this reſpect, I made the following experiment *.

As ſoon as the ſkin could be removed from a ſheep that was newly killed, a ſquare piece of muſcle was cut off, which was afterwards divided into three pieces, in the direction of the fibres: each piece was put into a baſon of water; the water in each baſon being of different temperatures, viz. one 125°, about 27 degrees warmer than the animal; another 98°, the heat of the animal; and the third 55°, about 43 degrees colder than the animal. The muſcle in the water heated to 125°, contracted directly, ſo as to be half an inch ſhorter than the other two, and was hard and ſtiff. The muſcle in the water heated to 98°; after ſix minutes began to contract and grow ſtiff: at the end of twenty minutes it was nearly, though not quite, as ſhort and hard as the above. The muſcle in the water heated to 55°; after 15 minutes, began to ſhorten and grow hard: after 20 minutes it was nearly as ſhort and as hard as that in the water heated to 98°. At the end of 24 hours they were all found to be of the ſame length and ſtiffneſs.

Here is alſo a ſimilarity in the excitements of coagulation in the blood, and of contraction in muſcles, both apparently depending on the ſame principle, namely, life †.

If it ſhould ſtill be difficult to conceive how a body in a fluid ſtate, whoſe parts are in conſtant motion upon one another, always ſhifting their ſituation with reſpect to themſelves and the body, and which may loſe a portion without affecting itſelf or the body, can poſſibly be alive, let us ſee if it is alſo difficult to conceive that a body may be ſo compounded as to make a perfect whole of itſelf, having no parts diſſimilar, and having the ſame properties in a ſmall quantity as in a great. Under thoſe circumſtances, the removing a portion is not taking away a conſtituent part, upon which the whole depends, or by which it is made a whole, but is only taking away a portion of the whole; the remaining portion being equal in quality to the whole, and in this reſpect is ſimilar to the reducing a whole of any thing. This might be perfectly illuſtrated without ſtraining the imagination, by conſidering the opera-

* Vide Philoſ. Tranſ. vol 66, page 412. Paper on Drowning; alſo, Obſervations on certain Parts of the Animal Economy.

† The application of this principle in diſeaſe, I ſhall not at preſent take notice of.

tion of union by the firſt intention. Union, by the firſt intention, is an immediate ſympathetic harmony between divided parts, when brought ſimply into contact, which I call, contiguous ſympathy. In this caſe it is not neceſſary that the very ſame parts ſhould oppoſe each other, elſe harmony, and conſequently union, could never take place; it is ſimply neceſſary that the two parts be alive, and they might be ſhifted from one ſort of a living creature to another for ever, without any injury to either, or without exciting irritation; and the whole would ſtill be as perfect as ever. Neither can the motion of one living part upon another affect the body, becauſe all its parts are ſimilar and in harmony with each other. It is exactly the ſame with the blood, for neither its motion on itſelf, nor its motion on the body, can either affect it, or the body, ſince all the parts are ſimilar among themſelves. This is the caſe with all matter, where the property does not depend upon ſtructure, or configuration, but upon the compound; for water, is ſtill water, whether its parts are moving on each other, or at reſt: and a ſmall portion has the ſame property with the whole, and is in fact, a ſmaller whole. One of the great proofs that the blood poſſeſſes life, depends on the circumſtances affecting its coagulation; and, at preſent, we are only to explain the principles upon which theſe are founded, which it will be in ſome degree neceſſary to recapitulate; but, perhaps, the ſtrongeſt conviction on the mind will ariſe from the application of this principle to diſeaſes, eſpecially inflammation. While the blood is circulating, it is ſubject to certain laws to which it is not ſubject when not circulating. It has the power of preſerving its fluidity, which was taken notice of when treating of its coagulation; or, in other words, the living principle in the body has the power of preſerving it in this ſtate. This is not produced by motion alone, for in the colder animals, when almoſt in a ſtate of death during the winter, when their blood is moving with extreme ſlowneſs, and would appear to preſerve ſimply animal life through the whole body, and keep up that dependence which exiſts between the blood, and the body already formed, the blood does not coagulate to accompliſh theſe purpoſes. If the blood had not the living principle, it would be, in reſpect of the body, as an extraneous ſubſtance. Blood is not only alive itſelf, but is the ſupport of life in every part of the body; for mortification immediately follows, when the circulation is cut off from any part, which is no more than death taking place in the part, from the want of the ſucceſſive changes of freſh blood. This ſhows, that no part of the body is to be conſidered as a complete living ſubſtance, producing and continuing mere life, without the blood: ſo that blood makes one part of the compound; without which life would neither begin nor be continued. This circumſtance, on its firſt appearance, would ſeem a little extraordinary, when we conſider that a part, or the whole, are completely formed in themſelves, and have their nerves going to them, which are ſuppoſed to give animal life; yet that perfect living part, or whole, ſhall die in a little time, by ſimply preventing the blood from moving through the veſſels: under this idea, it is not clear to me, whether the blood dies ſooner without the body, or the body without the blood. Life, then is preſerved by the compound of the two, and an animal is not perfect without the blood: but this alone is not ſufficient, for the blood itſelf muſt be kept alive; becauſe, while it is ſupporting life in the ſolids, it is either loſing its own, or is rendered incapable of ſupporting that of the body. To accompliſh all this it muſt have motion, and that in a circle, as it is a continuance of the ſame blood which circulates, in which circle it is in one vieu ſuperſaturated, as it were, with living powers, and in another is deficient, having parted with them while it viſited the different parts of the body. Life is in ſome degree, in proportion to this motion, either ſtronger, or weaker; ſo that the motion of the blood may be reckoned, in ſome degree, a firſt moving power; and not only is the blood alive in itſelf, but ſeems to carry life every where; however, it is not ſimply the motion, but it is that which ariſes out of, or in conſequence of the motion. Here then would appear to be three parts, viz. body, blood, and motion; which latter preſerves the living union between the other too, or the life in both. Theſe three make up a complete body, out of which ariſes a principle of ſelf-motion; a motion totally ſpent upon the machine, or which may be ſaid to move in a circle, for the ſupport of the whole: for the body dies without the motion of the blood upon it; and the blood dies without the motion of the body upon it; perhaps, pretty nearly in equal times.

So far, I have conſidered the blood when compounded with the body and motion, in which we find it preſerves its fluidity, and continues life in the body; but fluidity is only neceſſary for its motion to convey life, and the continuance of life is, probably, owing to its being coagulated, and becoming a ſolid; or at leaſt, the ſupport of the body is owing to this cauſe. For this, however, it requires reſt, either by extravaſation, or by being retained in the veſſels till the utility of circulating is loſt; or till it can anſwer ſome good purpoſe by its coagulation, as in mortification. Under any of theſe circumſtances it becomes a ſolid body; for the moment it is at reſt, it begins to form itſelf into a ſolid, and changes into this or that particular kind of ſubſtance, according to the ſtimulus of the ſurrounding parts which excites this coagulum into action, and makes it form within itſelf, blood, veſſels, nerves, etc.

The coagulation is the firſt ſtep towards its utility in the conſtitution, and this ariſes from its living principle; for if that principle be deſtroyed it does not coagulate at all, that is naturally; for I do not here ſpeak of any chemical coagulation.

I ſhall now endeavour to prove that the coagulation of the coagulating lymph bears ſome analogy to the actions of muſcles, which we know to depend upon life; and which affords one of the ſtrongeſt proofs of the exiſtence of this principle: and though the action of coagulation itſelf be not ſimilar to the actions of muſcles; yet, if we can ſhow that they are governed by the ſame laws, we may reaſonably conclude, that the firſt principle is the ſame in both. When I was treating of the coagulation of the lymph, I took notice that cold did not cauſe it, and ſupported the opinion by ſeveral experiments; at the ſame time I mentioned an experiment of Mr. Hewſon, to prove the ſame thing, and which he conceived to be concluſive, but which does not appear to me in any way to affect his hypotheſis. This experiment I had often made, but with another view, viz. to illuſtrate the living principle of the blood, which to me, it in ſome meaſure does, more eſpecially when compared with ſimilar experiments on living muſcles.

As the coagulation of the blood is a natural proceſs, and as all natural proceſſes have their time of action, unleſs influenced by ſome exciting cauſes, and ſince cold is not a cauſe of the blood's coagulation, even when removed out of the circulation, the blood may be frozen much more quickly than it can coagulate, by which change its coagulating power is ſuſpended. To prove this by experiment, I took a thin leaden veſſel, with a flat bottom, of ſome width, and put it into a cold mixture below 0, and allowed as much blood to run from a vein into it, as covered its bottom. The blood froze immediately, and when thawed, became fluid, and coagulated, I believe, as foon as it would have done had it never been frozen.

As the coagulation of the blood appears to be that procefs which may be compared with the action of life in the folids, we fhall examine this property a little further, and fee if this power of coagulation can be deftroyed; if it can, we fhall next enquire, if by the fame means life is deftroyed in the folids; and if the phænomena are nearly the fame in both. The prevention of coagulation may be effected by electricity, and often is by lightening: it takes place in fome deaths, and is produced in fome of the natural operations of the body; all of which I fhall now confider.

Animals killed by lightening, and alfo by electricity, have not their mufcles contracted: this arifes from death being inftantaneoufly produced in the mufcles, which therefore cannot be affected by any ftimulus, nor confequently by the ftimulus of death. In fuch cafes the blood does not coagulate. Animals who are run very hard, and killed in fuch a ftate, or what produces ftill a greater effect, are run to death, have neither their mufcles contracted, nor their blood coagulated; and in both refpects the effect is in proportion to the caufe*.

I had two deer run, till they dropped down and died; in neither did I find the mufcles contracted, nor the blood coagulated.

In many kinds of death, we find that the mufcles neither contract, nor the blood coagulate. In fome cafes the mufcles will contract while the blood continues fluid, in fome the contrary happens; and in others the blood will only coagulate to the confiftence of cream.

Blows on the ftomach kill immediately, and the mufcles do not contract, nor does the blood coagulate. Such deaths as prevent the contraction of the mufcles, or the coagulation of the blood, are, I believe, always fudden. Death from fudden gufts of paffion, is of this kind; and in all thefe cafes the body foon putrifies after death. In many difeafes, if accurately attended to, we find this correfpondence between mufcles and blood; for where there is

* This is the reafon why hunted animals are commonly more ender than thofe that are fhot.

ſtrong action going on, the muſcles contract ſtrongly after death, and the blood coagulates ſtrongly.

It is unneceſſary, I imagine, to relate particular inſtances of the effects of each of thoſe cauſes: I need only mention that I have ſeen them all. In a natural evacuation of blood, viz. menſtruation, it is neither ſimilar to blood taken from a vein of the ſame perſon, nor to that which is extravaſated by an accident in any other part of the body; but is a ſpecies of blood, changed, ſeparated, or thrown off from the common maſs, by an action of the veſſels of the uterus, ſimilar to that of ſecretion; by which action the blood loſes the principle of coagulation, and I ſuppoſe life.

The natural deduction from all theſe facts, and obſervations, I think is perfectly eaſy; it is impoſſible to miſs it.

This living principle in the blood, which I have endeavoured to ſhow to be ſimilar in its effects to the living principle in the ſolids, owes its exiſtence to the ſame matter which belongs to the other, and is the materia vitæ diffuſa, of which every part of an animal has its portion*: it is, as it were, diffuſed through the whole ſolids and fluids, making a neceſſary conſtituent part of them, and forming with them a perfect whole; giving to both the power of preſervation, the ſuſceptibility of impreſſion; and, from their conſtruction, giving them conſequent reciprocal action. This is the matter which principally compoſes the brain; and where there is a brain, there muſt neceſſarily be parts to connect it with the reſt of the body, which are the nerves; and as the uſe of the nerves is to continue, and therefore convey the impreſſion or action of the one to the other, theſe parts of communication muſt neceſſarily be of the ſame matter; for any other matter could not continue the ſame action.

From this it may be underſtood, that nothing material is conveyed from the brain, by the nerves; nor vice verſa, from the body to the brain: for if that was exactly the caſe, it would not be neceſſary for the nerves to be of the

* I conſider that ſomething ſimilar to the materials of the brain is diffuſed through the body, and even contained in the blood; between this and the brain a communication is kept up by the nerves; I have, therefore, adopted terms explanatory of this theory; calling the brain, the materia vitæ coacervata; the nerves, the chordæ internunciæ; and that diffuſed through the body, the materia vitæ diffuſa.

ſame materials with the brain; but as we find the nerves of the ſame materials, it is a preſumptive proof, that they only continue the ſame action which they receive at either end.

The blood has as much the materia vitæ as the ſolids, which keeps up that harmony between them; and as every part endued with this principle has a ſympathetic affection upon ſimple contact, ſo as to affect each other, (which I have called contiguous ſympathy) ſo the blood, and the body, are capable of affecting, and being affected, by each other; which accounts for that reciprocal influence which each has on the other. The blood being evidently compoſed of the ſame materials with the body, being endued with the ſame living powers, but from its unſettled ſtate, having no communication with the brain, is one of the ſtrongeſt proofs of the materia vitæ making part of the compoſition of the body, independent of the nerves; and is ſimilar, in this reſpect, to thoſe inferior order of animals that have no nerves, where every other principle of the animal is diffuſed through the whole. This opinion cannot be proved by experiment; but I think daily experience ſhows us, that the living principle in the body acts exactly upon the ſame principle with the brain. Every part of the body is ſuſceptible of impreſſion; and the materia vitæ, of every part, is thrown into action; which, if continued to the brain, produces ſenſation; but it may only be ſuch as to throw the part of impreſſion into ſuch actions as it is capable of, according to the kind of impreſſion; ſo does the brain or mind. The body loſes impreſſion by habit; ſo does the brain; it continues action from habit; ſo does the brain. The body, or parts of the body, have a recollection of former impreſſions, when impreſſed anew; ſo has the brain; but they have not ſpontaneous memory as the brain has, becauſe the brain is a complete whole of itſelf, and therefore its actions are complete in themſelves. The materia vitæ of the body being diffuſed, makes part of the body in which it exiſts and acts for this part, probably for this part alone. The whole, taken together, hardly makes a whole, ſo as to conſtitute what might be called an organ; the action of which is always for ſome other purpoſe than itſelf: but this is not the caſe with the brain. The brain is a maſs of this matter, not diffuſed through any thing, for the purpoſe of that thing, but conſtituting an organ in itſelf, the actions of which are for other purpoſes, viz. receiving, by means of the nerves, the vaſt variety of actions in the diffuſed materia vitæ, which ariſe from impreſſion, and habit, combining theſe and diſtinguiſhing from what part they come. The whole of theſe actions form the mind; and, according to the reſult, impreſs more or leſs of the materia vitæ of the body in return, producing in ſuch parts conſequent actions. The brain then depends upon the body for its impreſſion, which is ſenſation; and the conſequent action is that of the mind: and the body depends upon the conſequence of this intelligence, or effect of this mind, called the will, to impreſs it to action; but ſuch are not ſpent upon itſelf, but are for other purpoſes, and are called voluntary.

But mere compoſition of matter does not give life; for the dead body has all the compoſition it ever had: life is a property we do not underſtand: we can only ſee the neceſſary leading ſteps towards it.

If nerves, either of themſelves, or from their connection with the brain, gave vitality to our ſolids, how ſhould a ſolid continue life, after a nerve is deſtroyed? or ſtill more, when paralytic? for the part continues to be nouriſhed, although not to the full health of voluntary action; and this nouriſhment is the blood; for deprive it of the blood, and it mortifies.

The uterus, in the time of pregnancy, increaſes in ſubſtance and ſize, probably fifty times beyond what it naturally is, and this increaſe is made up of living animal matter, which is capable of action within itſelf. I think we may ſuppoſe its action more than double; for the action of every individual part of this viſcus, as this period, is much increaſed, even beyond its increaſe of ſize; and yet we find that the nerves of this part, are not in the ſmalleſt degree increaſed. This ſhews that the nerves, and brain, have nothing to do with the actions of a part: while the veſſels, whoſe uſes are evident, increaſe in proportion to the increaſed ſize: if the ſame had taken place with the nerves, we ſhould have reaſoned from analogy. It is probably impoſſible to ſay where the living principle firſt begins in the blood: whether in the chyle itſelf, or not till that fluid mixes with the other blood, and receives its influence from the lungs. I am, however, rather inclined to think, that the chyle is itſelf alive; for we find it coagulates when extravaſated; it has the ſame powers of ſeparation with the blood; and it acquires its power of action in the lungs as the venal blood does. I conceive this to be ſimilar to the influence of the male and female on an egg, which requires air, and a due warmth, to produce the principle of action in it; and is ſomewhat ſimilar to the venal blood coming to the lungs to receive new powers, which it communicates to the body. To endeavour to prove whether the chyle had the power of action in it, ſimilar to the blood, I made the following experiment:

I opened the abdomen of a dog, and punctured one of the largeſt lacteals at the root of the meſentery, out of which flowed a good deal of chyle: I then allowed this part to come in contact with another part of the meſentery, to ſee if they would unite, as extravaſated blood does; but they did not; however, this experiment, though performed twice, is not concluſive; for ſimilar experiments with blood might not have ſucceeded.

From what has been ſaid with regard to the blood, that it becomes a ſolid, when extravaſated in the body, we muſt ſuppoſe that ſome material purpoſe is anſwered by it; for if the blood could only have been of uſe in a fluid ſtate, its ſolidity would not have been ſo much an object with nature. It appears to me to be evident that its fluidity is only intended for its motion; and its motion is only to convey life, and living materials, to every part of the body. Theſe materials when carried, become ſolid; ſo that ſolidity is the ultimate end of the blood, as blood.

The blood when it naturally increaſes the body, or repairs a part, may be ſaid to be extravaſated, although not commonly ſo conſidered; what is uſually underſtood to be extravaſation, is when it ariſes from accident of ſome kind, or diſeaſe in the veſſel, and of courſe is obvious to the ſight; but even this extravaſation is of uſe by the blood coagulating, although too often it is in too large a quantity. Accident does not calculate the ſize of the veſſel ruptured, to be juſt equal to the effect wanted by the rupture: but nature has made a wiſe proviſion for this overplus.

As extravaſation ariſes from a rupture of the veſſel, it is of ſervice in the reunion of that veſſel: if there are more ſolids ruptured than a veſſel, as in a fracture of a bone, it becomes a bond of union to thoſe parts; and this may be called, union by the firſt intention: but the union is not that of the two parts to each other, but the union of the broken parts to the intermediate extravaſated blood; ſo that it is the blood and parts uniting, which conftitutes the union by the firft intention.

This blood, fo extravafated, forms either veffels in itfelf, or veffels fhoot out from the original furface of contact into it, forming an elongation of themfelves, as we have reafon to fuppofe they do in granulations. I have reafon, however, to believe that the coagulum has the power, under neceffary circumftances, to form veffels in, and of itfelf; for I have already obferved, that coagulation, although not organic, is ftill of a peculiar form, ftructure, or arrangement, fo as to take on neceffary action, which I fhould fuppofe is fomewhat fimilar to mufcular action. I think I have been able to inject what I fufpected to be the beginning of a vafcular formation in a coagulum, when it could not derive any veffels from the furrounding parts. By injecting the crural artery of a ftump, above the knee, where there was a fmall piramidal coagulum, I have filled this coagulum with my injection, as if it had been cellular; but there was no regular ftructure of veffels. When I compare this appearance, with that of many violent inflammations on furfaces where the red blood is extravafated, forming as it were fpecks of extravafation like ftars; and which, when injected, produce the fame appearance with what I have defcribed in the injection of the coagulum: when I compare thefe again with the progrefs of vafcularity in the membranes of the chick, one can perceive where a zone of fpecks beyond the furface of regular veffels clofe to the chick, fimilar to the above extravafation, and which in a few hours become vafcular, I conceive that thefe parts have a power of forming veffels within themfelves, all of them acting upon the fame principle. But where this coagulum can form an immediate union with the furrounding parts, it either receives veffels at this furface, or forms veffels firft at this union, which communicate with thofe of the furrounding furface; and they either fhoot deeper, and deeper, or form veffels deeper, and deeper, in the coagulum, till the whole meets in its centre: if it is by the firft mode, viz. the fhooting of veffels from the furrounding furfaces into the coagulum, then it may be the ruptured veffels in cafes of accident, which fhoot into the coagulum, and where a coagulum, or extravafation of coagulable lymph is thrown in between two furfaces only contiguous, there it may be the exhaling veffels of thofe furfaces which now become the veffels of the part. In whatever way they meet in the centre, they inftantly embrace, unite, or inofculate: now this is all perfectly, and eafily conceived, among living parts, but not otherwife.

As the coagulum, whether wholly blood, or coagulating lymph alone, has the materia vitæ in its compofition, which is the caufe of all the above actions, it foon opens a communication with the mind, forming within itfelf, nerves. Nerves have not the power of forming themfelves into longer chords, as we conceive veffels to have; for we know, that in the union of a cut nerve, where a piece has been taken out, it is by means of the blood forming a union of coagulum; and, that the coagulum gradually becomes more and more of the texture, and has, of courfe, more and more the ufe of a nerve, fomewhat fimilar to the gradual change of blood into a bone, in fractures.

It would appear then, that the blood is fubfervient to two purpofes in an animal: the one is the fupport of the matter of the body when formed; the other is the fupport of the different actions of the body.

VII. SOME UNCONNECTED EXPERIMENTS RESPECTING THE BLOOD.

THE following experiments have rather been imagined than fully executed, and the fubject is rather broached and touched upon than profecuted; but as I have not time, at prefent, to go through with the experiments, fo as to arrive at fome general refult, I thought it better to bring forward, what, in my opinion, fhould be done, than to omit the fubject altogether*.

I wifhed to fee if blood that coagulated with an inflammatory cruft putrified later than that which coagulated without it; for I conceived that the ftrength of coagulation was fomething fimilar to the ftrength of contraction in a muf-

* Many of thefe experiments were repeated, by my defire, by Dr. Phyfic, now of Philadelphia, when he acted as houfe-furgeon at St. George's Hofpital, whofe accuracy I could depend upon.

U

cle refifting putrifaction. For this purpofe I ordered the following experiments to be made:

Experiment I. Four ounces of blood were taken from the arm, which, after coagulation, had the inflammatory cruft upon its furface, and was alfo cupped.

Experiment II. On the fame day, four ounces of blood were taken from another perfon's arm, which, on coagulating, fhewed no inflammatory cruft on its furface. Both thefe quantities of blood were kept, in order to fee which would refift putrifaction longeft.

By the fourth day, that without buff was putrified; but the blood with the inflammatory cruft did not putrify till the feventh day.

In thefe two experiments it would appear that the inflammatory blood preferved its fweetnefs longeft; but, from a repetition of thefe experiments, it did not appear upon the whole that there was much difference.

To fee whether the blood in a young perfon or an old one become fooneft putrid, I defired that the following trials fhould be made:

June 24t. Some blood was taken from a woman of twenty years of age, and its furface, after coagulation, was covered with an inflammatory cruft.

On the fame day, fome blood was taken from a woman, aged fixty, when the craffamentum was alfo covered with an inflammatory cruft.

Thefe quantities of blood were fet by.

The blood from the old woman putrified in two days. That from the young woman kept quite fweet till the fifth day, when it began to fmell difagreeably; in this ftate it continued two days more, and then emitted the common odour of putrid blood.

Several experiments were made in the courfe of the fummer, of a fimil r nature with the laft, in all which it appeared that the blood from young people, kept longer fweet than that which was taken from the old.

Experiment III. In October, 1790, when the weather was cold, fome blood was taken from two men, one of whom was feventy-five years of age, and the other eighty-three, about fix ounces from each. The blood in each kept fweet till the fifth day; but, on the fixth, both quantities fmelt equally putrid, which uniformly accords with the above experiment.

To see if recent blood or coagulated blood lost their heat soonest.

Experiment IV. Four ounces of blood, after coagulation, was heated till it raised the mercury of a thermometer, placed in the middle of the coagulum to the 98th degree. The thermometer was put into a similar quantity of blood, immediately after it was taken from the vein, and the mercury stood at 90°. These were placed by each other, and the thermometer put alternately into each, to observe how they parted with their heat.

Coagulated blood............98°	Recent blood............. 90°
Do. after two minutes....97°	Do. after two minutes..89°
Do. after four do. more...93°	Do. after four do. more88°
Do. after two do. more...92°	Do. after two do. more coagulated...............87°
Do. after two do. more...91°	Do. after two do. more86°

This experiment was not accurately made, for the two bloods should have been of the same temperature, because the warmer any body is, the faster it will lose its heat to any neighbouring colder body; yet I believe that the coagulated blood lost its heat faster than the fluid blood.

To see whether a stimulus can be applied to the blood, so as to make it coagulate faster than it does naturally, I desired the following experiment to be made:

Three ounces of blood were taken from a boy about ten years of age, and immediately after, the cup was put into water heated to 150°. A similar quantity was taken in another cup from the same boy, at the same time, which was put into water heated only to 48°. The first coagulated completely in five minutes, but the latter remained quite fluid for twenty minutes, and then began to coagulate, but was not completely coagulated for five minutes more. When looking at each portion of blood an hour afterwards, it appeared that the blood which coagulated in the warmest water, had the greatest proportion of serum, and the least of crassamentum; but by next morning, the serum in each was equal in quantity, and the crassamentum of equal size.

This experiment shews that heat above the natural standard, acts as a stimulus upon the blood, and makes it coagulate confiderably fooner than cold does, though not more firmly. This heat did not act as heat upon the blood, but only as the ftimulus; for heat acting as heat would alfo have coagulated the ferum, which was not the cafe.

This experiment, or a fimilar one, is brought forward as one of the proofs of the living principles of the blood, where it is contrafted with a fimilar experiment on living mufcles.

To fee whether blood, when mixed with different fubftances in ftrong folution, and which appeared to prevent coagulation, would, when diluted with water, admit of coagulation.

In December, half an ounce of blood, immediately after it was taken from the arm, was mixed with one pound of water. This was intended as a ftandard to judge of the others.

More blood was taken from the fame perfon at the fame time, to which a ftrong folution of Glauber's falts was added; this altered its colour to a florid red, and was found to prevent it from coagulating. A ftrong folution of Glauber's falts, therefore, has the power of preventing the coagulation of the blood. Ten minutes after this mixture, half an ounce of it was mixed with one pound of water; half an hour after, another half ounce was mixed with one pound of water; at the end of an hour, the fame was done, and alfo after two hours; all thefe were allowed to ftand twenty-four hours, when the pure blood and water had depofited a confiderable dark coloured fediment, and a light coloured blood was fufpended, which had begun to fubfide, leaving the fluid above perfectly tranfparent, and of a beautiful red colour. The different portions of blood which had been firft mixed with the falt, and afterwards with water, had the cloud exactly like that of the pure blood, but there was no fediment whatever at the bottom of the veffel: this cloud gradually fubfided, and left the fluid above of a beautiful red colour, and alfo quite tranfparent. At this time, (viz. twenty-four hours after the mixture of the falt with the blood) another half ounce was mixed with one pound of water, and next day the appearances were exactly fimilar to what have been already defcribed.

The fediment in the pure blood was moft probably the coagulating lymph; and as there was none in the others, it is moſt likely that the lymph in them did not now coagulate.

As medicines, when taken into the circulation, whether by the ſtomach or by the ſkin, produce conſiderable effects on the conſtitution, I wiſhed to know what effect ſuch ſubſtances would have upon the blood, with regard to the act and power of its coagulation.

Two ounces of blood were received from the arm into a veſſel, as a ſtandard of natural coagulation.

Two ounces more were taken in another veſſel, to which one ounce of water was added. The intention of this addition was to put this blood in the ſame circumſtances with blood in other comparative trials, reſpecting water, ſo that the difference, if there was any, muſt belong to the ſubſtance mixed with the blood, independent of the water.

Two ounces more blood were received in another veſſel, to which was added one ounce of the decoction of bark.

Theſe different quantities were taken from one perſon, one after the other in the ſame order in which they are here ſet down. After ſix minutes, the blood mixed with water was quite coagulated: after nine minutes, that mixed with the decoction of Peruvian-bark formed a looſe coagulum: after twelve minutes, the blood firſt drawn coagulated; the coagula of the firſt and ſecond drawn blood were equally firm; the water in the ſecond having been ſqueezed out along with the ſerum; but that mixed with the decoction of bark was much leſs ſo. It appears from theſe experiments, that water rather haſtened coagulation, but made it neither firmer or looſer in the texture.

In the following experiments, the blood was firſt all received into one veſſel, and ſtirred before it was mixed with the different ſubſtances.

The intention of this was, that the three portions of blood might all be exactly under the ſame circumſtances.

Two ounces were poured into a veſſel as a ſtandard of natural coagulation.

Two ounces more of blood were poured into another veſſel, to which was added two ounces of water, as in the former experiment. Two ounces more were mixed with two ounces of the decoction of bark: after twelve minutes the two firſt were coagulated, and the coagula were equally firm: after fourteen minutes, that with the decoction of bark coagulated, but the coagulum was very looſe. Upon comparing the three coagula next day, that which had the decoction of bark mixed with it, was by much the leaſt firm.

This experiment was repeated, and the reſult was nearly the ſame; and it ſhews, that even putting equal parts of water and blood together, did not alter the time, or the firmneſs of coagulation; but that the decoction of bark evidently did.

Some blood was taken from the arm into a baſon, ſtirred, and then mixed with different infuſions, as follows:

Two ounces were mixed with the ſame quantity of the infuſion of columba-root.

Two ounces, with the ſame quantity of the infuſion of gentian; two more, with two ounces of the watery ſolution of opium; and two ounces were kept in a veſſel by themſelves.

The blood which had been mixed with the bitter infuſions, and the ſimple blood, all coagulated at the ſame time, viz. in ſix minutes; but that which had been mixed with the infuſion of gentian was firmer than with the infuſion of columba-root, but was not more firm than the coagulum of the ſimple blood. The blood which had been mixed with the ſolution of opium did not coagulate for twelve minutes, and then the coagulum was very looſe.

This experiment, with the opium, was repeated, and the reſult was exactly the ſame.

Of extraneous matter in the blood.

Whatever is diſſolved in the blood muſt be only diffuſed through it, not chemically combined with it, otherwiſe the nature of the blood itſelf would be altered, and the effect of medicine deſtroyed. The blood can receive and retain extraneous matter, capable of deſtroying the ſolids, by ſtimulating to action ſo as to deſtroy them.

Extraneous matter in the blood is capable of altering the chemical properties of the ſolids, in thoſe who work in lead, as is evident in the following caſe:

Morgan, a houſe-painter, who had been paralytic in his hands and legs for a conſiderable time, was thrown down, and had his thigh-bone broken juſt below the little trochanter. The upper end of the inferior portion had paſſed over the outſide of the other, and moved with the knee, ſo that the end of the lower bone was taken for the great trochanter; but I diſcovered the fracture, by extending the leg, and got the portions of bone in their places, and bound up the limb with a wroller. It went on well for near a fortnight, only his hands ſwelling at times, which gave way to fomentations; in the third week he grew very ill, became low, had a kind of lethargy, a great deal of blood came out of his mouth, he ſunk ſtill lower, and died about three weeks after the accident.

On examining the body after death, the muſcles, particularly thoſe of the arms, had loſt their natural colour; but inſtead of being ligamentous and ſemitranſparent, as happens in common paralyſis, they were opaque, reſembling exactly, in appearance, parts ſteeped in a ſolution of Goulard's extract. From this caſe it appears the lead had been evidently carried along with the blood, even into the muſcles themſelves.

CHAPTER II.

OF THE VASCULAR SYSTEM.

I. GENERAL OBSERVATIONS ON MUSCULAR CONTRACTION AND ELASTICITY.

IT is not my prefent intention to explain all the circumftances connected with mufcular contraction and relaxation, nor that other power of action introduced into an animal body, called elafticity. I propofe only to ftate a few of the facts which throw fome light upon the vafcular fyftem, by fhewing that there is in veffels a power of mufcular action; and that the co-operation of elafticity is alfo neceffary to their function; thefe may likewife affift in explaining the manner in which the two powers are combined; I may, however, occafionally be led to mention caufes and effects, which cannot be immediately confidered as applicable to the veffels themfelves, though they will render many of the phenomena in the vafcular fyftem more eafy to be underftood.

The common action of a mufcle, from which its immediate ufe is derived, is its contraction; and the effect produced by it, is that of bringing the origin and infertion, or the parts which it is fitted, to move nearer each other*; which is univerfally the cafe whether the mufcle is ftraight, hollow, or circular. It is likewife neceffary that a mufcle fhould relax, or be capable of relaxation; a condition which allows it to be ftretched, by permitting the parts acted upon to recede from each other. Mufcles, in common, probably, with every other part of the body, have a power of

* I do not here confider the circumflex tendons; for, by the origin and infection, I mean the mufcular ends of the fibres.

adapting themselves to the necessary distance between origin and insertion, in case an alteration has taken place in the natural distance; and I have reason to believe, that under certain circumstances, they have a power of becoming longer, almost immediately, than they are in the natural relaxed, or even the natural elongated state of their fibres. This opinion will be best illustrated in inflammation.

Muscular contraction has been generally supposed to arise from some impression, which is commonly called, a stimulus; I doubt, however, of an impression being always necessary; and I believe that in many cases the cessation of an accustomed impulse may become the cause of contraction in a muscle. The sphincter iridis of the eye contracts when there is too much light; but the radii contract when there is little or no light. I can even conceive that a cessation of action requires its stimulus to produce it, which may be called, the stimulus of cessation; for relaxation is not the state into which a muscle will naturally fall upon the removal of a continued stimulus; a muscle remaining contracted after absolute death, when the stimulus of relaxation cannot be applied; so that a muscle can as little relax after death, as it can contract. If a stone is raised, and the raising power removed, it falls; but it would not fall if not acted upon. When it has fallen it lies at rest, but so it would have done, when raised, if gravitation would have allowed it. The stone is passive and must be acted upon. Whatever becomes a stimulus to one set of muscles, becomes a cause of relaxation to those which act in a contrary direction*; and whatever becomes a stimulus to one part of a muscular canal, where a succession of actions is to take place, becomes also a cause of relaxation in the part beyond it, as in an intestine.

Muscular contraction, in some of the involuntary muscles, does not constantly arise from immediate stimuli, as in the sphincters; for the sphincter ani contracts whenever the stimulus of relaxation is removed, which may be said to produce the stimulus for contraction.

Muscular actions have been divided into the voluntary, involuntary, and mixed, which is only dividing them ac-

* This might be called a sympathetic stimulus, and is that which regulates the actions of the whole machine; and which I have called, in another place the stimulus of necessity.

cording to the different natural modes of stimuli, or causes of their action: to these a fourth might be added, where the actions are in consequence of accidental stimuli or impressions, to which both the voluntary and involuntary muscles are subject, viz. such as arise from affections of the mind*, or are the immediate effects of violence.

The involuntary contraction should be first considered, as the more necessary operations of the machine are carried on by it; for the machine could even exist independent of any voluntary contraction; but it could not go on if left wholly to the voluntary contraction of the muscles, unless we were endued with innate ideas capable of producing a will. This involuntary contraction is very extensive in the system, and is employed in carrying on a number of operations, of which the circulation is one; and which may said to be, in a great measure, the œconomy of the animal within itself.

The mixed kind of contraction is most to our present purpose, and is of two kinds, though it has been in general supposed to be of one kind only, and that belonging solely to the muscles of respiration, as being in them the most conspicuous. But in fact, we find another mode of involuntary actions in other muscles of the body where it answers very useful purposes. In these the involuntary contraction may be reckoned the natural state; and it is a kind of permanent contraction, these muscles only relaxing occasionally; by which means parts are sustained or supported; the voluntary contraction of such muscles is also only occasional. All sphincter muscles in some degree partake of this power, and therefore should be called, muscles with power of occasional relaxation. For although many circular muscles may not have these mixed contractions, as the orbicularis palpebrarum; yet that muscle has a disposition to contract peculiar to itself. Its relaxation is to be reckoned of the active kind, which may be called, the relaxation of watchfulness, and it is when tired of this species of action that it contracts; which, on the contrary, may be called, the contraction of sleep: or it may be considered as an elongator muscle to the levator palpebræ, with a disposition to remain relaxed while that muscle is contracted; but contracting when the elevator is tired. The na-

* Mind and Will are often blended together, but Will has nothing to do here.

tural contraction of the orbicularis muſcle is involuntary; the relaxation, both natural and occaſional is involuntary; but it has likewiſe a voluntary contraction and relaxation, which can be made to exceed the involuntary, reſembling what is inherent in all the ſphincters.

Sphincter muſcles, as thoſe of the anus and urethra, and probably the expulſatores, ſeminis, and crura of the diaphragm, have both a voluntary and involuntary contraction. In the two ſphincters of the anus and urethra this is evident; and the involuntary contraction in theſe muſcles I have called, ſphinctoric. The ſphincter ani poſſeſſes it to a degree juſt ſufficient to reſiſt the preſſure of the air and fœces, while the parts above are inactive, preventing the eſcape of theſe, till they give the ſtimulus for expulſion, and then an involuntary relaxation naturally takes place, ſimilar to what happens in muſcular canals.

The ſphinctoric contraction reſembles, in its effects, that produced by elaſtic ligaments in other parts of the body, which action may be called, contractile elaſticity, as bringing back the parts to a certain neceſſary ſtate, and retaining them there. But elaſticity would not here have anſwered all the purpoſes, ſince, as it has no relaxing power, more force would have been required to overcome its reſiſtence in the expulſion of the fœces than the gut above could have been able to exert. But the ſuſtaining power being muſcular contraction, a relaxation or ceſſation of that contraction during the time of expulſion, leaves nothing for the fœces to do; but, by means of the action above, ſimply to dilate the relaxed parts. There is, likewiſe, in theſe muſcles, a ſtill further power of contraction, which is produced by the will, and for the purpoſe of giving on particular occaſions greater force than what is commonly neceſſary. The voluntary action of theſe muſcles is, therefore, we find more powerful than the involuntary; but upon the whole I think we have reaſon to ſuppoſe, that the involuntary muſcles are much ſtronger than the voluntary. Can we believe that ſo thin a muſcle as the colon of a horſe could ſqueeze out its contents, conſiſting of a column of dung about eight inches diameter, if thoſe involuntary muſcles had no more ſtrength than the muſcles of an extremity? When we ſee the bladder of urine throwing out its contents through a large tube, to a diſtance perhaps two yards beyond its extreme end, we muſt ſuppoſe a much greater force exerted than could belong to any ſuch quantity of voluntary muſcle. For I believe that by graſping the bladder with both hands we could not make the water flow out to an equal diſtance. It may be here obſerved, that the power of involuntary contraction commonly remains longer than that of the voluntary, though I believe not in all inſtances; which difference produces a greater variety in the former, than in the latter. Thus the muſcular action of the arteries is longer retained than that of the heart.

Elaſticity is a property of matter (whether animal or not) which renders it capable of reſtoring itſelf to its natural poſition, after having been acted upon by ſome mechanical power, but having no power of action ariſing out of itſelf; this is exactly the reverſe of muſcular contraction. Muſcles, as has been already obſerved, have the power of contraction and of ceſſation, which laſt is called, relaxation; but not the power of elongation, which would be an act of reſtoration, ſuch as exiſts in elaſticity. A muſcle, therefore, has the power of action within itſelf, by which it produces its effects, but is obliged to other powers for its reſtoration, ſo as to be able to act again; whereas elaſticity is obliged to other powers to alter the poſition of the parts, ſo as to require recovery or reſtoration; but this it is capable of doing itſelf, and by this power it produces its effects, becoming a cauſe of motion in other bodies. A body poſſeſſed of this property, when brought from the ſtate of reſt, is always endeavouring to arrive at this ſtate, which it alſo endeavours to preſerve; and it is capable of ſupporting itſelf in this ſtate in proportion to the degree of elaſticity which may belong to it.

The action of elaſticity is continual, and its immediate effects are produced whenever the reſiſtance is removed; by which it may be diſtinguiſhed from other powers. Elaſtic matter can neither be extended beyond its ſtate of reſt, or brought within it. Thus a ſpring being bent, its concave ſide is brought within this ſtate, and the convex ſide is carried beyond it: when under theſe circumſtances it is left to itſelf, both ſides endeavour to reſtore themſelves. The power of an elaſtic body is permanent, always acting with a force proportioned to the power applied, and therefore reacts as the body is elongated, bent, or compreſſed; but this is very different from the action of a muſcle, as this laſt may act with its full force, or only part, or not at all, according to circumftances. Elafticity*, which has the power of refifting the action of other parts, as well as of reftoring the fubftance endowed with it, when forcibly removed from a ftate of reft, is introduced into an animal body, in order to co-operate in many refpects with the mufcles, and fo to act as to reftore or fit them for a new action, becoming in many cafes antagonifts to the mufcles, which will be defcribed when we fpeak of the combination of the two.

II. GENERAL OBSERVATIONS ON THE ELONGATION OF RELAXED MUSCLES.

EVERY thing in nature that has the power of action has two kinds of motion exerted alternately, and a ftate of reft. Of the former the one may be called, the active; the other, the ftate of recovery. In a mufcle the active is the ftate of contraction; the other, the ftate of relaxation: the ftate of reft is merely the ftate of inaction. The contractile ftate of a mufcle, as well as the relaxed, arifes from a power inherent in itfelf: but the recovery, or elongation, muft depend on fome other power.

Simple relaxation of a contracted mufcle is not fufficient to enable it to produce another requifite effect; it is, therefore, neceffary that there fhould be an elongator equal to the quantity of contraction intended to be produced: and as no mufcle has the power of extending itfelf into what I fhall call, the ftate of recovery, an elongater of fome kind or other is required, to enable every mufcle to produce its effect, by a renewal of contraction. This, although in fome refpects fimilar to the winding up of a clock, in others differs

* It is to be obferved, that elafticity in animals does not, like mufcular contraction, depend on life; an elaftic body poffeffing that quality as perfectly after death as before. Elafticity admits of two actions, a contraction, when the fubftance is extended beyond the natural ftate, and an extenfion, when it is compreffed within it; both thefe is poffeffed by the elaftic parts which compofe the vafcular fyftem; whereas, mufcles have but one action, or, at leaft, but one which can produce an immediate effect, and that is contraction.

materially from it. For the muſcle being capable of relaxing itſelf, there is no reſiſtence to overcome, except the vis inertiæ and friction of the matter to be removed; whereas in the clock, the power that winds it up muſt be greater than the ſpring or weight, to be capable of overcoming the gravity of the weight, or the elaſticity of the ſpring, together with the vis inertiæ.

The elongation of muſcles is not the immediate cauſe of their relaxation, but the effect of a contrary and neceſſary motion of the elongaters, by which they are recovered ſo as to be enabled to renew their action with effect.

The elongaters, or powers which enable muſcles to recover themſelves, are not always muſcular; for when ſimple elongation is required, is is effected by other means, as elaſticity, which is the caſe, in part, in the blood-veſſels; and ſometimes by motion in matter foreign to the body, yet propelled either by muſcles or elaſticity, as is alſo the caſe in blood-veſſels. The elongaters may be divided into three kinds, with their compounds.

The firſt kind is muſcular, and theſe may either act immediately, or they may act on ſome other ſubſtance, by which action that ſubſtance becomes the immediate cauſe of the elongation. Thoſe which act immediately, and become elongaters to other muſcles by their contraction are in turn elongated by the contraction of theſe very muſcles, to which they ſerved as elongaters; the two ſets thus becoming reciprocally elongaters to each other. This is the caſe with the greater part of the muſcles in the body, and in ſome muſcles, as the occipito, frontalis, two different portions are reciprocally elongaters; yet theſe may ſtrictly be conſidered as two muſcles; for although there is no interruption, in the tendon they move the ſame part in two oppoſite directions, like diſtinct antagoniſt muſcles.

Theſe reciprocal elongaters, by their mutual action on each other, bring out a middle ſtate between the extremes of contraction and elongation, which is the ſtate of eaſe, or tone, in both. This appears not to be ſo much required for the eaſe of the relaxed muſcle, as for that of the part moved; either extreme of motion leaving the muſcle in an uneaſy ſtate. We find, therefore, that as ſoon as any ſet of muſcles ceaſe to act, the elongaters which were ſtretched during their action, are ſtimulated either by this ceſſation, or by the uneaſy ſtate into which the parts moved have been put, they act to bring theſe parts into a ſtate the furtheſt removed from the extremes which were uneasy, and by which the stimulus arising from both is equally balanced.

This, however, can only happen in such parts of the body as are furnished with muscular elongaters; where these are wanting, the muscles of the part having but one office, their state of ease is that of simple relaxation, as they can have no middle state from the action of antagonists, but such are commonly muscular parts, or so constructed as not to be thrown into an uneasy position by the action of their muscles. I suppose, however, that an elongated state in a muscle is an uneasy state; a muscle, therefore, that is stretched, although in a relaxed state, is uneasy and will contract a certain length, to what is probably the middle state.

It is still necessary that such parts as are simply muscular, and having no antagonist muscles appropriated immediately for such purposes should have their muscles elongated; this is still performed by muscles, but in a secondary way; for instance, by a succession of actions in different parts, each performing the same effect, the last action becoming an antagonist to the succeeding.

The second mode of elongation takes place in all the muscles which assist in forming canals. In them the muscles, if once contracted, cannot be elongated, or the part dilated again; but by the contraction of some other part of the canal, propelling its contents into the relaxed part, and by that means serving as an elongater. This, in some instances, goes on in regular succession, as we know the dilatation of the fauces to be occasioned by the action of the mouth and tongue; that of the œsophagus, by the contraction of the fauces; of the stomach, by that of the œsophagus; the upper part of the intestines by the stomach, and so on; the successive contractions of the last dilated parts pushing on the contents, and in that manner becoming elongaters of the muscles next in succession of action. A first propelling power, such as a heart, could in these instances have had but little effect, and would even have been unnecessary; for as there must be a succession of contractions and dilatations, its power would soon have been lost. This mode of propelling substances through canals, as stated above, would probably have been too slow for the circulation in many animals; but I believe is very much the case in others.

The elongation of the muſcles of the bladder, from the diſtention of urine, becomes the means by which they are excited to recover themſelves ſo as to renew their action, and may be referred to the ſame general head.

The third kind is by means of elaſtic ſubſtances: which render the combined actions produced by muſcular contraction and elaſticity more complicated. Elaſticity we find to be introduced both as an aſſiſtant to the contraction of the muſcles, and as an antagoniſt or elongater; the natural poſition being that which is produced by the elaſticity. Thus we ſee elaſticity combined with muſcular action aſſiſting in the contraction of muſcles on one ſide, and likewiſe performing the office of elongaters or antagoniſts on the oppoſite, by bringing parts, which have been moved by muſcles, back into their natural poſition. Such parts too as have yielded to the action of ſome other power, as gravitation, are brought back into what may be called, a natural ſtate, and are retained there by elaſticity, till that power is again overcome by another, as in the necks of ſome animals. We may hence ſee that the application of thoſe powers is twofold; one, where the muſcles and elaſtic ſubſtances aſſiſt each other; the ſecond, where they are antagoniſts, the elaſtic being neither aſſiſted by the muſcular parts, nor the muſcular by the elaſtic: for many parts of the body are ſo conſtructed, as to admit of but one kind of muſcular action, the other action ariſing from elaſticity alone; it being neceſſary that ſuch parts ſhould have a determined or middle ſtate, though not intended as a ſtate of eaſe.

Of this kind are the blood-veſſels, trachea, bronchia, the ears of animals, etc. in which therefore elaſticity is introduced to procure that determined ſtate, and is chiefly employed where the middle ſtate is much limited. For it is to be obſerved, that the middle ſtate, when produced by muſcular action, has not commonly a determined point of reſt, but admits of conſiderable latitude between the two extremes; except in the ſphincters. Where it is produced by elaſticity, it is always more determined, provided the elaſticity has ſufficient power to overcome the natural or accidental reſiſtance; and where that is the caſe, we muſt ſuppoſe that a ſtate in ſome degree determined was neceſſary to ſuch parts. But where the elaſtic power is not ſufficient to overcome the natural, or accidental reſiſtance, then it is aſſiſted by the muſcular, which forms one of the compounds of the three modes of elongation; inſtances of which we have in many joints.

The relaxed ſtate of a muſcle would appear in general to be the moſt natural; but to this there are exceptions; a degree of contraction appearing natural to ſome muſcles.

The face, for inſtance, is a part where the action of the muſcles on one ſide influences the poſition of the parts on the other ſide; a circumſtance, perhaps, peculiar to the face; here, therefore, the muſcles bring and keep the ſkin in one poſition, till altered by an increaſed action in ſome other muſcle; and when this increaſed action ceaſes, the conſtant and natural contraction of the whole (ſimilar to that of the ſphincter) immediately takes place *.

Sphincter muſcles are the moſt remarkable inſtances of this, being always above three parts contracted †.

The conſtant and regular degree of contraction in thoſe ſphincter muſcles, ſerves the purpoſes of elaſticity, and may have ſuperior advantages; as we know that they have a power of relaxing when their elongaters act, which no elaſtic ſubſtance can have. Hence, we ſee, that where a continued action only is wanted, there is elaſticity: where an alternate action and relaxation, there is the action of muſcles; where only an occaſional relaxing power is required, there are muſcles under under certain reſtrictions; and where a conſtant power of contraction is neceſſary, but which is occaſionally to be overcome by muſcles, there are introduced both elaſticity and muſcular powers co-operating with each other in their actions.

Where conſtant action is not neceſſary, muſcles alone are employed, as in the greater number of moving parts in moſt animals; and where any poſition is required to be conſtant, and the motion only occaſional, from being ſeldom wanted, their elaſticity alone is employed for the purpoſe

* As a proof that this is muſcular contraction, and not elaſticity, we find that the face in a dead body does not keep its natural form, nor reſume it when loſt.

† The parts ſupplied with ſphincters, do not contract after being dilated in the dead body, which they certainly would do if the contraction in the living body had ariſen from elaſticity.

of constant position, and muscles for the occasional action*.

When a position is to be pretty constant yet elastic substances are not employed, we have muscles endowed with the power of constant contraction to a certain degree, but capable of either relaxation, or a greater contraction, as in the sphincters.

We find, therefore, that in many parts of an animal body fitted for motion, a tolerably constant position is necessary, at the same time that an occasional self-moving power is also wanted, to serve as a sort of auxiliary to the performance of the necessary action. For such occasional actions, muscles, assisted by elastic substances, are employed; the elastic power easing the muscles in the fixed position, and the muscular giving the increased occasional action; and in other parts of the body, where a more constant action was wanted, and could not be completely obtained by elasticity, there are to be found muscles endowed with the property of both permanent and occasional contraction.

The elastic power is very remarkable in such parts of an animal body as require a constant effort to support them elasticity being introduced to act against the power of gravitation, as in the necks of animals whose heads are held horizontally, or beyond the centre of gravity. This is effected by an elastic ligament, and is strikingly illustrated in the camel, whose neck is long. Between the vertebræ of the neck and backs of fowls, are placed elastic ligaments for the same purpose; the wings of birds and bats are also furnished with them, by which means they are retained close to the body when not used in flying. On the abdomen of most quadrupeds are likewise to be found elastic ligaments, especially on that of the elephant, which is a constant support to the parts in their horizontal position, and even the cellular membrane of the elephant has a degree of elasticity much above what is generally met with in cellular membranes. Hence there is less expence of muscu-

* Some bibalves (as the oyster) have a strong muscle passing between the shells for closing them occasionally; but for opening them no muscles are made use of, as this is performed by an elastic ligament in the joint of the two shells, which is squeezed, when shut, by the contraction of the muscle; and when the muscle ceases to contract, the elasticity of the ligament expands it, so that the shell is opened.

lar conntraction in ſuch parts. The thrachea and its branches are inſtances of theſe two powers; being compoſed of cartilages, muſcles, and membranes, the proportion of muſcular ſubſtance, however, is ſmall, the muſcles which act principally upon this part being thoſe of reſpiration; but the tendency of the action of the proper muſcles of the trachea is to compreſs and alter the ſize of the trachea; this is counteracted by the elaſticity of the cartilages, and membranes, exerting a conſtant and regular endeavour to keep it of one certain ſize.

The external ears of many animals furniſh us with another inſtance of the joint application of theſe two powers; for being chiefly compoſed of elaſtic cartilage, they retain a general uniformity of ſhape, although that is capable of being altered occaſionally by the action of the muſcles.

It is however to be obſerved, that in all caſes where theſe two powers are joined, the muſcular, as it can always act in oppoſition to the elaſtic, muſt be the ſtrongeſt and capable of being carried further than the other; it therefore muſt always be proportionably ſtronger than it otherwiſe need to have been.

Parts in which theſe two powers are employed, are capable of being in either three ſtates, the natural, the ſtretched, and the contracted; but in ſome parts the natural ſtate may coincide either with the ſtretched, or contracted, and conſequently ſuch parts are only capable of being in two ſtates. The natural ſtate is produced by the elaſtic power ſimply, the contracted is the effect of the muſcular power alone, and the ſtretched is produced either by ſome foreign force or body protruded, which may be effected by a muſcular power.

III. OF THE STRUCTURE OF ARTERIES.

THE arteries in an animal, as far as we can examine them, are endowed with the property of elaſticity, the uſe of which we perceive in the action of thoſe parts; and this power is at all times demonſtrable, while the muſcular has been by ſome overlooked, by others denied, and has only been aſſerted by others as appearing neceſſary by reaſoning from analogy.

The quantity of elaſticity in any artery, on which an experiment can be made, is eaſily aſcertained, as it only requires the application of an oppoſing force, to prove both its power and extent. But it will appear from experiment, that the power varies according to the diſtance from the heart, being greateſt at the heart; while probably the extent may be the ſame in every artery.

To endeavour to aſcertain the elaſticity of arteries, I made comparative experiments on the aorta and pulmonary artery. Having cut off a portion of about an inch in length from the aſcending aorta, at half an inch above the valves, and having ſlit it up, it meaſured, tranſverſely, two inches and three quarters, but when ſtretched to its full length, three inches and three quarters, having gained rather more than one third, and having required a force equal to the weight of one pound ten ounces to produce this effect. A ſimilar ſection was made of the pulmonary artery in the ſame ſubject, which meaſured two inches one half, tranſverſely; and when ſubjected to trial in the ſame manner, was ſtretched to three inches and an half, being rather more in proportion than the aorta; ſo that the pulmonary artery appears to have rather more elaſticity than the aorta. It is not impoſſible that this difference might ariſe from the aorta having loſt ſome of its elaſticity by uſe; for although I choſe for my experiment the arteries of a young man, where I conceived them to be perfectly ſound, yet if there could have been any diminution of the elaſticity from uſe, it would be moſt conſiderable in the aorta.

Theſe experiments were made on different arteries with nearly the ſame reſult, and ſeemed to prove that there was almoſt the ſame extent of elaſticity, though not the ſame powers.

An artery being compoſed of an elaſtic and inelaſtic ſubſtance, its elaſticity is not altogether ſimilar to that of a body which is wholly elaſtic. There is an effect produced from ſtretching it that is expreſſive of the nature of both theſe ſubſtances, till it gives way or breaks; for an artery has a check to its yielding to ſo great a degree, and is ſtopt at once, when ſtretched to a certain point*, which check is occaſioned probably by the muſcular, together with the internal inelaſtic coat.

To prove the muſcularity of an artery, it is only neceſſary to compare its action with that of elaſtic ſubſtances.

Action in an elaſtic body can only be produced by a mechanical power; but muſcles acting upon another principle, can act quickly or ſlowly, much or little, according to the ſtimulus applied; though all muſcles do not act alike in this reſpect.

If an artery is cut through or laid bare, it will be found that it contracts by degrees till the whole cavity is cloſed; but if it be allowed to remain in this contracted ſtate till after the death of the animal, and be then dilated beyond the ſtate of reſt of elaſtic ſubſtances, it will only contract to the degree of that ſtate; this it will do immediately, but the contraction will not be equal to that of which it was capable while alive.

The poſterior tibial artery of a dog being laid bare, and its ſize attended to, it was obſerved to be ſo much contracted in a ſhort time as almoſt to prevent the blood from paſſing through it, and when divided, the blood only oozed out from the orifice.

On laying bare the carotid and crural arteries, and obſerving what took place in them while the animal was allowed to bleed to death, theſe arteries very evidently became ſmaller and ſmaller.

When the various uſes of arteries is conſidered, ſuch as their forming different parts of the body out of the blood, their performing the different ſecretions, their allowing at one time the blood to paſs readily into the ſmaller branches, as in bluſhing, and at another preventing it altogether, as in paleneſs from fear; and if to theſe we add the power of producing a diſeaſed increaſe of any or every part of the body, we cannot but conclude that they are poſſeſſed of muſcular powers.

The influence of the heart in the body, like that of the ſun in the planetary ſyſtem, we know extends to every part;

* This gives a determined ſize to an artery.

all the parts of the vafcular fyftem being fupplied according to the neceffity it has, though every part is not equally endowed with power, or difpofition to make ufe of that power.

The arteries, upon the whole, may be faid to poffefs confiderable living powers, and to retain them for a long time. This is evident when we obferve what muft happen in tranfplanting a living part of one body with an intention that it fhould unite with another body and become a part of it: the part tranfplanted muft retain life till it can unite fo as to receive its nourifhment from that into which it has been inferted. It is however to be fuppofed, that in fuch fituations, life can be retained longer than in others, although it is well known that it is preferved in the vafcular fyftem, even when there is no colateral affiftance. I found in the uterus of a cow, which had been feparated from the animal above twenty-four hours, that after its having been injected and allowed to ftand another day, the larger veffels were become much more turgid than when I firft injected them, and that the fmaller arteries had contracted fo as to force the injection back into the larger. This contraction was fo obvious that it could not but be obferved at the time, which was forty-eight hours after the feparation from the body of the animal.

This fhews too the mufcular power of the fmaller arteries to be fuperior to that of the larger, and that it is probably continued longer after the feparation from the body; a property which the involuntary mufcles poffefs to a degree greater than the voluntary, in the former of which claffes the mufcular ftructure of the arteries is to be confidered.

To afcertain how long the living power exifted in an artery after feparation from the body, or, perhaps, to fpeak more properly, after that communication with the body was cut off, by which we have reafon to fuppofe life to be continued in a part, I made the following experiments, for which I chofe the umbilical arteries, becaufe I could confine the blood in them, and keep them diftended for any length of time. In a woman delivered on the Thurfday afternoon, the naval ftring was feparated from the fœtus; it was firft tied in two places and cut between, fo that the blood contained in the chord and placenta was confined in them.

The placenta came away full of blood; and on Friday morning, the day after, I tied a ſtring round the chord about an inch below the other ligature, that the blood might ſtill be confined in the placenta and remaining chord. Having cut off this piece, the blood immediately guſhed out, and by examining the cut ends of the chord, I attentively obſerved to what degree the ends of the arteries were open; and the blood having now all eſcaped from this portion, the veſſels were left to contract with the whole of their elaſtic power, the effect of which is immediate.

Saturday morning, the day after this laſt part of the experiment, having examined the mouths of the arteries, I found them cloſed up, ſo that the muſcular coat had contracted in the twenty-four hours to ſuch a degree as to cloſe entirely the area of the artery. That ſame morning I repeated the experiment of Friday, and on Sunday morning obſerved the reſult of this ſecond experiment to be ſimilar to that of the former.

On this morning, Sunday, I repeated this experiment the third time, and on Monday obſerved that the reſult had not been the ſame as before, the mouths of the arteries remaining open; which ſhewed that the artery was become dead.

There was but little alteration perceived in the orifices of the veins in all the experiments.

Theſe experiments ſhew that the veſſels of the chord have the power of contraction above two days after ſeparation from the body.

Having given a general idea of muſcular action, including muſcular relaxation, together with the union of the muſcular and elaſtic power in an animal, I ſhall now apply them to the arteries.

There are three ſtates in which an artery is found, viz. the natural previous ſtate, the ſtretched, and the contracted ſtate which may or may not be previous.

The natural previous ſtate is that to which the elaſtic power naturally brings a veſſel which has been ſtretched beyond or contracted within the extent which it held in a ſtate of reſt.

The ſtretched is that ſtate produced by the impulſe of the blood in conſequence of the contraction of the heart; from which it is again brought back to the natural ſtate by the elaſtic power, perhaps aſſiſted by the muſcular.

The contracted ſtate of an artery ariſes from the action of the muſcular power, and is again reſtored to the natural ſtate by the elaſtic. It has been ſhewn that certain muſcles have both a voluntary and involuntary contraction, and that in ſome of theſe the involuntary action having brought the part to a neceſſary poſition, ſupports it in that ſtate till it be either neceſſary for the muſcle to relax, or for the voluntary action to take place; inſtances of which I have given in the ſphincter muſcles.

I ſhall now endeavour to ſhew that the arteries have a middle ſtate; but that in them the power of bringing the coats into a certain poſition and ſuſtaining them in it, is not the effect of a muſcular but of an elaſtic power; and that the muſcular action, both in contraction and relaxation, is involuntary.

In parts endowed with conſiderable elaſtic powers, although not apparently muſcular, as many arteries, but which we yet know from other modes of information to be poſſeſſed of muſcular power, elaſticity is ſo combined as to produce a middle or natural ſtate, by acting to a certain degree only as an elongater of the muſcular part in ſome of its actions*.

These two powers, muſcular and elaſtic, are probably introduced into the vaſcular ſyſtem of all animals, the parts themſelves being compoſed of ſubſtances of this deſcription, together with a fine inner membrane, which I believe to be but little elaſtic, and this membrane is more apparent in the larger than in the ſmaller ramifications; although when we conſider the conſtruction and uſe of the arteries, we muſt at once ſee the neceſſity of their having theſe two powers; yet in the greateſt number it is impoſſible to give clear occular demonſtration of the exiſtence of diſtinct muſcular fibres. But ſtill, as arteries are evidently compoſed of two diſtinct ſubſtances, one of which is demonſtrably elaſtic, and we know them likewiſe to be certainly endowed with the power of contraction peculiar to a muſcle, it is reaſonable to ſuppoſe the other ſubſtance to be muſcular; I ſhall endeavour alſo to prove its exiſtence in ſuch veſſels, from their having a power of contraction in the action of death.

* We can hardly ſuppoſe that the muſcular coat of the artery aſſiſts the elaſtic in bringing it to the middle ſtate when already contracted within it.

As the human body is always alluded to in this account, I shall found my experiments and observations on such animals only as have a similar structure, as in other animals, as the turtle, alligator, &c. we can plainly discern muscular fibres, the insides of the arteries and veins being evidently fasciculated with them.

Every part of the vascular system is not equally furnished with muscular fibres; some parts being almost wholly composed of the elastic substance, such as the larger vessels, especially the arteries, in which, were they equally muscular with the smaller vessels, the existence of muscular fibres might be more easily proved. Neither does the elastic substance equally prevail in every part, for many, especially the smaller arteries, or what have been called, the capillary vessels, appear to be almost entirely muscular; at least I am led to think so by my observations and experiments on that subject. From these I have discovered that the larger arteries possess little muscular powers, but that as they recede from the heart towards the extremities, the muscular power is gradually increased, and the elastic diminished. Hence I imagine there may exist a size of vessels totally void of elasticity; but this I should conceive to be in the very extremities only. For it is to be observed, that every portion of an artery, of a considerable length, is capable of assuming the middle state, which state must be referred to the elastic power.

The greatest part of the arterial system evidently appears to be composed of two substances, which structure is most remarkable in the middle sized arteries, where the two substances are more equally divided, and where the size admits of a visible distinction of parts. The best method to see this is to cut the vessels either across or longitudinally, and to look upon the edges that have been cut.

If the aorta be treated in this way, we shall find that though it appears to be composed of one substance, yet towards the inner surface it is darker in colour, and of a structure which differs, although but in a small degree, from that of the outer surface.

If we proceed by this mode of investigation, following the course of the circulation, we shall find that the internal and external parts become evidently more distinguishable from each other: the internal part which is darker, but with a degree of transparency, begins almost insensibly in the larger veſſels, and increaſes proportionably in thickneſs, as the arteries divide, and of courſe become ſmaller, while the external, being of a white colour, is gradually diminiſhing, but in a greater degree, according to the diminution of ſize in the artery, and of the increaſed thickneſs of the other coat, ſo that the two do not bear the ſame proportion to each other in the ſmall arteries, as in the larger.

The diſproportion, however, between them appears greater than it really is, ſome deception ariſing from the greater muſcular power, poſſeſſed by the ſmaller arteries, in cönſequence of which the inner coat will be more contracted, and therefore ſeem thicker. This circumſtance alone makes the difference of thickneſs between the whole coats of a large artery, and thoſe of a ſmall one, appear leſs than it really is; accordingly we find the coats of the humeral artery in the horſe apparently thicker than the coats of the auxillary, the coats of the radial as thick as thoſe of the humeral, and the artery near the hoof as thick in its coats as any of the others. There is yet another circumſtance which alſo deſerves attention in comparing the two coats, namely, that in many places, but eſpecially at the ſurfaces of contact in the elaſtic and muſcular ſubſtances of the middle ſized arteries, the fibres of the muſcular and elaſtic are very much blended or intermixed. I mention this, becauſe otherwiſe we might be led to draw falſe concluſions, with regard to the comparative quantity of each ſubſtance; and, becauſe it explains by what means both theſe coats are made elaſtic.

The external coat, however, is more ſo than the internal, being compoſed almoſt entirely of elaſtic ſubſtance, while the internal has a mixture of muſcular with its elaſtic fibres. As there is, therefore, a difference in the elaſtic power of the two coats, there muſt be a difference in their powers of contraction after death; for inſtance, the external coat contracting more than the internal, and alſo, as there is a difference between the muſcular and elaſtic powers of contraction, the muſcular having the greateſt, there muſt have been a difference between the contracting powers of theſe two coats during life, but contrary to that which takes place after death.

In thoſe arteries, which are evidently compoſed of two diſtinct ſubſtances, eſpecially in the ſmaller, we may obſerve two very oppoſite appearances, according as the elastic or muscular coats have contracted most. In the one, when we make a transverse section, and look upon the cut end, we may observe that the inner surface has been thrown into rugæ, so as to fill up the whole cavity; and if such an artery be slit up longitudinally, so as to expose its inner surface, we shall find that inner surface forming wrinkles, which are principally longitudinal. If the finger is passed over that surface, it feels hard, while the external is soft; but if the artery be stretched, and allowed to recover itself by its elasticity, which is the only power it now has, it will be felt equally soft on both surfaces, and its coats will be found to have become thinner than before. On the contrary, I have observed in many of the smaller arteries, when the muscular contraction has been considerable, the external or elastic coat to be thrown into longitudinal inequalities, from not having an equal power of contraction with the muscular, an artery under such circumstances being to the touch as hard as a cord. But if the muscular contraction be destroyed by stretching, or passing something through the artery, then it becomes very soft and pliant, and the muscular coat having once been stretched, without having the power of contracting again, is thrown into irregularities by the action of the elastic.

The elastic coat of an artery is fibrous, and the direction of its fibres is principally transverse or circular; but where a branch is going off, or at the division of an artery into two, the direction of the fibres is very irregular. I cannot say that I have found any fibres which are to a great degree oblique or longitudinal, a circumstance that shews their simple elasticity to be equal to the intention or use, a transverse or circular direction of fibres not being the most advantageous for producing the greatest effect*. They are also elastic laterally, from the direction of their fibres, which property shortens the artery when elongated by the blood; and I believe the muscles have little share in this action; the whole of which tends to shew that the elastic power is equal to the task of producing, and really does produce the natural state of the artery. What the direction of the muscular fibres may be, I never could discover,

* This is a principle in mechanics so well known, that it need not here be explained; we find it happily introduced in the disposition of muscles in various parts of the body.

but should suppose them oblique, because the degree of contraction appears greater than a straight muscle could produce, in which light a circular muscle is to be considered, as its effects are in the direction of its fibres; for either the diameter or the circumference of the artery will decrease in the same proportion, but not the area, which will decrease in proportion to the square of the diameter.

We should naturally suppose that where the action of the heart is strong, elasticity is the best property to sustain its force; and that where the force and elasticity are well proportioned, no mischief can ensue. Where the force, therefore, of the heart is greatest there is a degree of elasticity, which yields with reluctance, and constantly endeavours to oppose and counteract that force.

From these active powers of an artery, together with a foreign power, viz. the blood acting upon them in a manner somewhat similar to the common action of fluids in canals, protruding their contents, we may perceive that there are three actions which take place, all of them, operating in concert with each other, and producing one ultimate effect.

As the filling of the cavity of an artery produces an extension of its coats in every direction, the arteries are endowed with the elastic power, which, by contracting in all directions, may bring the vessels back again to their natural state.

The action of the muscular power being principally in a transverse direction, tends, when the artery is extended, to lessen its diameter, and assist the elastic power; but as its quantity of contraction is superior to that of the elastic power, it does or may contract the artery within what the latter could effect. When the muscular action ceases, elasticity will be exerted to dilate the vessel and restore it to a middle state again, becoming the elongater or antagonist of the muscular coat, and by that means fitting it for a new action as described in other parts of the body. This will be most evident in the middle sized vessels; for in the smaller, the proportion of elastic substance is not so considerable, and therefore it will contribute less to the dilatation of the vessel, when the muscular coat relaxes. Yet we must suppose that no vessel, even to its very extremity, is ever entirely collapsed; but that it possesses an elastic power sufficient to give it a middle state. Although these differences do not in all cases bear the same proportion to the size of the artery, yet we must conclude there is in the arteries themſelves a certain regular proportion preſerved; and I am inclined to believe, that this is in ſome degree in an inverſe proportion to the decreaſe of ſize, preſuming at the ſame time that the muſcular power increaſes in the ſame proportion. A veſſel is ſtretched beyond its natural ſtate, firſt by the force of the heart, and in ſucceſſion by the firſt order of veſſels; then it is that the elaſtic power is exerted to contract the veſſel, and reſtore it to the natural ſize; and in the performance of this it will be more or leſs aſſiſted by the muſcular power, according to the ſize of the veſſels; leaſt in the larger, and moſt in the ſmaller veſſels, as was obſerved above.

There appears to be no muſcular power capable of contracting an artery in its length, the whole of that contraction being produced by the elaſticity. For in a tranſverſe ſection of an artery, made when the muſcles of the veſſel are in a contracted ſtate, it may always be obſerved, that the external or elaſtic coat, immediately contracts longitudinally, and leaves the internal or muſcular projecting; which would not be the caſe if there was a longitudinal muſcular contraction, equal to the elaſtic; and were not the quantity of muſcular contraction greater than the elaſtic there would be no occaſion for muſcles,

Another proof of this is, that if a piece of contracted artery be ſtretched tranſverſly, or have its area increaſed and be allowed to recover itſelf, it loſes a part of its length. To underſtand this it will be neceſſary to know that muſcular fibres, by contraction, become thicker, and in proportion correſponding with the degree of contraction in the muſcle.

The thickening in the muſcle of a horſe was found to be an increaſe of one fourth part of thickneſs to one third of a contraction*; from which it follows, that the more the muſcular fibres of any veſſel contract, the more the veſſel is lengthened; but deſtroy the muſcular contraction by dilating the artery, and the elaſtic power, which acts in all directions, will immediately take place and reſtore the veſſel to its proper ſize; which is a proof that the effect of the lateral ſwell, produced by the muſcular contraction, is greater than that of the longitudinal elaſticity of the artery.

* This calculation is not accurate; for in the experiments made to diſcover if the muſcle loſt of its ſize in the whole when contracted, I found it hardly did; therefore what it loſt in length, it muſt have acquired in thickneſs.

If we examine how much the veſſel has loſt of its length in this trial, we ſhall find it will amount to about one twelfth of the whole; a proof that the internal coat does not contract ſo much longitudinally by its muſcular power, as the external does by its elaſticity. By multiplying ſuch experiments we have further proofs that the power of muſcular contraction acts chiefly in a circular direction; for in a longitudinal ſection of an artery in its contracted ſtate, the internal coat does not project as in a tranſverſe ſection, both coats remaining equal, or rather indeed the elaſtic coat projects beyond the other, from the internal muſcular coat having contracted moſt. But if this ſection be ſtretched tranſverſely, the external coat then contracts and leaves the internal moſt projecting; becauſe the internal or muſcular has now no power of contraction. If the tranſverſe extention be repeated, and to a greater degree, the artery, when allowed to recover itſelf, will have its inſide turned outwards, as well as bent longitudinally, having the inſide of the artery on the outſide of the curve, and often bringing the two ends together; but this is eaſily accounted for, as by the tranſverſe extention of the artery its muſcular contraction is deſtroyed, it becomes pliant, and the only reſiſtance to the elaſtic power on this ſide being removed, it is allowed to exert itſelf to its utmoſt extent. In doing this it bends the ſection in a longitudinal direction, which alſo inclines us to believe, that the external part of the elaſtic coat, is the moſt elaſtic.

Theſe experiments not only prove that the muſcular power of an artery, acts chiefly in a tranſverſe direction; but alſo, that the elaſtic power exiſts almoſt entirely in the external coat, and therefore that the internal coat muſt be the ſeat of the muſcular power.

Experiments on the arteries of a horſe bled to death.

To aſcertain the muſcular power of contraction in the arteries, and determine the proportions which it bears to their elaſticity, I made the following experiments upon the aorta, iliac, axillary, carotid, crural, humeral, and radial arteries of a horſe.

In this animal the muſcles were all allowed equally to contract, and therefore we might reaſonably preſume that the veſſels (at leaſt ſuch of them as were furniſhed with muſcles) would alſo be contracted, the ſtimulus of death acting equally upon muſcles in every form, and every ſituation. The animal had alſo been bled to death, ſo that the veſſels had an additional ſtimulus to produce contraction in them; as we know that all veſſels in animals endeavour as much as poſſible to adapt themſelves to the quantity of fluid circulating through them.

As I ſuppoſed the larger arteries had leſs of this power than the ſmaller, and that perhaps in an inverſe proportion to their ſize, in order to aſcertain that fact, and alſo to contraſt the two powers, I made my firſt experiments upon the aorta and its neareſt branches; continuing them on the other branches as theſe became ſmaller and ſmaller.

The arteries were taken out of the body with great care, ſo as not in the leaſt to alter their texture, or ſtate of contraction.

The experiments were made in the following manner: I took ſhort ſections of the different arteries, ſlit them up in a longitudinal direction, and in that ſtate meaſured the breadth of each, by which means as I conceived, I could aſcertain their muſcular contraction; then taking the ſame ſections and ſtretching them tranſverſly, I meaſured them in that ſtate, which gave me the greateſt elongation their muſcular, and elaſtic powers were capable of. As by this extention I had entirely deſtroyed their muſcular contraction; whatever degree of contraction they exerted afterwards muſt, I believe, have been owing to elaſticity. Having allowed them to contract, I again meaſured them a third time in that ſtate, and thus aſcertained three different ſtates of veſſels, between which I could compare the difference either in the ſame or different ſections, ſo as from the reſult to deduce with ſome degree of certainty the extent of theſe powers in every ſize of veſſel. I ſay only with ſome degree of certainty; for I do not pretend to affirm that theſe experiments will always be exact; circumſtances often happening in the body which prevent the ſtimulus of death from taking place with equal effect in every part. I have accordingly ſeen in the ſame artery ſome parts wider than others, even when the more contracted parts were neareſt the heart, and this merely from a difference of action in the muſcular power; for when that was deſtroyed by ſtretching, the parts contracted equally in both.

Experiment I. A circular ſection of the aorta aſcendens when ſlit up and opened into a plane, meaſured five inches and a half; on being ſtretched, it lengthened to ten inches and a half; the ſtretching power being removed, it contracted again to six inches, which we must suppose to be the middle state of the vessel. Hence the vessel appeared to have gained by stretching half an inch in width or rather circmference, which may be attributed to the relaxation of its muscular fibres, whose contraction must have been equal to one-eleventh part; six inches being the natural size, or most contracted state of the elastic power.

Experiment II. A circular section of the aorta at the origin of the first intercostal artery, measuring four inches one-fourth, extended by stretching to seven inches and one-half; it contracted again to four inches and one half, and therefore gained one-seventeenth part.

Experiment III. A circular section of the aorta at the lower part of the thorax, on being stretched, and being allowed to contract again gained one-tenth part.

Experiment IV. A circular section of the iliac artery, measuring two inches, when stretched and allowed to contract again, measured two inches and four-twelfths, and therefore gained one-sixth.

Experiment V. A circular section of the axillery artery, measuring one inch, when stretched and contracted again, measured an inch and one-eight, therefore gained one-eighth.

Experiment VI. A circular section of the carotid artery, measuring six-twelfths of an inch, when stretched, measured sixteen-twelfths and one-half; and when contracted again, ten-twelfths; therefore had gained two-thirds.

Experiment VII. A circular section of the crural artery, measuring ten-twelfths, when contracted after being stretched, measured one inch and two-twelfths, therefore gained one-third.

Experiment VIII. The humeral artery, near the joint of the elbow, in a contracted state, was thicker in its coats than the axillary; the circumference of the artery in that state being seven twelfths and one-half; after being stretched and contracted again, it measured nine-twelfths, therefore gained one-seventh and one-half.

Experiment IX. A circular section of the radial artery being taken, was found so contracted as hardly to be at all pervious; and the coats, especially the inner, much thicker than even the humeral: when slit up it scarcely measured three-twelfths of an inch; when stretched, and allowed to contract again, six-twelfths; therefore gained three-twelfths of an inch, which was about the whole contraction of the artery.

To see how far this power of recovery in the same artery took place at different distances from the source of the circulation, I made the following experiments on the spermatic artery of a bull; and likewise, on the artery of the fore-leg and penis. The spermatic artery, near the aorta, when stretched longitudinally, recovered perfectly the former length; when stretched transversly, it likewise recovered perfectly. About the middle, when stretched transversly, it gained one-twelfth. Upon the testicle a portion separated; when stretched transversly gained one-fourth, which was its muscular power.

The humeral portion of the artery of the fore-leg, when stretched transversly, and also longitudinally, recovered entirely.

The artery of one hoof, or rather finger, when stretched transversly, gained one-twentieth, when stretched longitudinally it recovered perfectly; which one-twentieth was the muscular power.

The artery of the penis, when stretched longitudinally, or transversly, recovered itself perfectly. This artery is considerably more elastic longitudinally than the others, but not more transversly. This increased elasticity in the longitudinal direction may be intended to allow of the difference in the length of the penis at different times.

From these experiments we see that the power of recovery in a vessel is greater in proportion as it is nearer to the heart; but as it becomes more distant it lessens; which shews the decrease of the elastic, and the increase of the muscular power.

		stretched to	Recovered to	Had contracted by death
Aorta ascendens	$5\frac{6}{12}$ inch.	$10\frac{6}{12}$ inch.	6 inch.	$\frac{1}{11}$ part.
Aorta descendens at first intercostal,	$4\frac{1}{4}$	$7\frac{6}{12}$	$4\frac{6}{12}$	$\frac{1}{17}$
Aorta descendens at the lowest part,				$\frac{1}{10}$
Illiac artery	2		$2\frac{4}{12}$	$\frac{1}{6}$
Axillery	1		$1\frac{1}{8}$	$\frac{3}{8}$

Carotid	$\frac{6}{12}$	$1\frac{4}{12}\frac{1}{2}$	$\frac{10}{12}$	$\frac{1}{3}$
Crural	$\frac{10}{12}$		$1\frac{2}{12}$	$\frac{1}{8}$
Humeral	$\frac{7}{12}\frac{1}{2}$		$\frac{9}{12}$	$\frac{1}{7}\frac{1}{2}$
Radial	$\frac{3}{12}$		$\frac{6}{12}$	equal to the whole.

Experiments on the power of arteries to contract longitudinally.

To prove that arteries do not produce the same power of muscular contraction in a longitudinal, which they do in a transverse direction, the following experiments were made:

Experiment I. A longitudinal section of the aorta ascendens, measuring two inches, when stretched and allowed again to contract, measured the same length.

Experiment II. A longitudinal section of the aorta descendens at the lower part of the thorax, of a given length, after having been stretched, contracted exactly the same length.

Experiment III. Two inches of the same carotid artery used in the sixth experiment, when stretched longitudinally, recovered itself, so as not to be longer than before the experiment.

Experiment IV. A portion of that humeral artery used in the eighth of the former experiments was not altered in its original length, when it recovered itself after being stretched.

These experiments appear to be decisive, and prove that the muscular power acts chiefly in a transverse direction; yet it is to be observed that the elastic power of arteries is greater in a longitudinal than in a transverse direction. This appears to be intended to counteract the lengthening effect of the heart, as well as that arising from the action of the muscular coat; for the transverse contraction of that coat lengthens the artery, therefore stretches the elastic, which again contracts upon the diastole of the artery.

From the account we have given of those substances which compose an artery, we may perceive it has two powers, the one elastic and the other muscular. We see also that the larger arteries are principally endowed with the elastic power, and the smaller with the muscular, that the elastic is always gradually diminishing in the smaller, and the muscular increasing, till, at last, probably, the action of an artery is almost wholly muscular; yet I think it is not to be supposed but that some degree of clasticity is continued to the extremity of an artery; for the middle state cannot be procured without it; and I conceive the middle state to be essential to every part of an artery. Let us now apply those two powers of action; or, to speak more properly of re-action, with their different proportions in the different parts of the arterial system. From these we must suppose the elastic to be best fitted for sustaining a force applied to it, such as the motion of the blood given by the heart, and propelling it along the vessel: the muscular power, most probably, is required to assist in continuing that motion, the force of the heart being partly spent; but certainly was intended to dispose of the blood when arrived at its place of destination; for elasticity can neither assist in the one nor the other; it is still, however, of use through the whole to preserve the middle state. Elasticity it better adapted to sustain a force than muscular power; for an elastic body recovers itself again, whenever the stretching cause suspends its action; while muscles endeavour to adapt themselves to circumstances as they arise. This is verified by different sorts of engines whose pipes are made of different metals. A pipe made of lead will, for instance in time dilate and become useless*; whereas a pipe of iron will react on the fluid, if the force of the fluid be in proportion to the elastic power of the iron; but the lead having little or no elasticity whenever it is stretched, it will remain so, and every new force will stretch it more and more. We are therefore to suppose that the force of the heart is not capable of stretching the artery so much as to destroy its clasticity; or in other words, the force of the heart is not able to dilate the artery beyond the contracting power. As the motion of the blood is mechanical, elasticity is best adapted to take off the immediate force of the heart; and, as we go from the heart, this property become less necessary; because in this course, the influence of the heart is gradually lessened, by which means a more equal motion of the blood is immediately produced, and even in the first artery a continued stream is at all times obtained; although it is considerably increased by each contraction of the heart. Without this power the motion of the blood in the aorta

* This accounts for the size of aneurisms whose coats must have lost their elasticity before they could be dilated.

would have been similar to what it is in its passage out of the heart, and would have been nearly the same in every part of the arterial system.

For though the motion of the blood out of the heart be by interrupted jerks, yet the whole arterial tube being more or less elastic, the motion of the blood becomes gradually more uniform from this cause. Elasticity in arteries acts like a pair of double bellows; although their motion be alternate, the stream of air is continued; and if it were to pass through a long elastic pipe, resembling an artery, the current of air would be still more uniform. The advantage arising from elasticity in the arterial system, will be more complete in the young subject than in the old; for in the latter, the elasticity of the arteries being very considerably diminished, more especially in the larger trunks, where the force of the heart ought to be broken, the blood will be thrown into the second and third order of vessels with increased velocity. In the young, the current is slower, from the re-action of the elastic power during the relaxed state of the heart, whereas at the heart, the motion is equal to the contraction of the heart; and as the heart is probably twice the time relaxing that it is in contracting, from this cause alone we may suppose the whole is two thirds less in the smaller vessels. As elastic bodies, I have already observed, have a middle state, or state of rest, to which they return after having been dilated or contracted by any other power, and as they must always be acted upon before they can re-act, the use of elasticity in the arterial system will be very evident. It is by this means that the vessels are adapted to the different motions of the body, flexion and extention; so that one side of an artery contracts while the other is elongated; and the canal is always open for the reception of blood in the curved, stretched, or relaxed state.

The muscular power of an artery renders a smaller force of the heart sufficient for the purposes of circulation; for the heart need only act with such force as to carry the blood through the larger arteries, and then the muscular power of the arteries takes it up, and, as it were, removes the load of blood while the heart is dilating. In confirmation of this remark, it is observable in animals whose arteries are very muscular, that the heart is proportionably weaker, so that the muscular portion of the vessels becomes a second part to the heart, acting where the power of the heart begins to fail, and increasing in strength as that decreases in power. Besides this, it disposes of such part of the blood as is necessary for the animal œconomy, principally in growth, repair, and secretions. At the extreme ends of the arteries, therefore, we must suppose that their actions are varied from that of simply conveying blood, except those arteries which are continued into veins.

IV. OF THE VASA ARTERIARUM.

The arteries are furnished with both arteries and veins, although it cannot be said that they are to appearance very vascular. Their arteries come from neighbouring vessels, and not from the artery itself which they supply.

This we see in dissection; and I found by filling an artery, such as the carotid, with fine injection, that still the arteries of the artery were not injected. On laying the coats of arteries bare in the living body we can discern their vessels more evidently some little time after the exposure, for then they become vessels conveying red blood, as in a beginning inflammation, growing turgid, when the arteries may be easily discerned from the veins by the difference of colour of the blood in each: these observations will also generally apply to the corresponding veins.

Perhaps arteries afford the most striking instance of animal substance furnished with two powers existing in the same part, one to resist mechanical impulse, the other to produce action. The first of these powers is greatest where there is the most impulse to resist; therefore we find it particularly in the arteries, nearest to the heart, the better to support the force of that organ; but in these parts where gravitation is gradually increasing, the diminution of power in the artery is not in proportion to the diminution of the force of the heart.

In the veins, the allotment of strength is commonly the reverse; for as they have nothing mechanical to resist, but the effect of gravitation, their principal strength is at the extremities.

We are to suppose that the power of the heart, and the mechanical strength of the arteries, bear a just proportion to each other; and therefore by ascertaining the last we may give a tolerable good guess with respect to the other.

In this view, to determine the strength of the ventricles, so far as I was able, I made comparative trials of the strength of the aorta and pulmonary arteries in a healthy young man. I separated a circular section of each, and on being slit, they measured three inches and three-eights, their breadths being also equal. On trial I found the aorta being stretched to near five inches, broke with a weight of eight pounds. The pulmonary artery stretched to near five inches and a half, and then broke with four pounds, twelve ounces.

This experiment I have repeated, but with very different results, for in one experiment, although the aorta took one pound ten ounces to stretch it, while the pulmonary artery took only six ounces; yet to break this pulmonary artery required eleven pounds, three ounces, while the aorta broke with ten pounds, four ounces; but this difference I impute to the aorta having lost its elasticity, which is very apt to happen in that vessel.

There is nearly the same proportion of elasticity in both arteries; but the strength of the aorta in the first experiment appeared to be nearly double that of the pulmonary artery; while in the second it was less: yet we must suppose the result of the first experiment nearer the truth; for we seldom find the pulmonary artery diseased, while the aorta is seldom otherwise.

The mechanical strength of arteries is much greater in the trunk than in the branches; which is evident from accidents and from injections in dead bodies. For when we inject arteries with too much force, the first extravasation takes place in in the smaller vessels. This can only be proved by subtile injections, which do not become solid by cold; such injections keeping up an equal pressure throughout the arterial system; and the smaller arteries being found to give way first, viz. those of the muscles, pia-mater, and the cellular membrane; which contradicts Haller's theory of the relative strength of the coats of the vessels.

I am however inclined to suppose that they are even weaker in proportion to their size, viz. in proportion to the diminished force of the heart, or motion of the blood; but how far this is the case I will not venture to determine as mechanical strength is not so much wanted in the smaller arteries, as muscular; for the mechanical strength of muscles appear to be less than the power of their own contraction; experiments, therefore, made in the dead body upon parts whose uses arise from an action within themselves when active are not conclusive. The flexor policis longus, being one of the most detached muscles in the body respecting structure and use, has been selected for experiments on this subject, and is found to raise by its action a greater weight than it can sustain after death. This however is liable to fallacy, as the two experiments are made on different muscles, one certainly healthy, the other most probably weakened by the disease preceeding death.

The coats of arteries are not equally strong on all sides of the same artery; at the bending of a joint they are strongest on the convex side through the whole length of the curve; this is most evident in the permanent curves, such as in the great curvature of the aorta. Arteries are likewise strongest at the sharp angles made by a trunk and its branch, and at an angle formed by a trunk divided into two.

These parts have the blood as it were dashing against them. Those likewise are the parts which first lose their elasticity and soonest ossify, being generally more stretched than the other parts of an artery, and making a kind of bag. These circumstances are chiefly observable in the curvature of the aorta, that of the internal carotids, and the division of the aorta into the two iliacs.

V. OF THE HEART.

The heart is an organ which is the great agent in the motion of the blood, but is not essential to animals of every class, nor for the motion of the blood in every part where it is perfect; it is less so than the nerves, and many even possess the organs of generation, that have no heart. Its actions in health are regular and characteristic of that state; and in disease its actions are in some degree characteristic of the disease; but although there is that connection between the body and the heart, yet there seems not to be such a connection between the heart and the body; for the heart may be in some degree disordered in its action, yet the body but little affected; it is therefore only to be considered as a local agent very little affecting the constitution sympathetically, except by means of the failure in its duty. The heart in the more perfect animals is double, answerable to the two circulations, the one through the lungs, the other over the body; but many that have only single hearts have what is analagous to a double circulation; and this is performed in very different ways in different animals, so that one of the circulations in these is performed without a heart.

A large class of animals, well known and pretty perfect in their construction, namely, all the class of fish, have no heart for the motion of the blood in the great circulation, or that over the whole body, having only a heart for the lungs or branchea, while the snail has only a heart for the great circulation, and none for the lungs; as also in the liver of the most perfect animals, the motion of the blood, in the vana portarum, and vena cava hypatica, is carried on without a heart. The absorbing system in every animal has no immediate propelling power; therefore this propelling power is not universally necessary. The heart varies in its structure in different orders of animals, principally with respect to the number of cavities and their communications with each other, yet in all nearly the same purpose is answered. I shall here observe, that in the bird and quadruped there is a double circulation, which requires a double heart, namely, a heart for each circulation, each heart consisting of an auricle and ventricle, called the right and the left; and from their forming but one body among them, they are all included in one heart; the right side, or heart, may be called the pulmonary, and the left may be called the corporeal. In many classes of animals there is to be found only one of those hearts; and according to the class, it is either the pulmonary or corporeal. In the fish, as was observed, the heart is the pulmonary; and in the snail, the heart is the corporeal; so that the corporeal motion of the blood in the fish, is carried on without a heart; and in the snail the pulmonary motion is carried on without a heart; and in the winged insects which have but one heart, as also but one circulation, there is this heart, answering both purposes; and in all these varieties, breathing is the principal object.

The heart in most animals is composed principally of a strong muscle thrown into the form of a cavity or cavities; but it is not wholly muscular, being in part tendinous or ligamentous, which last parts have neither action nor reaction within themselves, but are only acted upon; they are therefore made inelastic and rigid to support the force of the acting parts in this action, without varying in themselves.

The heart is in all animals which have red blood, the reddest muscle in the body. Thus in the bird whose muscles are mostly white, the heart is red; we find it the same in the white fish.

As it differs in the different orders of animals respecting the number of cavities, it may admit of dispute what are to be reckoned truly hearts, and what only appendages; for some of its cavities may only be considered as reservoirs peculiar to some hearts.

The most simple form of heart is composed of one cavity only, and the most complicated has no more than two; it would seem indeed to increase progressively in the number of cavities from one to four, which includes the mixed; yet two of these belonging to the heart with four cavities, ought not to be called parts of the heart although they belong to it. The single cavity of the heart in the most simple class, or the two in the most complicated, are called ventricles. The other cavities belonging to it are called auricles, many of those which have one ventricle only have no auricle, such as insects; but there are others which have both a ventricle and auricle, such as fish, the snail, many shell fish; some of the last class have indeed two auricles with only one ventricle; which shows that the number of auricles is not fixed under the same mode of circulation; those animals which have two distinct ventricles, constituting four cavities, are what are called quadrupedes, or mammalia, and birds. If the auricles are considered as parts of the heart, we might class animals which have hearts according to the number of their cavities, viz. monocoilia, dicoilia, tricoilia, tetracoilia; the tricoilia is a mixture of the dicoilia and tetracoilia. This is the case in distinct classes of animals; but it takes place in other classes at different stages of life; for the fœtus of the class possesfing four cavities may be claffed with the mixed, having but one auricle, by the communication between the two and alfo one ventricle, by means of the union between the two arteries which produces an union of blood although not in the fame way. Thofe paffages however are fhut up almoft immediately after birth, or at leaft the canalis arteriofus*, which immediately prevents the foramen ovale from producing its former effects; therefore it is not fo neceffary it fhould be fhut up in the adult. I have feen it, to common appearance, as much open as in a fœtus.

The heart may be confidered as a truly mechanical engine; for although mufcles are the powers in an animal, yet thefe powers are themfelves often converted into a machine, of which the heart is a ftrong inftance; for from the difpofition of its mufcular fibres, tendons, ligaments and valves, it is adapted to mechanical purpofes; which make it a complete organ or machine in itfelf. It is moft probable that by means of this vifcus a quicker fupply of blood is furnifhed than otherwife could be effected.

In birds and quadrupedes the heart by its action firft throws out the blood, both that which is fit for the purpofes of life, and that which requires to be prepaired; the laft having loft thofe falutary powers in the growth, repairs, fecretion, etc. in the machine.

It may be faid to give the firft impulfe to the blood, producing a greater velocity where the blood is fimply conveyed to the parts for whofe ufe it is deftined. This velocity is alternately greater and lefs, and from the conftruction of the arteries alone is gradually diminifhed, becoming more uniform where flownefs and evenefs in motion is neceffary. This velocity of the blood in thofe parts where it is to be confidered as paffing only, allows a much larger quantity to flow through the part to which it is deftined than otherwife could be tranfmitted.

The heart is placed in the vafcular fyftem, to be ready to receive the blood from the body, and to propel it back on the body again, although not in the centre of the whole; but it is reafonable to fuppofe that its fituation is fuch as to be beft fuited to the various parts of the body; fome parts

* There have been inftances of the canalis arteriofus being open in the adult.

requiring a brisk, others a more languid circulation. Some also require a greater supply of blood than others.

We may suppose that the parts near the heart will receive more blood than those at a greater distance, because the resistance will be less if the vessels are of equal size in proportion to the size of the part. The situation of the heart in the body varies in different animals. One would imagine when the animal was divided into its several portions appropriated for the different purposes, that the situation of the heart would be nearly the same in all; but we find this not to be the case; its situation depends upon the organs of respiration, more than any other part. It is placed in what is called the chest in the quadruped, bird, amphibia, in fish, and in the aquatic and terrestrial insect; but not in what may be called the chest in the flying insect. The chest in the above named animals seems best suited to contain the lungs and branchia, and therefore the heart is placed there; but as the lungs of the flying insect are placed through the whole body, the heart is more diffused, extending through the whole length of the animal. The situation, therefore, of the heart is chiefly connected with that of the lungs; and when it is united with the body at large, it is because the lungs are also so disposed. We must suppose that these two have a relation to each other.

A heart is composed of an auricle and ventricle; and it is the ventricle which sends the blood through its course in the circulation; and from what has been said, it must appear that the ventricle is the true heart, the other parts having only secondary uses; and as the ventricle is the part which propels the blood to the different parts of the body, its muscular power must be adequate to that purpose, and therefore it has a very strong muscular coat. Much more pains than were necessary have been taken to dissect and describe the course and arrangement of the muscular fibres of the heart, as if the knowledge of the course of its fibres could in the least account for its action. But as the heart can, in its contracted state, almost throw out its whole contents, to produce this effect, its fibres must pass obliquely.

Its red colour arises probably from its being at the fountain head of the circulation: for those animals that have but little red blood have it only in those parts near the heart;

and the heart being neareſt to its own powers, receives the blood before the veſſels can ſo act as to diſpoſe of the red blood, or allow of a kind of ſeparation by diſtance; its conſtant action too renders it more red, as happens in other muſcles.

The ventricles in the quadruped, bird, and amphibia, are called right and left, and this accords very well with the ſituation in ſuch animals; but where there is only one ventricle, and that in ſome acting the part of right, as in fiſh, and in others acting the part of the left, as in the ſnail, we ought to have ſome term expreſſive of their immediate uſe, and ſuch as would apply to all animals that have ſuch a viſcus.

The auricles of the heart are to be conſidered only as reſervoirs for the blood to be ready to ſupply the ventricles; for an auricle is not to be found in all the animals which have a ventricle; nor does the number of auricles always correſpond to that of the ventricles. Where the veins entering into the heart are ſmall, in compariſon to the quantity of blood which is wanted in the ventricles, there we have an auricle; but where the veins near to the heart are large, there is no auricle; as in the lobſter, and generally in inſects. In the ſnail, where the veins in common are large, yet as they are ſmall where they enter the heart, there is an auricle; and as its office is ſomewhat ſimilar to a large vein, it has ſome of its properties, viz. being in ſome degree both elaſtic and muſcular.

The name ſinus venoſus is a very proper one; and as a proof that it is only ſuch in the circulation, there are no valves placed between it and the veins.

As the heart is an engine formed to keep up the motion of the blood, and as it is neceſſary that this motion ſhould be determined in a particular direction, it is adapted, as are alſo the other parts of the vaſcular ſyſtem, to this purpoſe.

The heart is formed into a cavity through which the blood muſt paſs, receiving at once a conſiderable quantity of this fluid, upon which it immediately acts with equal force, although not progreſſively, as an inteſtine; and that this motion of the blood may be regulated, and a retrograde motion prevented, we find the valves conſtructed.

A valve, I believe, is in general underſtood to be a part in every machine, calculated to allow whatever is to paſs to move in one direction only; and the valves in the vaſcular ſyſtem are intended for this purpoſe. They are of two kinds, having two modes of attachment, which is ſuited to the action of the part to which they are attached, and making a very eſſential difference in their formation.

They are thin inelaſtic membranes, having no action within themſelves, with one edge fixed, the other looſe in ſome, but not entirely ſo in others; they are either attached in a circular form, or in an oblique one. The circular attachment belongs to thoſe of the ventricles, and the oblique to thoſe of the arteries and veins. The circular are the moſt complex, requiring an additional apparatus to make them anſwer the intended purpoſe; it is neceſſary that their looſe floating edges ſhould be reſtrained from inverting themſelves into the auricle upon the contraction of the ventricles: this is done by tendons, which are fixed at one extremity along the edge of the valves, and at the other to ſome part upon the inſide of the ventricle.

The tendons which are longeſt are inſerted into columns of muſcle, the intention of which is very evident; for if they had gone the whole length in form of a tendon, they would have been too long when the heart contracted, and the valves in ſuch a caſe would have allowed of being puſhed into the auricles, ſo far as to admit of the blood eſcaping back again into the cavity; but the carniæ columnæ keep the valves within the ventricle, in the contracted ſtate of the ventricles; and the dilatation of the ventricles counteracts them and places the valve in their proper ſituation in that ſtate.

If the valves in this cavity had been placed obliquely along the inner ſides of the ventricle, as in the beginning of the arteries, and in the veins, the attachment then would not have been permanent; for it would have varied according to the relaxed or contracted ſtate of the heart; it would have been ſhort in the contracted ſtate, and longer in the relaxed; therefore to have a fixed baſe, it was neceſſary for them to be attached all round the mouth of the ventricles.

I have reaſon to believe, that the valves in the right ſide of the heart do not ſo perfectly do their duty as thoſe of the left, therefore we may ſuppoſe it was not ſo neceſſary.

The vessels of the heart are called coronary arteries and veins. In quadrupeds and birds, there are two coronary arteries, which arise from the aorta just at its beginning, behind two of the valves of the artery; from this circumstance a theory respecting the action of the heart was raised; but in the amphibia they arise at some distance, and not always from the same artery in the same species, often from the subclavian, and often from the anterior surface of the ascending aorta, which is reflected back. In the fish they arise from the artery as they are coming from the gills. The veins pass into the right auricle.

In all animals, which have an auricle and ventricle, so far as I know, there is a bag (unattached) in which they are placed, called a pericardium*, but the insect tribe, whether ærial, aquatic, or terrestial have none, their heart being attached to the surrounding parts by the cellular membrane, or some other mode of attachment. In those animals which have this bag, it is not a smooth termination of the cellular membrane, as the peritonæum may be supposed to be; but a distinct bag, as in man, and in all quadrupeds.

The use of this bag is probably that the heart may move with more ease and facility; the two parts, to wit, the contained and containing, acting as a kind of joint with a capsular ligament, and like such joints it contains a fluid, but not a synovia, as the two surfaces are not hard like cartilage; besides, the heart is kept very much in its place, which we must suppose is of use. I have conceived it also to be possible, as it is a pretty strong membrane, that it might in some degree preserve the heart from too great distention; for I have observed by injections, that a little force will distend it beyond its natural size, if a part of the pericardium be taken off; but in the heart mentioned by Dr. Baillie there was no particular increase of bulk.

This bag has, like most others, a fluid which moistens the two surfaces. In other cavity of the body the fluid is no more in quantity than what is simply sufficient to moisten

* There have been instances where the pericardium has been wanting in the human subject: a case of this kind is published by Dr. Baillie, in a periodical work, entitled, "Transactions "of a Society instituted for promoting medical and chirurgical "Knowledge."

the parts. In this bag, however, it is more, from whence it has acquired the name of liquor pericardii. There may be about a tea spoon-full in the whole. This fluid appears to be serum, and is commonly a little tinged with blood which arises from the transudation of the red blood after death.

That this cavity has more water in it than most other cavities of the body, may arise from their being a greater action of those parts on one another than takes place in others; it may also fill up the interstices formed between two round bodies, so that when the pulmonary artery and aorta are filled, they may more easily assume a round figure.

The size of a heart we should naturally suppose is proportioned to the size of the animal, and the natural quantity of blood; which last is, we might conceive, ever in proportion to the size of the animal; but I believe these modes of calculation will not be found to be just; for certainly some animals have much more blood in proportion to their size than others; and I believe the heart is not in size proportioned to the size of the animal, but bears a compound proportion or ratio to the quantity of blood, to be moved, and the frequency of the stroke it has to make; for when it is decreased in the one respect it must be increased in the other; and as a proof of this we find when an animal loses a considerable quantity of blood, the heart increases in its frequency of strokes, as also in its violence. That it principally bears proportion to the quantity of blood is evident; for the right ventricle is equal in size to the left, if not larger, which sends its blood to the lungs only, which are infinitely small when compared to the body; and the hearts of those animals which have but one ventricle, as fish for instance, which is similar in use to our right, are perhaps made as large in proportion to the size of the body as both ventricles in the quadruped.

The strength of a heart is commonly, if not always, in proportion to the size of the parts to which the blood is carried with the velocity with which the blood is propelled, which becomes a collateral proof that it is an universal agent in the circulation. In the complete heart this is not equal in every part of the same heart; the right ventricle being much weaker than the left, but still in the above proportions. The proportion between the two will be best known by ascertaining the difference in the strength of the two arteries, and this again will differ according to the whole parts the blood is sent to by the heart. In the fish, for instance, it is only necessary it should bear the proportion in strength to the whole fish, that our right ventricle bears to our lungs, which is not in the least equal to that of the left ventricle; or in other words, its strength should commensurate with the size of the lungs; however, it is most probable that the right ventricle in the quadruped is stronger than in this proportion, because it is obliged to move a larger quantity of blood than is contained in any other part of the body of the same size, and with greater velocity; in the double heart, therefore, such as the human, the two cavities are not of equal strength, each being nearly in proportion to the size of the parts, or rather to the distance the blood is to go; the right ventricle only throwing it into the lungs, the left into the body. As a proof of this doctrine, we find that in the fœtal state of this class of animals, the two ventricles and the two large arteries, are equal in strength. Indeed, from reasoning, we should expect this, and even that the right ventricle should rather be the strongest; for at this period it sends the blood to the lower extremities; but since both the arteries unite into one canal we must suppose it to be necessary that the velocities of the blood in both should be equal; upon examination we find the two ventricles to be nearly equal in thickness in this young state of the animal.

The mixt kind of heart, as that of the turtle, etc. is under the same predicament. The two ventricles are to be considered as joint agents in the circulation; and as the pulmonary artery and aorta are equally strong, it becomes a proof that the strength of the heart must be equal every where.

If we were to estimate the strength of the ventricles in those possessed of four cavities, by the strength of the aorta and pulmonary arteries, either by their absolute strength or elasticity, we might come pretty near the truth.

Dr. Hales made an experiment on a horse, to ascertain the strength of the arteries, which gives us the power of the left ventricle; but all this explains nothing, for its power is equal to the use wanted.

The power of contraction of the ventricle must be within the strength of the artery; but it is hardly possible to ascertain what is the strength of an artery, nor, if we could, would it ascertain the strength of the ventricle, for the force of the heart is in part immediately lost by the blood being allowed to pass on, although not so freely as if the artery was open at the other end; in proportion, therefore, to the retardment, the artery is affected. We can ascertain the elastic power of a given section of an artery, and also its absolute strength, but we are not unacquainted with the size of a section that will give the strength of the artery to which it belonged when the whole was in a perfect state or form.

Experiment I. A section of a sound aorta, close to the valves, three quarters of an inch long, was stretched transversely to its greatest extent, which state was ascertained by measuring it with a pair of compasses, and the artery was allowed to contract. The weight required to stretch it again to the same degree was one pound ten ounces. To break the artery required ten pounds and a quarter.

Experiment II. A section of the pulmonary artery, similar to the former in length and situation, required six ounces two drachms to stretch it to its full extent. To break it required eleven pounds three quarters.

The use of this viscus is in general very well known; however, its use has been frequently supposed to be more universal than it really is. It gives to the blood its motion in most animals, and in all it sends the blood to the organs of respiration: in the flying insect it sends the blood both to those organs and to the body at large; but in fish to those organs only, the body at large in them having no heart. In the amphibia there is an attempt towards a heart both for the lungs and body, but not two distinct hearts. In the bird and quadruped there is a distinct heart for each. We may say, therefore, that there is one heart for respiration, and another for the life, nourishment, etc. of the animal; these constitute the two ventricles.

As the extent of these two circulations is different, the two hearts, or in other words, the two ventricles, are suited in their strength to the different extents of each circulation, as was observed above in treating of the strength of the heart.

How far the heart is alone capable of carrying on the circulation is not to be ascertained; for although the circulation is carried on in paralytic cases, yet this does not exclude the involuntary nervous influence of the part; this, however, varies very much in different classes of animals; for I have already observed concerning the structure of the arteries, that their muscularity assisted in the circulation, and that in proportion as the vessels in general were endowed with this power the heart was weaker. I believe that the quadruped has the strongest heart of any class of animals; and I believe that their vessels have the least muscular power, more especially near the heart.

The immediate use of the heart in an animal, would seem to be generally subject to as little variety as that of any other viscus; but perhaps the heart is subject to more variety than any other part in its construction. I have observed that it is either single, double, or mixed, that it is single without an auricle, single with one auricle, single with two auricles, double with a union of the two, making the mixed, and double with two auricles. With respect to its use, it is, in the most simple kind of single heart, to propel the blood through the body, immediately from the veins, which blood is to receive its purification in this passage, when the lungs are disposed throughout the body, as in the flying insect. In another single heart it is intended to mix both the purified and the adulterated blood, and of course to throw it out to the body and lungs equally in this mixed state, as in the lobster. In the single heart, with an auricle, its use is, in one class, to throw the blood throughout the body, after being purified, as in the snail; and in another single kind, with an auricle, it is to receive the blood from the body, and send it to the lungs only, as in all fish. In the single heart with two auricles, it is formed to receive the blood both purified and unpurified, and dispose of it to both body and lungs in that state, as was observed in the lobster: the same thing happens, in some degree, in the turtle, snake, fœtus, etc. In the double heart with two auricles, it acts like an union of the heart of the snail with that of the fish, one heart receiving the blood purified from the lungs, and sending it over the body, as in the snail; and the other receiving the blood from the body, and sending it into the lungs to be purified, as in the fish. From the above account we must see that the immediate use arising from the heart in one class of animals will not agree with its immediate use in another; but still in all, it is the engine employed to throw the blood to those parts into which the arteries conduct it.

It is impossible to say what the quantity of blood is that is thrown out of the heart at each contraction. The size of a relaxed heart, in the dead body of any animal, gives us the size of the cavity, or what it is capable of holding; but muscles seldom or ever are obliged to relax themselves to their full extent in common actions, although they often are when extensive effects are to be produced. The heart, like every part constructed for action, has its times of action beyond, and also within its natural limit of action; but it is its natural action which should be ascertained.

If we compare the actions of the heart with those of the body, we may suppose that the common quantity of motion in the heart is about half what it can perform, that is, it relaxes three-fourths and contracts one-half; therefore a ventricle which contains four ounces, will, in common, only dilate so as to contain three, and will only contract so as to throw out two.

The question is, when the heart acts with more frequency, as from exercise, does it, or does it not also dilate and contract more fully, and also act with greater velocity in its contraction? I believe that all these circumstances take place; for in exercise, the pulse not only becomes more frequent, but fuller, as if more was thrown out of the heart; and the heart is found to make a greater emotion in the chest, striking with its apex against the inside of the chest with greater force *, which can only arise from a greater quantity being thrown out, and with greater velocity. The breathing corresponds with the quantity of blood and the velocity; for if a larger quantity passes through the

* The reason why the apex of the heart strikes against the chest in its actions, was, I believe, first accounted for by the late Dr. William Hunter, in his lectures, as far back as the year 1746. The systole and diastole of the heart, simply, could not produce such an effect; nor could it have been produced, if it had thrown the blood into a straight tube, in the direction of the axis in the left ventricle, as is the case with the ventricles of fish, and some other classes of animals; but by its throwing the blood into a curved tube, viz, the aorta. that artery at its curve endeavours to throw itself into a straight line to increase its capacity; but the aorta being the fixed point against the back, and the heart in some degree loose or pendulous, the influence of its own action is thrown upon itself, and it is tilted forwards against the inside of the chest.

lungs in a given time, the breathing must be in the same proportion increased; if with a greater velocity, the same thing must necessarily take place; and if a greater quantity is thrown out, and with a greater velocity, then the arteries must relax in proportion, since the different parts must correspond with each other; we must suppose, therefore, that in health, whenever there is any exertion greater than common, (which always increases the pulse) the heart dilates more, contracts more, and does both with greater velocity; this I conceive arises from a necessity, which begins first in the veins; for when the body is in action, the blood in the veins is obliged to move with greater velocity than when at rest: how far there may be other reasons for this, I will not pretend to determine.

Another question naturally arises; as we find that the times of repetition of the pulse or actions of the heart increase in many diseases, Does the same thing happen, that is above supposed to arise, from exercise in health? viz. Does the heart dilate more, contract more, and also contract with more velocity; I believe this case does not in the least correspond with our former position. The pulse in such circumstances, although frequent, is small and hard, showing the arteries to be too much contracted by their muscular power, and therefore unfit to receive a large quantity of blood from the heart in any given time. The breathing does not correspond with the frequency of the pulsations, as in the former instance; yet it is possible that nearly the same quantity of blood may pass as when in health, the velocity in the contracted state of heart and vessels making up for the quantity in the enlarged. That it moves faster in such state of vessels, is, I think probable; for in bleeding, the blood in the veins during such a state of vessels, is commonly more florid.

Observations upon the heart's motion, while under the influence of artificial breathing.

I. I observed that the auricles contracted but very little, so that they did not nearly empty themselves.

II. That the ventricles were not turgid at the time of their diastole; for I could feel them soft, and could easily compress them.

III. That the ventricles became hard at the time of their systole.

IV. That the heart, when it ceased to act, became nearly twice as large as when acting, and that it recovered its small size again whenever it began to act.

OBSERVATIONS on the above appearances.

From the first observation it would appear, that the auricles are only reservoirs, capable of holding a much larger quantity than is necessary for filling the ventricles at any one time, in order that the ventricles may always have blood ready to fill them.

From observation the fourth, it would appear, that any idea we form of the size of a heart from those in dead bodies, must be far from the truth; for the blood coming from every part of the body to the heart, in some measure distends it while it is in a relaxed state, so that when the heart begins to contract (as muscles do some time after death) it is kept dilated by the contained blood. However, it may be observed that the increased size of the heart would be less in the present case, than natural; for the very quick motion of this viscus, under this irritation, hindered a full diastole; but when I left off blowing, and the heart ceased acting, it became large; and on resuming my artificial breathing, it again became small; which I did three times in the course of this experiment. But I think I have observed in general that the heart is not so much affected by the stimulus of death as the other muscles of the body. We seldom see a dead body that is not stiff; but we very often find the heart large and flabby, not in the least contracted: and I am not certain but this may be the case also with some of the other vital parts, as the stomach and intestines.

It is to be set down as a principle, that the action of every muscle is alternate contraction and relaxation; and it cannot be otherwise; but as there is a necessity for a more constant and regular motion in the heart, than probably in any of the other muscles, more disputes have arisen about the cause of its regular alternate motion. Some have accounted for it from the position of the mouths of the coronary arteries respecting the valves of the aorta, supposing, erroneously, that the heart has its blood in the time of its relaxation*; but the circulation, whether existing or not,

* This will be readily understood when I come to explain the mode of action in the valves of the arteries.

has not ſuch immediate effect upon a muſcle; nor would it account for the action of the auricle in the ſame animal, nor would it account for the action of the heart in a fiſh; but from what we ſhall obſerve on the valves of the aorta, we ſhall find that this opinion immediately falls to the ground. An eaſy experiment may put this beyond a doubt; for, if the heart of a dog be laid open and the coronary artery wounded, it will be found to jet out its blood as the aorta diſtends. Others have accounted for the alternate motion of the heart, from the courſe of its nerves paſſing between the two great arteries, ſo as to be compreſſed when the arteries are dilated; but this could only produce relaxation. We know too that ſuch immediate compreſſion on a nerve has no ſuch immediate effect upon a muſcle; and it would moſt probably make it contract; for when the nerves of the heart are cut, it does not ſtop its motion, but rather makes it contract for the inſtant. The heart's motion does not ariſe from an immediate impulſe from the brain, as it does in the voluntary muſcles, and as it is only in the quadruped and bird that the nerves can be influenced in their paſſage to it; it does not account for this alternate motion in other claſſes of animals. The flowing of the blood into the heart has been aſſigned as a cauſe of its contraction; but even that will not account for it; although it will for many of its phenomena, yet not for all; for a local ſtimulus merely is too mechanical to produce all the variety attending the action of this viſcus; it would not be attended with that regularity which it has in health, nor that irregularity which we find in diſeaſe; neither could it ever ſtop, unleſs when abſolute death took place; nor reſume its action if it ever did ſtop. We find that thoſe parts which have occaſion for the immediate ſtimulus to produce action, have that action very irregular; as for inſtance, the bladder of urine and inteſtines. The bladder is taking up its action as ſimply for itſelf, and not ſecondarily, however beneficial that might be for the whole in a ſecondary degree; but the heart's actions ariſe from its being ſo much part of the whole, as the whole immediately to depend upon it; therefore we muſt look out for another cauſe of this regular alternate action of the heart, than that ariſing from mechaniſm or mechanical impreſſion; ſomething more immediately connected with the general laws of the animal œconomy.

The alternate contraction and relaxation of the heart conſtitutes a part of the circulation; and the whole takes place in consequence of a necessity, the constitution demanding it, and becoming the stimulus, it is rather therefore the want of repletion which makes a negative impression on the constitution, which becomes the stimulus, than the immediate impression of something applied to the heart.

This we see to be the case, wherever a constant supply, or some kind of aid, is wanted in consequence of some action; we have as regularly the stimulus for respiration, the moment one is finished an immediate demand taking place; and if prevented, as this action is under the influence of the will, the stimulus of want is increased. We have the stimulus of the want of food, which takes place regularly in health, and so it is with the circulation. The heart, we find, cannot rest one stroke, but the constitution feels it; even the mind and the heart is thereby stimulated to action. The constant want in the constitution of this action in the heart, is as much as the constant action of the spring of a clock is to its pendulum, all hanging or depending on each other.

The nearest dependence of the heart is upon the lungs, and probably they have the same upon the heart; the two together become in their immediate use interwoven with the whole; for a stoppage of respiration produces a stoppage of circulation, and a restoration of respiration produces a restoration of the circulation or heart's motion. Thus, in my experiments on artificial breathing, the heart soon ceased acting whenever I left off acting with my bellows; and upon renewing my artificial breathing, it, in a very short time, renewed its action, first by slow degrees; but became quicker and quicker till it came to its full action.

I believe this experiment cannot be reversed; we cannot make an artificial circulation, so as to know, that if we stopped the heart's motion, we should so readily stop respiration; and on producing the heart's motion, respiration would again take place; but if we could do this, I doubt very much its being attended with equal success, because I believe that in all deaths, respiration stops first; however it must be supposed, that if the heart stopped for any length of time, respiration would also stop; and if I were to take the following case as proof, it would appear that respiration would not go on without the heart's motion.

A gentleman was attacked with a pain in the situation of the pylorus. The pains were such as indicated its seat to be in the nerves of the ſtomach and its connections. It was ſuch as he could hardly bear. The other attending ſymptom was a total ſtoppage in the actions of the heart; and of courſe the face was pale and ghaſtly. Not the leaſt ſigns of motion in the heart could be felt. In this ſtate he was about three quarters of an hour. He was attended by Drs. Hunter, Sir George Baker, Sir William Fordyce and Dr. Huck Saunders. As he was perfectly ſenſible at the time, and could perform every voluntary action, he obſerved, that he was not breathing, which aſtoniſhed him; and at firſt conceiving he muſt die if he did not breathe, he performed the act of breathing voluntarily. This ſhews that breathing depends on the actions of the heart; and it alſo ſhews, that under certain circumſtances the actions of both may be ſuſpended, and yet death not be the conſequence. As he ſpoke while in this fit, without attending to his breathing, it ſhews that the breathing which produces ſound, is voluntary; and if we had only the power of involuntary breathing, then probably we could not ſpeak; for it is probable we could not regulate the action of the glottis and tongue, which are voluntary, to ſo regular an action of the lungs; for in ſpeaking, it is the one acting ſo as to correſpond with the other, both becoming voluntary. A gentleman who had a ſingular aſthmatic affection, his breathing gradually ſtopt, and again gradually recovered, but became violent, and this conſtantly and alternately held two or three minutes; and when the breathing ceaſed yet he ſpoke, although but faintly.

In thoſe animals which have two ventricles, it has been aſſerted by ſome, that their actions are alternate; but obſervation and experiment ſhews us, that the two auricles contract together, and that the two ventricles alſo contract together. This can be obſerved ſimply by looking on the heart in its actions; and if we in that ſtate make a puncture into the pulmonary artery and the aorta, we ſhall find the jet in both at the ſame inſtant, correſponding with the contractions of the ventricles. Indeed the circulation in the fœtus is a proof of it; for in the child there would otherwiſe be two pulſations inſtead of one.

This alternate motion of the heart is quicker in ſome claſſes of animals, than others; in ſome being extremely quick, in others very ſlow. In all the more inferior orders of animals, I believe it is the ſloweſt; and this may probably be in some degree in proportion to their imperfection. It is also slower, probably, in each class in proportion to the size; and we know it is slower in each species, in some degree in proportion to the size; though not exactly so. The impulse is also found to be quicker in the young than in the old of each species, in greater proportion than what we find arising from size only. Thus the motion of the heart of a catterpillar is extremely slow, and also of a snail. The motion of the heart in fish is not frequent; and we know it is extremely slow in the amphibia. But in those possessed of two ventricles, as in birds and quadruped, the motion of this viscus is much quicker. In them too it differs very much in proportion to their size, although not nearly in the same proportion. Thus a horse's pulse is about thirty-six in a minute; while a man's is about seventy. In the same species it is nearly of equal quickness; for in a man of three feet high, the pulse was eighty, while a man above eight feet high, had a pulse about seventy.

VI. GENERAL OBSERVATIONS ON BLOOD-VESSELS.

By the vessels in an animal, are commonly understood those canals which carry the juices of the body, called the blood of the animal, to and from the heart, for the immediate purposes of the animal œconomy; and in those animals where no heart is to be found, yet vessels are found, though their uses are not so demonstrable; and in some of a still more inferior order, where no vessels can be demonstrated, yet, from analogy, canals may be supposed to exist; and those should still be called vessels*.

The vascular system in an animal, is, in some degree, to be considered as the efficient part of the whole animal

* Of this, I am not certain. I have an idea, that some animals absorb their nourishment, even without action, somewhat similar to a sponge; but dispose of it immediately by converting it into its own increase.

respecting itself; every other part of the body being more or less subservient to it, and depending upon it, for existence and support; and therefore the greatest attention should be paid to every circumstance that can possibly explain the various uses of the vessels; for there is no operation respecting the internal œconomy of the animal, but is performed by them; insomuch, that for the convenience of the vessels in performing those peculiar actions, they seem to constitute various combinations, which are called organs†. And although many parts have actions, independent of the vessels, yet these are not for the purposes of growth, support, etc. So that the vessels are constructed for the immediate use of the machine, and may be called labourers in the machine. This naturally implies something that is not a vessel, or vessels; a something that constitutes the different parts of the body, and is only more or less vascular. They are probably the very first active parts in the system; for we find them in action before they have formed themselves into a heart; and in such a state of parts we find them the only part that has any strength; the other parts only preparing for action: this is so remarkable that we can dissect the vessels of a chicken in the egg without injection, the other parts easily giving way. These parts are formed of living animal matter, so composed as to constitute the different structures fitted for their different uses in the machine; yet some parts are so vascular as to appear almost to consist wholly of vessels; as if vessels were formed into such structures; but this, we cannot conceive, for then they must lose the action of vessels.

In those animals where the vascular system is connected with a heart, which may be called the termination, as well as origin of the vessels, we find that viscus to make so ma-

† Perhaps it may be difficult to give a definition of an organ that will meet every one's ideas; or will distinguish those bodies, accurately, from what may be said, not to be an organ. A muscle may be called an organ; but I would only consider it among the materials of which an organ is composed. I have the same idea of elastic substances, cellular membrane, bone, cartilage, etc.

I would, at present, define an organ to be a part of a particular construction, composed of a variety of substances, which are combined together to answer some particular purpose, which is the result of the actions of the whole.

terial a part of this ſyſtem, as to require particular attention.

In many of theſe animals, we find two ſyſtems of veſſels, the arteries, and veins; and moſt probably they exiſt in all of them: there is alſo a third, which conſiſts of the abſorbents. The heart is the ſource of the arteries, and the termination of the veins and abſorbents. The two firſt depending on each other, form the circulation; and the third, is eſſential to both, bringing the materials which are to circulate*.

The arteries are to be conſidered as the acting part of the vaſcular ſyſtem, ſince they perform a variety of actions, the uſes of which are very important in the animal œconomy. They may be called univerſal, or conſtitutional, for their actions are immediately productive of health, or diſeaſe, in the conſtitution; and if they could be diſeaſed as a ſyſtem, that diſeaſe would, of courſe, be univerſal; as their actions are expreſſive of health, or diſeaſe, they become alſo one means of diſcovering either.

There is no internal operation in the machine reſpecting growth, natural repair, and ſecretion, that is not performed by them: no new part is formed, nor additional alteration made in the ſtructure of natural parts, nor repair for the loſs of natural ſubſtance, either by diſeaſe or accident, but is made by the arteries, although of all operations we know nothing, but from the effect produced. Theſe operations are performed by the termination of the arteries, which may be ſuppoſed to be of three kinds: one may be called arterial, conveying debelitated blood into the veins, and through their whole length, may be called arteries: another kind conſiſts of the ſeparaters from the blood, performing the different ſecretions: and the third contains the formers and ſupporters of the body: the two latter kinds I ſhould not call arteries, they are the workers, or labourers.

The abſorbing ſyſtem alſo takes a very active part in the animal œconomy, whether natural or diſeaſed, and ſeems in many actions to be the antagoniſt of the arteries; while the veins are much more paſſive, being principally employed in returning the blood to the heart.

* This ſyſtem is too extenſive to be deſcribed, in the preſent work, although it will be neceſſary to deſcribe one uſe not hitherto attributed to it, as it explains one part of my ſyſtem of diſeaſe.

It is probable, that every part of the body is equally vafcular, although they may not all have equal quantities of blood paffing through them, which muft arife from the fmallnefs of the veffels, and not from their being fewer in number. When we fay that a part is very vafcular, we can only mean that it is vifibly fo, by having a large veffel, or veffels, going to it, and ramifying in it; from which circumftance it contains a certain proportion of red blood, rendering the veffels vifible; which may alfo eafily be made confpicuous by injections. Where the veffels are fmaller this is not the cafe. When we fay, therefore, that a part is not vafcular, we mean it is not vifibly fo; but ftill we muft fuppofe fuch parts to be equally vafcular, fo far as refpects their œconomy within themfelves; but in fuch parts I conceive the blood to be more languid in its motion. Many parts appear to be much more vafcular than they really are, from their veffels dividing, and anaftomifing, and taking a winding courfe before they terminate*; for it is by the number of terminations of an artery in a given fpace, that a part is made vafcular, or not vafcular: mufcles appear to be more vafcular than they really are. When parts have another ufe, in which blood furnifhes the materials to be difpofed of, as in fecretion, and refpiration, where veffels fitted for fuch purpofes are fuperadded, then parts become proportionably more vafcular. When blood does not feem to be the matter to be difpofed of, yet if there are other operations continually carried on in a part, befides its fimple fupport, as in a mufcle, which has both the power of contraction, and confiderable fenfation, etc. then the veffels are larger, and of courfe appear in great numbers: this is evident in the living body, for if a mufcle is hardly allowed to act, its veffels become fmall, and it becomes pale; but if thrown into a more violent action, for a continuance it becomes red: we cannot here fuppofe an increafe of veffels, but only an increafe of fize. Thus we have parts vafcular in proportion to the quantity of action they are capable of, or under the neceffity of performing: and this particularly in parts whofe ufes may be called double, as the organs of fecretion in general, brain, and mufcles; even in inflammation, and in proportion as thefe

* By fimply cutting into the fpermatic artery of a bull it appears to be extremely vafcular, though, according to our idea of vafcularity, it is as little fo as any part.

parts are employed in their peculiar actions, they become to appearance more vascular. Some animals have naturally red muscles, without its being the effect of considerable action: this is very remarkable in the hare; but the redness in the muscles of this animal may be intended to adapt its muscles naturally for violent exertions at all times. Muscles are of different colours, respecting red and white, in the same animal; but that I believe is also in proportion to the quantity of action the parts are put to.

This effect the epicure is well acquainted with; he knows that the wing of a partridge is whiter than the leg: and that the leg of a woodcock is whiter than the wing. The veal of this country is a remarkable instance of this; for the calf is hardly allowed to stir, and the muscles are white; but when the calf is allowed to follow its mother, the muscles are of a reddish colour: it may be, however, remarked, that white meat is commonly the least juicy; and we find it remarkably so in those animals which are fed for this purpose, because, they require nothing but their simple support, and having little or no action within themselves, they have but little waste. Such change of appearance we find carried to a considerable extent in the uterus, at the time of the menses; but much more particularly at the time of uterine-gestation, where the vessels increase both in size and length, in proportion to the actions required. But parts whose use in the machine may be said to be passive, as tendon, cellular membrane, ligaments, investing membrane, bone, and cartilage, which last is probably the most passive, have all small vessels, and of course but few that are visible. As bone, however, is composed of two parts, viz. animal substance, and earth, it is probable there may be more action required to form the latter than either tendon or cartilage, and therefore there will be more vessels.

As a further proof that this is a general principle, we find that all growing parts are much more vascular than those that are come to their full growth; because growth is an operation beyond the simple support of the part: this is the reason why young animals are more vascular than those that are full grown. This is not peculiar to the natural operation of growth, but applies also to disease, and restoration. Parts become vascular in inflammation; the callus, granulations, and new formed cutis, are much more vascular in the growing state, or when just formed than afterwards; for we ſee them crowded with blood-veſſels when growing, but when full grown, they begin to loſe their viſible veſſels, and become not even ſo vaſcular as in the other neighbouring original parts, only retaining a ſufficient number of veſſels to carry on the ſimple œconomy of the part; which would now ſeem to be leſs than in an original part. This is known by injections, when parts are in the growing ſtate, or are juſt grown, and for ſome time after. We may obſerve, when the ſmall-pox is cured, that the remains of the puſtules are red, and continue ſo for ſome time; which is owing to thoſe parts being viſibly more vaſcular than common: and thoſe who have had the ſmall-pox ſeverely, are, in general, afterwards more pale than others, when thoſe parts have arrived at their permanent ſtate. If we cut into a part that has had a wound, or ſore, upon it, which has been healed for a conſiderable time, we ſhall find that the cicatrix, and the new formed parts, are not nearly ſo vaſcular as the original, which correſponds with what has been advanced; for we know that thoſe parts are not equal in power to original parts. In ſhort, whenever nature has conſiderable operations going on, and thoſe are rapid, then we find the vaſcular ſyſtem in a proportionable degree enlarged.

The number of veſſels in a part, and alſo the circulation of the blood through them, appears to keep pace with its ſenſibility; for firſt we find that moſt probably all parts endowed with veſſels are ſenſible; and all ſenſible parts are, to appearance, very vaſcular. Where any increaſed action is going on, requiring increaſed ſenſibility, there is alſo an increaſed circulation through thoſe veſſels, as in the parts of generation, during the time of coition, more eſpecially in the female; and this increaſe of veſſels, circulation, and ſenſibility in a part, takes place in diſeaſe, as is well illuſtrated in inflammation, where the whole ſeems to be increaſed in the ſame proportion, eſpecially the two laſt, viz. circulation and ſenſibility.

Theſe obſervations can only be made in animals which have red blood; and beſt in thoſe which have the moſt red blood; but it is not poſſible to aſcertain, with accuracy, the proportion that one blood-veſſel bears to another, ſo as to know the exact quantity of blood each part may poſſeſs; which would better aſcertain the action of the part; for they may be ſaid not to be meaſurable with any degree of accuracy; and therefore such investigation must be taken in the gross.

Vessels have a power of increase within themselves, both in diameter and in length; which is according to the necessity, whether natural, or diseased. The necessity appears to arise from an increase of the part to which the artery is going, the formation of a new part, or an irritation. The first may be reckoned the natural increase of the body: the second, the occasional increase of parts, as of the uterus, in uterine-gestation, where the vessels are increased in width, in proportion to the whole solid contents, including the young: besides this, they are considerably increased in length before they reach the uterus, which obliges the spermatic artery, in particular, to be thrown into a serpentine form: this is more remarkable in some animals than in the human species.

Instances of new formed parts, where the vessels are increased, are to be found in the stag, or all those of the deer kind which cast their horns; such animals having the arteries considerably increased at the time the young horn is growing, so that the carotid arteries, which before had only to supply the head, and the external carotid, which before had only to supply the sides of the head, now become larger, and are continued into the horn, which is extremely vascular.

After the separation of the fœtus, or the full growth of the horn, the vessels naturally lessen, to adapt themselves to the diminished size of the parts.

It is curious to observe how vessels become enlarged upon any irritation; not only the arteries, but the veins; and not only the smaller branches, but the larger trunks. This was evident in the following case: I applied a caustic to the ball of the great toe of a patient every other day, for more than a month, and after each application the surrounding parts put on a blush; and all the veins on the top of the foot, as well as up the leg, immediately began to swell, and became large and full. This was so remarkable, that the patient watched for this effect, on the days on which the caustic was applied, from its happening only on those days.

In diseases where there is an increased size of the part, as in tumors, etc. the increase of vessels is no less conspicuous; and they have the power of dilatation, and increase of strength, in proportion to the size of the vessels; which are now endowed with new dispositions, and action, different from those they had before.

The arteries often perform diseased operations in the body, which become symptoms both of local and constitutional actions, as in inflammation, fever, etc. for they are not only active in local disease, but their action often becomes a symptom of a constitutional disease, whether original, or arising from a local cause: but these symptoms become mostly sensible to us in those arteries whose actions we can feel; because they have a peculiar action in their diastole, as well as in their systole, which is sensible to the touch; from which sensation, we, in many cases, judge of the state of the body at the time; as also the state of the cause, when it is local, and out of sight. The heart, the source of the circulation, is also affected from the same cause; so that its motion, and the motions of the arteries, commonly, if not always, correspond.

VII. VALVES OF ARTERIES.

The arteries arising from the heart, I believe in all animals, have valves, which are so many flood-gates, to hinder a return of the blood into the cavities: and as there are two main arteries in the human body, so there are two sets of valves, viz. one belonging to each artery. These are situated at the beginning of the artery, and from their shape, are called semilunar. Veins have similar valves, almost through their whole course. The valves are inelastic, being similar to the inner coat of an artery; but the difference in the properties of the valves, and the arteries themselves, which are elastic, will be further considered in in treating of the use, and mode of action of the valves. Each of these sets is made up of three valves*; but in veins, there are commonly only two. This difference in the valves of the arteries, and veins, is perhaps to bring the artery into a more rounded figure, than could have taken place by two valves only: each of these valves is of a semilunar

* I have found in the human subject, only two valves to the aorta; but this is very rare.

form, having one convex edge, and the other nearly ſtraight. Theſe valves are attached to the inſides of the artery, at its very beginning, by their ſemicircular edge, which is oblique; the points, as it were, running a little way into the artery. Theſe terminations in each valve come cloſe to one another; but the looſe edges, which conſtitute the diameter, are not cut ſtraight off, but rounded. There is, beſides, a ſmall body on each, attached to, or near, the edge, between the two points, called corpora-ſeſamoidea. Theſe bodies are not placed exactly on the edge, but rather on that ſide next to the artery, leaving the edge of the valve looſe: this ſituation is beſt adapted to their intended uſe; the reaſon of the looſe edge being a little rounded, and of the bodies called corpora-ſeſamoidea being placed there, ariſes from there being three valves to each artery. Each of theſe valves, with its artery, forms a pouch, whoſe mouth, or cavity, opens toward the artery; and the convexity of each of the valves, when the artery is dilated, makes nearly the third of a circle, which is turned inwards, towards the centre of the artery, as well as towards the heart. It is from this oblique direction in the attachment that the valves perform their office, ſimply from the action of the heart upon the blood; and the blood upon the artery. This is entirely mechanical; depending on mechanical principles alone, as much as the action of a joint.

I have above obſerved, that the area deſcribed by the valves is the ſame with the artery, when that veſſel is in its ſyſtole, their outer ſurface lining the inner ſurface of the artery; but the artery being elaſtic, its diameter becomes larger when the blood flows into it; and the valves being inelaſtic, their looſe margins, or edges, are brought more into ſtraight lines acroſs the area of the mouth of the artery, and nearer to each other, ſo as to make an equilateral triangle. Thus they are fitted to catch the returning blood; and the artery re-acting with conſiderable force on the blood, preſſes on the valves, ſo as to puſh them inwards: theſe having no preſſure on the ſide next the heart become convex on this ſide, ſhutting up entirely the mouth of the artery. Here then is an effect ariſing naturally out of a variety of cauſes, viz. the oblique direction of the valves; their want of elaſticity; the elaſticity of the artery; and the dilatation of the artery; ſo that the return of the blood does not open the mouths of the valves, and in that way, ſhut up the mouths of the artery. To demonſtrate this, let us ſuppoſe the extreme length of each of theſe valves to be an inch; then the circumference, of the artery, when in its ſyſtole, will be three inches: in that caſe the valves lie cloſe to the ſides of the artery, and deſcribe a circle of three inches circumferenee, (as in figure I.); but if you dilate this artery, as far as the valves will allow, which will be rather more than one fifth, the valves will run nearly into ſtraight lines, and make an equilateral triangle, (as in figure II.) whoſe ſides are a little curved inwards. As the artery is filled from the contraction of the heart, it is diſtended: and as it is diſtended, the valves do more and more their duty, till at length, by the full diſtention of the artery, they are made to bulge inwards, and the looſe edges, with the corpora-ſeſamoidea, are puſhed further towards one another; by all of which poſitions the area of the artery is entirely ſhut up.

Figure I. ſhews the artery in its ſyſtole, with the three valves, nearly cloſe to its ſides. The two black dots are deſigned to repreſent the mouths of the coronary arteries, now covered by the valves.

a a a.....The circular ſection of the aorta.
b b.....The mouths of the coronary arteries almoſt covered by the valves.
c c c.....The hollow poueh of the valves.
d...... The area within the valves.

Figure II. ſhows the artery in its diaſtole, where the three valves run nearly into ſtraight lines, making an equilateral triangle of the area of the aorta, d d d. But as their edges are rounded, and the bodies of the valves make a curve inwards, they by theſe means fill up in part this triangular ſpace, as is ſeen at f; and the corpora-ſeſamoidea, fill up the other part at e. In this way the whole area of the artery is filled up.

a a a......The cireular ſection of the aorta, in its ſtate of diaſtole; being now larger about one fifth.
b b........The mouths of the coronary, now quite expoſed.
c c c c c e...The hollow poueh of the valves, now enlarged.

Fig. 1.

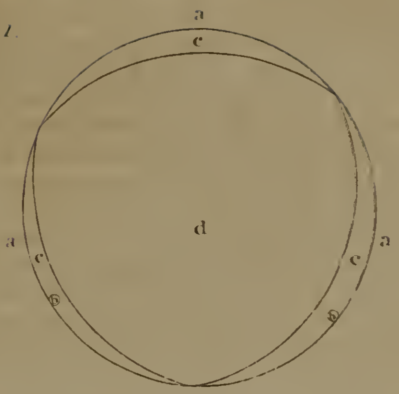
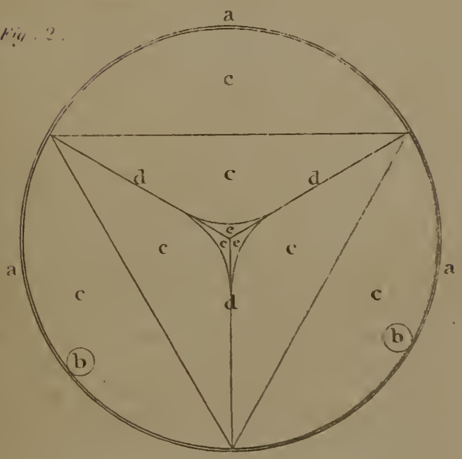


Fig. 2.



d d d. . . . . . .The circular edges which fill up more of the area of the artery than if they were ſtraight.
e e e. . . . . . .The corpora-ſeſamoidea.

The foregoing account is proved by injections againſt the valves; but it is ſtill more clearly proved that the diaſtole of the arteries makes the valves do their duty, when it is injected with the current of blood: for in proportion as the artery is diſtended, the valves recede from the ſides of the artery: and if the artery is fully diſtended, the communication is entirely cut off between the two pieces of injection, viz. that which is within the heart, and that which is within the artery. It may be objected here, that it will require a certain quantity of blood to make theſe valves do their office: and when there is not that quantity, it muſt be done by regurgitation. To this it may be anſwered, that nature always keeps a due proportion; and all the parts depend on one another: ſo that the quantity of blood, that is juſt ſufficient to keep the animal alive, is ſufficient to diſtend the artery ſo as to ſhut the valves*. The valves of the pulmonary artery do not do their duty ſo completely as thoſe of the aorta; for in them we do not find the corpora-ſeſamoidea; and if we inject a pulmonary artery, towards the right ventricle, it does not ſo completely hinder the injection paſſing into that cavity: nor are the two portions of injection completely ſeparated when the artery is injected from the ventricle as in the left ſide. So far as reſpects injections, the ſame obſervations are applicable to the valvulæ tricuſpides; therefore I believe the valves of the right ſide of the heart, are not ſo perfect as thoſe of the left: from hence we may ſuppoſe that the univerſal circulation requires to be more perfect than that through the lungs. We muſt ſee from this account of the action of the valves, that the

* As people advance in life, eſpecially men, we find the aorta loſing its elaſticity: and as it is acted upon with great force by the impetus of the blood, it loſes that elaſticity in the ſtate of its diaſtole; which throws the valves continually acroſs the area of the veſſels; and as the valves in thoſe caſes commonly become thicker, are often very irregular, and bony, we find that they neither recede from the ſides of the aorta, during the contraction of the heart, nor towards it during the ſyſtole of the artery: ſo that more blood is allowed to regurgitate into the ventricle, than in a regular circulation.

mouths of the coronary arteries are opened by the action of the heart; for as the arteries dilate, they become more and more exposed.

VIII. OF THE DIVISION, OF BRANCHING, OF ARTERIES.

As all the arteries in animals possessed of a heart arise from, or begin at that heart, by one, or two trunks only, they are obliged to divide into, or send off branches, or smaller trunks, which again divide into still smaller, till at last the whole body is supplied by the ultimate divisions. This is called the branching, or ramification of arteries; and is somewhat similar to the branching of a tree.

This branching of an artery does not depend on the artery itself, or on the powers propelling the blood, as in in a tree, but is governed by the formation of the body; that is, according as a greater, or less quantity of blood, or a greater, or less velocity is necessary to different parts.

Various modes of branching are made use of to answer the above purposes.

In general the most favourable mode for the free passage of the blood is adopted, viz. branching with acute angles; more especially those which are to carry the blood some considerable way; and still more so in those which are at a great distance from the propelling impulse of the heart; which I shall now more particularly consider.

As the force of the blood in the artery is stronger, the nearer it is to the heart, the difference in the velocity of the blood, near, and at a distance from the heart, if there was nothing to retard it, would be too great for the difference in parts; the near and the distant parts being in many instances of the same kind. To keep up a velocity sufficient for the parts, and no more, nature has varied the angle of the origin of arteries, at different distances, from the source of the circulation. Thus we find that near the heart the arteries arise by obtuse angles, some of them being reflected and the angles become less and less, till at length they are very ſharp. The moſt remarable inſtance of this is in the intercoſtal and lumbar arteries ; becauſe ſince they are a ſet of branches in the body, whoſe length and uſes are ſo much the ſame, if there be any difference in the angles, at the origin of the arteries, at equal diſtances from the heart, it muſt be made with regard to their length, from the origin to the part ſupplied. We find a difference even in the arteries which ariſe from the intercoſtals ; for they are much more obtuſe at the beginning of the intercoſtals, than at their termination. The reaſon why this is not ſo evident, in all the arteries of the body, is, that there are ſo few arteries on the ſame ſide of the body, which take the ſame courſe, go to the ſame diſtance, and have the ſame office: for ſome parts require a greater velocity than others, which will make a difference in the origin of the two arteries, ſuppoſing they ſhould go the ſame length, and take the ſame courſe. We ſee the ſame thing in the ſecondary arteries, ſuch as the ſubclavian; for it ſends off its branches near its origin, at much more obſtuſe angles than it does further on. Haller, in his Phyſiology, ſays, That the arteries ariſe at an angle of forty-five degrees; which is the greateſt angle in projection : but he did not conſider, that in projection there are two powers, viz. gravitation, and the force applied ; while the blood in the arteries has only one. It may be aſked, Whether the blood in an artery of a given ſize, ariſing from a large one, is ſent in with the ſame force as if the artery had ariſen from a much ſmaller trunk ; or from an artery of the ſame ſize with itſelf, whoſe blood paſſed with the ſame velocity as in the large one ? We find ſmall arteries coming off at once from large ones, inſtead of being a third, fourth, or fifth, from the large one. Arteries ſend off their branches at a longer, or ſhorter diſtance, according to circumſtances ; or, in other words, they divide, and ſubdivide, more quickly in ſome places than in others. I believe this quick diviſion is more peculiar to glands, than moſt other parts, though it does not take place in all, as in the teſticle. They divide alſo quickly in the the ſubſtance of the brain. In the kidney, this is alſo remarkable ; they would ſeem in that gland to be hurrying to their termination. The ſame happens as ſoon as the arteries enter the ſubſtance of the brain. Other parts appear to have the arteries elongated before they enter the part, as the ſpermatic artery ; more eſpecially in ſome animals, as the bull, boar, etc. and in the female, in the time of uterine-geftation, where we fhould expect the quickeft circulation, we find the arteries elongated very confiderably, which throws them into a ferpentine courfe; all of which muft retard the blood's motion in the part. We alfo find arteries playing in the parts, ramifying and anaftomofing, which diminifhes the velocity of the blood; fuch as thofe of mufcles, membranes, etc. We may fuppofe from the foregoing inftances, that in fome, a quick fupply of blood was neceffary in fuch parts: in the one for the drain; in an other, for the fupport of the living powers: while in others, a more regular, flow, and even motion, anfwered the purpofe better.

Arteries, in common, pafs in as direct lines from their origin to their deftination, as poffible; but this is not univerfally the cafe, for in many parts they run in a ferpentine manner; fo much fo in fome as to form a body of themfelves. Thus the fpermatic artery in the male of many animals, more efpecially the bull, is fo convoluted, as to form a body. In the female alfo, the fpermatic artery increafes its ferpentine courfe in the ftate of uterine-geftation. The internal carotid artery in man, and many other animals, as the horfe, where it paffes through the fkull, runs in a ferpentine direction; and in the lion, bull, etc. it forms a plexus. This would appear to anfwer too purpofes; one to leffen the impulfe of the blood, as in the vetebral, and internal carotid, the fpermatic artery, etc. the other to allow of the ftretching of the parts, upon which the artery paffes, as the mouth, or lips, the uterus, and other parts of the body, which admit of being ftretched, or relaxed, as the bladder, ftomach, enteftines, etc. independent of their elafticity.

We find not only the different fyftems of veffels communicating with each other, as the arteries with the veins, the veins with the heart, to be continued into the artery again, and the abforbents with the veins, to communicate, in the end, with the whole, but alfo the branches of each fyftem, communicating with one another, which is called anaftomofis.

Anaftomofing of veffels, is the opening of one veffel into another; fo that if one of them be prevented from carrying its contents, the office can be performed by the other. The moft common mode of anaftomofing is, when two veſſels run into one, or are continued into each other; or one veſſel opens into another, from which others ariſe; but there is a peculiar communication between the two carotids, as well as between them and the vetebral, where a canal of communication paſſes directly between them; and this mode of communication takes place between the two deſcending aortas of ſome of the amphibia.

This anaſtomoſing is much more frequent in the ſmaller than the larger arteries. We ſeldom find trunks anaſtomoſe with one another. One reaſon for this is, the great diſproportion in number between the larger and ſmaller arteries; but the anaſtomoſis is much more frequent in the ſmaller in proportion to their number. The uſe of this is to give freedom to the circulation, as the chance of a ſtop being put to it is greateſt in the ſmalleſt arteries; the circulation in them not being ſo ſtrong; and paſſing through parts liable to be preſſed upon: this is readily ſeen in the tranſparent parts of the living body, when viewed through a microſcope. In ſome part of the body we find anaſtomoſis in pretty large trunks; but theſe are in parts eſſential to life, very liable to be compreſſed; or both.

The meſenteric artery anaſtomoſes by large trunks; the myſentery being a part eſſential to life, and very liable to compreſſion, from indurated fœces compreſſing the artery. In this caſe, if they only anaſtomoſed by the ſmall branches, on the inteſtines, the circulation might not be kept up ſufficiently to preſerve the gut. We obſerve the ſame thing in the brain; for there the arteries anaſtomoſe by large trunks, before they are diſtributed to the brain. The uſe of this is, that all parts of the brain might have an equal quantity of blood at all times, even where accident had put a ſtop to the circulation in any one veſſel; for the ſmall anaſtomoſis on the pia-mater, would not be ſufficient to keep up a due circulation; every where in the brain as I believe the arteries do not anaſtomoſe in the ſubſtance of the brain itſelf. There are large anaſtomoſes in the hand, and foot, for the ſame reaſon, as in the inteſtines. All the uſes ariſing from the anaſtomoſing of the veſſels are, perhaps, not yet perfectly underſtood: general reaſons can, I think, be aſſigned for them; but theſe will not apply to all caſes; there is ſomething, therefore, more than we are yet acquainted with. The abſorbents, and the veins, upon the whole, anaſtomoſe more frequently than the arteries; yet that circumſtance is reverſed refpecting the veins in fome places; and in the inftances the ufes of thefe fyftems of veffels are alfo in fome meafure reverfed. Where all the three fyftems of veffels have nearly the fame mode of action, we find that their manner of anaftomofing is fomewhat fimilar; and probably the differences might be eafily accounted for.

Wherever they appear to be fimply carriers, then their mode of anaftomofing is fomewhat fimilar: however, the abforbents anaftomofe more frequently than the veins; and the veins more than the arteries; and, probably, the abforbents anaftomofe every where. This is not fo much the cafe with the veins; and not in the leaft fo in fome parts with the arteries. Let us fee if we can affign reafons for all this variety in the different fyftems of veffels. The abforbents, from the office of abforbing, are to be confidered only as carriers; and as they have no propelling force applied to their contents, and their coats are not ftrong, it is very probable, that a free communication between veffel, and veffel, fhould take place; upon the fame general principle, the veins alfo anaftomofe; although perhaps not fo frequently; and this difference may be, becaufe they have in fome degree, a propelling power applied to their contents; namely, the action of the heart. The arteries having a very ftrong propelling power applied to their contents, it was in them not neceffary as a general principle; but where they are placed in fimilar circumftances, we find them fimilar in this refpect.

Although the anaftomofing of veffels is upon a general principle very proper, yet in many cafes it would appear in the following parts to be very improper. The arteries do not anaftomofe in the kidnies. This cannot arife fimply from there being no occafion for it, on account of there being no lateral, mechanical obftruction; fince from the fame mode of reafoning, the veins fhould not anaftomofe; which they do, very freely: this want of anaftomofis in the arteries, therefore, anfwers fome purpofe in the œconomy of the part. In the liver, the branches of the venaporta do not anaftomofe although the arteries do in their fmaller branches; we may, therefore, fuppofe fome particular purpofe anfwered, befides free communication; and I believe the arteries do not anaftomofe in the fubftance of the brain; which makes the brain appear lefs vafcular than it really is. We may obferve, perhaps, as a general principle, that arteries near to their deſtination, where they are to perform their particular functions, do not anaſtomoſe. Thus the artery of the kidnies, the vena-porta*; the arteries in the ſubſtance of the brain, do not anaſtomoſe; nor do the arteries on the villous coat of the inteſtines.

If it be queſtioned, whether anaſtomoſes are a means of retarding, or accelerating the circulation, I ſhould anſwer, that they appear to me, to retard the blood's motion; although we find veſſels anaſtomoſing as freely with one another, at the greateſt diſtance from the heart, as near to it; but at the ſame time we may obſerve, that where we ſhould ſuppoſe it was neceſſary for the circulation to be briſk, we find no anaſtomoſes in the arteries, as in the lungs, the kidnies; and I believe hardly in the liver, except on the peritoneal coat, whoſe arteries are continuations of the hypatic artery.

I believe that the anaſtomiſing of veſſels increaſes their volume on the whole, and therefore allows a greater quantity of blood to be in them, than if they did not: that kind of net work too, which they make, increaſes the magnitude of the vaſcular ſyſtem; for to anſwer this purpoſe, they take lateral and circular courſes; which give them greater length, than if they had ſimply paſſed between origin, and deſtination, in ſtraight lines.

The better to aſcertain the velocity of the blood in the arteries, at the different diſtances from the heart, it will be neceſſary to know whether an artery be a cylinder, or a cone; and when it divides into any number of branches, whether the whole of theſe, taken together, be leſs, equal, or greater, than the veſſel, or veſſels, from which they aroſe; and, therefore, whether they hold leſs, the ſame, or more blood. It may be obſerved, that arteries keep a pretty exact proportion with each other; the branches, with the trunk, etc. through the whole ſyſtem; and therefore, whatever may be their ſhape, they preſerve it pretty regular, viz. if they are cylindrical, they are ſo regularly; if conical, the ſame. I ſhould ſuſpect, however, that the anaſtomoſing of the arteries, in ſome degree, interferes with this regularity; but it is probable that the ultimate

* This veſſel ſhould be conſidered as an artery.

branches may come back again, and correspond with the original trunk. To ascertain this, it is necessary to make choice of arteries, which for some length either send off no branches, or at least such as are very small, when compared with the trunk: for it is impossible to measure with any degree of accuracy the size of branches, and then calculate their different capacity, in comparison with that of the trunk, from whence they are derived: and I think it is reasonable to suppose, that whether an artery divides or not, the size must be the same in both; for it is necessary that the ultimate effect should be the same.

The arteries which are best adapted for this experiment, are those of the placenta, and of the testicles; particularly in the bull. The carotid arteries in some animals are tolerably well formed for experiments of this kind; for though these do not give us the exact proportions which the one end bears to another, yet they plainly demonstrate which end is the largest.

The arteries of the placenta evidently increase in size, the nearer they approach to the placenta; and this is so very considerable as to require no experiment, unless it be intended to ascertain the difference correctly. In the spermatic artery of the bull, it is equally evident; but as these arteries are much longer than the distance between their origin, and the parts which they are to supply, it may be supposed that this increase is peculiar to them, in order to answer some particular purpose: but the carotid arteries in some animals afford sufficient proof that the arteries in common become larger as they pass on and ramify; for the carotids may be reckoned ramifying arteries, as they send off branches.

The carotid artery of the camel, among quadrupeds, and of the swan, among birds, are very proper arteries for such experiments.

To be as accurate as possible, I injected the arteries of two camels, and the arteries of a swan; and that one end might not be more distended than the other, the artery was well warmed, and placed in a perfectly horizontal position: the pipe was fixed into the lower end*, and the injection made so warm, as to keep fluid some time after having been injected: in this position it was allowed to cool. I made

* The fixing the pipe into the lower end was rather in favour of increasing the size of this end.

sections from each end; and, that they might be perfectly equal, I took a hard piece of wood, an inch thick, and bored a hole through it to the size of the artery, so as to contain a section exactly of that length, having a moveable button fixed at one end, which could be turned upon the hole, or off, at discretion. The artery being introduced through the hole, a projecting part was cut through, by a thin knife, in order that the artery might be divided at right angles to itself. After doing this, the artery was withdrawn, and the button was then turned upon the hole, so as to stop that end; and the cut end of the artery introduced to the bottom, or button: this piece, so enclosed, was separated in the same manner.

Having taken a piece of the carotid artery from each end, which were of course exactly of equal lengths, I weighed them, and found that the section of the upper end was one grain and a half heavier than that of the lower.

The carotid artery of another camel, measuring three feet and a half in length, was found to send off forty-four small branches, about the size of the human intercostal arteries; with one as large as the ulnar. Of this artery, a transverse section, of one inch in length, being taken from each end, and weighed; that from the lower end was found to weigh two scruples, sixteen grains and a half: while that from the upper end, weighed only two scruples, fourteen grains and a half.

In similar sections of the opposite carotid, which sent off forty-seven branches, the difference in weight, between the upper and lower section, was five grains.

Similar sections from carotid arteries of a swan being weighed, the lower sections were found to be three grains and a half heavier than the upper; the lower section weighing thirteen grains and a half.

Had the lateral branches been preserved an inch long, being the length of the sections of the trunk, I believe each might have weighed above a grain; and in that case, the forty-four would have been nearly equal in weight to the trunk: should this be true, the arteries increase very considerably, not only in their ramifications, but in their trunks. I imagine if the carotid artery, in the camel, did not send off any branch in its course, it would increase in size, nearly in the same proportion with the umbilical artery, or the spermatic, in the bull.

It is to be obferved, that as arteries divide they increafe in fize, much fafter than if they did not: for inftance, if a fection of an artery, two inches long, is equally divided into two, the fection that is the further from the heart fhall be heavier than the other, perhaps, by one grain; but if the moft diftant fection had divided into two branches, the two, taken together, would have been a grain and a half heavier; if three branches, two grains heavier, etc.

The increafe of fize in the arteries as they ramify, is an effect of the numerous ramifications.

From what has been already faid, it muft appear that arteries form a cone, whofe apex is at the heart: and if this be the cafe, in the adult, we fhall find that it muft be more fo in the young fubject; and will every day become lefs, as the child increafes in growth.

The capillary arteries in the fœtus are probably as numerous as in an adult, perhaps more fo; for we know that there is the fame number of principal arteries in each. As far as we can trace them, they feem to fend off the fame number of fmaller branches; and in many parts we find a great many more fmall veffels in the fœtus than in the adult.

In the eye, the membrane of the ear, etc. in all growing parts, fuch as callus, granulations, etc. we find a great many more veffels, than in fimilar grown parts; or in the fame parts, when completely formed; not in proportion to the fize of the part, but more in number.

Thefe are ftrong proofs that many arteries are obliterated in the adult. How much more vafcular, therefore, muft a child be, than an adult, in proportion to its fize, when in a much fmaller compafs a greater number of arteries are accumulated!

From this it would appears that the only great change in the vafcular fyftem, is elongation of the veffels. As we find very little difference between the blood of a fœtus, and of an adult, it is natural to infer, that the fmalleft veffels are nearly of the fame fize in both; for the termination of the arteries, or what may be called the operative part of the arterial fyftem, being intended to perform the fame functions in the fœtus, as in the adult, it is reafonable to fuppofe, that the increafe is in the length of the whole vafcular fyftem; and that the increafe in the fize of the trunks is in an uniform gradation, from the capillaries, towards the heart; but never becoming equal to the capillaries.

If the preceding account be true, or nearly ſo, we ſee that there muſt be a great proportional difference between the ſize of the two extremes of the arteries, in the young ſubject, and the adult. We may venture to ſay, that the aorta in the child in not one-fourth of the ſize of that veſſel in the adult; and that the capillaries are rather larger than thoſe in the adult, which would of itſelf make the whole capillaries in the fœtus more than four times the ſize of the aorta in the ſame; and as theſe arteries are very ſhort, the cone, of courſe, increaſes very faſt.

In the fœtus in utero, we are to conſider that the aorta, at the beginning from the ventricle, is larger than in the adult, in proportion to the quantity of blood that paſſes through the foramen ovale: and beyond the entrance of the canalis arterioſus the aorta is increaſed in proportion to the ſize of the canalis arterioſus; and it is at this part its ſize is to be eſtimated: this probably makes the aorta, beyond the entrance of the canalis anterioſus, twice as large as in the adult, in proportion to their ſize; but the drawback upon this, from the body, is the placenta; for the placenta is to be conſidered as part of the body, diſpoſing of the blood that afterwards circulates through the lungs: however, when it is ſeparated, it may take away with it nearly its own proportion of blood; although I rather ſuſpect it does not. But I do not ſuppoſe it is equal to the quantity paſſing through the foramen ovale, and canalis arterioſus; and if ſo, then the body has the overplus.'

The aorta of a fœtus is, therefore, not only larger than that of an adult, but larger than in that proportion which the ſize of the fœtus bears to the ſize of the placenta: or it may be put in this view, that beſides the difference in the ſize of the aorta, in a young ſubject (as before obſerved) and in an adult, the ſize of the aorta, in the foetus, is ſtill larger, viz. more than in that proportion which the circulation in the lungs of the adult, bears to the circulation in the lungs of the foetus; which is probably much more than that of the placenta.

EXPERIMENT on the arteries of a child.

I injected the deſcending aorta of the foctus, juſt above the diaphragm, in the ſame manner as I did the carotids in the camel, and ſwan, by which means I injected the myſenteric artery, the ſubject of experiment.

This artery has a trunk, which at first does not put off branches, and then sends off several; which may be called so many trunks. These again do not immediately give off branches, and are therefore measurable with the trunk, from which they arise.

I first made a section of the trunk of the mesenteric artery, near its root, before it sends off any considerable branches, one-third of an inch in length; and then another section of the same artery, having the same length, close to the origin of the first branch: all the branches arising from it being preserved of the same length with the trunk itself. When they were weighed in opposition to each other, the trunk without the branches was found to weigh thirteen grains and a half; while that with the branches weighed eighteen grains; four grains more than the trunk. A section of the aorta, near half an inch long, being made just above the origin of the inferior mesenteric artery, was weighed against a section of the same length, including the inferior mesenteric, likewise of the same length; the last section weighing one grain more than the other. The highest amounting to six grains, the lowest to seven. A section of the lower end of the aorta, including a portion of the two iliacs, was weighed against a section of the two iliacs, which was equal in length, and these were found to weigh rather heavier.

By the above is confirmed what I formerly asserted; that an artery, not giving off branches, does not increase so fast as another which does, if we include all the branches.

From all that has been said, it appears that there must be a much greater quantity of blood in a foetus, than in an adult, in proportion to their difference of size; and that the heart must be larger and stronger, in proportion, to move this blood; which will probably still circulate in the smaller vessels with less velocity.

The whole of these differences, between the foetus and the adult, must be intended for the purposes of growth; and indeed we may discern the necessity of it: for if a child was not more vascular in proportion to its size, than the adult, its growth, we might conceive, would only be in proportion to the number of its vessels; which would be twelve times less than they are; for a new born child is only one-twelfth in size to that of an adult. A child would, therefore, grow faster and faster every year; for instance, in proportion to its size, as the vessels would become numerous in that proportion.

But this is not really the case, for children grow less and less, every year, in proportion to the size; only adding its first year's growth to itself every succeeding year; though, perhaps, not quite so much, as the vessels rather decrease in number.

That this is the case may be proved by taking the eye for an example, which grows more the first year after conception, than it does any year after; so that the disproportion between the vessels of this part, in those two states, is particularly great.

The growth of an animal is, therefore, in proportion to the number of its capillary vessels: as the body grows, the vessels elongate to keep pace with that growth: the capillary vessels at last come to a stand; and the arterial system is daily losing ground.

The heart grows in proportion to the increased length of arteries, that it may be able to throw the blood through the whole, but not in proportion to the size of the whole body; because the vessels do not increase in number, or size, in proportion to the size of the body. But as the heart increases only in proportion to the size of the whole vascular system; while the body increases faster, and more, the heart cannot be in proportion to the size of the whole body; hence its actions must in time lose the power of elongating the body, and become merely sufficient to nourish what is already formed. Perhaps it does not even continue to do so much; for it is not impossible, that the body may begin to decline from the moment it ceases to grow; the heart having pushed the growth of the body, even beyond its own powers: to preserve it in that state.

IX. OF THE ACTION OF THE ARTERIES AND THE VELOCITY OF THE BLOOD's MOTION.

Arteries during their diaſtole, which ariſes from an increaſed quantity of blood being thrown into them, increaſe much more in length than width, being thrown into a ſurpentine courſe; therefore, inſtead of the term diaſtole, it ſhould rather be called, the elongated ſtate. It is, however, the increaſed diameter that becomes ſenſible to the touch. This, probably, ariſes from the muſcular coat oppoſing the dilatation of the arteries, while it cannot the lengthening. The dilatation of the artery producing the ſtroke, is either felt by the finger, or may be ſeen when ſuperficial; but were we to judge of the real increaſe of the artery by this, we ſhould deceive ourſelves; for when covered by the integuments, the apparent effect is much greater than it really is in the artery itſelf; for in laying ſuch an artery bare, the nearer we come to it, the leſs viſible is its pulſation; and when laid bare, its motion is hardly to be either felt, or ſeen.

The more an artery is covered, eſpecially with ſolid bodies, the more is the pulſation to be felt, or ſeen: thus tumors over large arteries have a conſiderable motion given to them; and have often been ſuppoſed to be aneuriſms.

The knowledge of this fact ariſing more from experiment than common obſervation in the living body, may be a ſufficient reaſon for keeping to the old expreſſion, dilatation.

This circumſtance, which has been but little taken notice of, produces an effect, which has alſo been unobſerved. If the arteries had been dilated by the force of the blood's motion, as has been ſuppoſed, its motion ſhould be much leſs retarded than it is; for even ſuppoſing that the increaſed area of the artery is the ſame when elongated, as if dilated, and therefore holds an equal quantity to a dilated one, it muſt appear evident, that the blood will not arrive ſo quickly at the oppoſite end.

The continual repetition of the cauſe of this ſurpentine courſe obliges the arteries in many places to retain this ſtate, eſpecially in parts that do not yield readily, as the ſkull, upon which the temporal artery is placed; and this retention of the ſerpentine courſe, is ſtill more obvious in thoſe arteries which have loſt a good deal of their elaſticity. However, this increaſe of the artery is ſo manifeſt, as to be felt, or ſeen: and produces what is called the pulſe; which muſt gradually diminiſh in proportion as the arteries divide into ſmaller branches; a ſmall artery having a proportional pulſe, and the arterial ſyſtem increaſing as it goes along; both of which cauſes diminiſh the velocity of the blood, render the diaſtole leſs, and its motions more uniform.

From the deſcription I have given of the heart, with its action, and the parts of which an artery is compoſed, it muſt appear that an artery is at all times full of blood, which is moving on with more or leſs velocity; becauſe it receives it from the heart, at interrupted periods; and when a given quantity is thrown in at one end, this will make a conſiderable difference between this part and the other; which part will of courſe be more upon the ſtretch; for although the artery dilates, yet as it is from the impulſe of the blood, the blood muſt move much faſter on in the diaſtole of the artery, than its ſyſtole. This part of the artery will contract, and throw the blood into the remaining part; but not with the ſame force it was received; but ſtill the artery beyond will receive it faſter, than it will give it. By theſe means, all the parts of the artery are brought to a more equal ſtate; for this additional quantity of blood, that was at firſt in the one part only, is in ſome degree equally diffuſed through the whole arterial ſyſtem; by which means too, it is becoming proportionably ſlower in its motion: but all theſe circumſtances will vary according as the arterial ſyſtem conſiſts of cylinders, or cones, and if of cones, then according to the extremity, which is the baſe; all of which may be conjectured, but cannot be exactly eſtimated. Yet that the force of the heart might not be loſt, the elaſticity of the great artery, over the ſmaller, is happily applied; becauſe it propels the blood more forcibly on, between the ſtrokes of the heart: for although we are to ſuppoſe that the heart, which was capable of diſtending a part, ſo as to make it react, and ſend the blood through any given length, was alſo capable of ſending it through that length at once; yet we muſt ſee, that by an elaſtic power being applied at one end, while this is gradually loſt towards the other, the elaſtic part acts with a ſuperior force over the other, in the proportion as the other has leſs elaſticity. This other being alſo leſs upon the ſtretch, is overcome by that which is more ſo; which is always the end next to the heart: for the muſcular part relaxes, requiring hardly any force to diſtend it; and indeed, as the muſcular power has contracted the artery, within its middle, or ſtationary ſtate; and this more and more, as we get into ſmaller veſſels, the muſcular coat is at firſt ſtretched by the recovery of the elaſtic power; ſo that the blood paſſes into the ſmaller branches with much leſs reſiſtance than it would have done if the veſſels had been elaſtic in proportion to their ſize. Theſe proportions, however, in the blood's motion, ariſing from the elaſtic power of the arteries, will not be the ſame in the fœtus, and adult; and will be ſtill more different in the aged ſubject: for in this laſt the elaſtic power of the artery is diminiſhing, as well as the muſcular, the coats becoming more rigid: beſides which, the veſſels vary from a conical ſhape, (whoſe apex is at the heart, and baſis at their extremities) towards a cylinder; and this change is alſo increaſed by the loſs of many of the ſmaller veſſels; ſo that as we grow up, the baſe of the cone is gradually diminiſhed from two cauſes.

The elaſtic power will allow of a quantity of blood in the animal, beyond the natural ſtate of the artery; and the muſcular power will allow of a ſmaller, without the animal being affected, although the muſcular alone would have anſwered both theſe purpoſes. Arteries then are the conductors, and diſpoſers of the blood; as conducters, they are in every animal above fiſh, both paſſive, and active; paſſive, in admitting of the propelling power of the heart; and active, in continuing that power to the extreme part.

Beſides theſe reaſons for a difference in the velocities of the blood, at different diſtances from the heart, I conceive there is a material difference between the velocities of the blood, in thoſe veſſels which carry red blood, and thoſe which carry only the coagulable lymph, and the ſerum; for where the red blood goes, there is a quicker return, than where there is only the coagulable lymph, and ſerum. For this, there are two reaſons, viz. that where the red blood paſſes, it is commonly nearer to the heart, while the other parts go to a greater diſtance: but, beſides this, the veſsels which carry the red blood, are larger, and I believe ramify more quickly; the velocity therefore of the blood, is greater in them. Where the lymph and serum pass only, the velocity of the blood is languid, and it appears merely to carry nourishment, such as in tendons, ligament, etc.

So far we are to consider the above as a general principle arising out of the construction of a blood-vessel; but they are secondary, or collateral circumstances, acting so as to accelerate, or retard, the blood's motion.

Since the solids and fluids have a mutual dependence on each other, and since the solids answer various purposes, for which, quantity, velocity, etc. are peculiarly necessary, we find that this intercourse between the two is with great exactness kept up. I have already observed that the angles, by which branches of an artery arise, either retard or allow of a freer motion in the blood; but Nature appears to have taken still more care in retarding the blood's motion, where velocity might do mischief. She seems also to have taken more care about the blood's motion in some parts than in others: as for example, in the brain; a part which probably cannot bear the same irregularity in quantity, or velocity, of the blood, as many other parts of the body. I should suppose, that by sending four arteries to the brain, instead of one, or which would have been more regular, two, the force of the motion of the blood is broken, as well as by the winding course of the internal carotid arteries. The verterbræ, likewise, are intended, we may suppose, to prevent a too great velocity of the blood; both because the artery is longer than it need be, and the blood is hindered from moving in a straight line: but besides the serpentine course of the arteries of the head, they pass through a bone; but principally the carotids, where the bony canal is closely applied to the coats of the ar ery; so that there can be no pulsation here, but a greater velocity of the blood in those parts, and probably less in the brain. This I should suppose retards also the motion of the blood in the brain; because the blood passing through a smaller place than common, must meet with a greater resistance, and therefore a small quantity must pass through this part in a given time, so that the pulsation of the arteries in the brain should be less than any where else: for we may suppose, that the motion is considerably lost by the blood coming into an elaſtic canal of the ſame diameter, with that through which it paſſed, before it came into the bony canal. If then this motion is loſt, and the quantity of blood is really leſſened in a given time, its motion muſt be more regular, and the pulſation leſs.

In ſome animals, the carotid artery is found to divide and ſubdivide, forming a plexus, and the branches unite again before it goes to the brain. This is called, rete mirabile; and in animals, which have it, will certainly break the force of the blood's motion: but ſince it is not univerſal, ſome peculiar purpoſe muſt be anſwered by it. It is not in the horſe, and aſs, for inſtance; but it is in the lion. Where the veſſels anaſtomoſe, there is alſo a conſiderable retardation to the blood s motion; and they are found to anaſtomoſe a good deal on the pia-matter, before they enter the brain; but I believe not within its ſubſtance.

X. OF VEINS.

THE veſſels* carrying the blood from any part of the body towards the heart, are called the veins: they are more paſſive than the arteries; and ſeem to be from their beginning, to their termination in the heart, little more than conductors of the blood to the heart, that it may receive its ſalutary influence from the lungs. However, this is not univerſally the caſe, for the vena portarum would ſeem to aſſume the office of an artery in the liver, and therefore becomes an active part; and we have many veins formed into plexuſes, ſo as to anſwer ſome purpoſe, not at all ſubſervient to the circulation; but ſtill in this reſpect, they are not to bereckoned active. They differ from the arteries in many of their properties, although in ſome they are very ſimilar.

They do not compoſe ſo uniform, or regular a ſyſtem of veſſels, as the arteries, either in their form, or uſe, being

* A vein is commonly a canal, eſpecially that which carries red blood; but in many animals it is entirely cellular yet I uſe the word as a general term, when applied to the blood.

subject to considerable variety in their uses, which are, however, passive, not active; and often answering, from their construction, collateral purposes.

The coats of the veins, upon the whole, are not so thick as those of the arteries; but differ materially in different situations of the body. Thus they become thinner, and thinner, in proportion to their size, the nearer to the heart: however, this is not equally so through the whole venal system, but principally in the depending veins, as those of the extremities, more especially the lower in the human, and still more so, the nearer to the extreme parts. In such parts it is often difficult to distinguish the vein from the artery: yet this is not to be remarked in the veins of ascending parts, or those coming from the head, or such as are horizontal, especially in the human subject; and in animals who have a large portion of their body horizontal, there is a little difference in the coats of such veins at different distances from the heart. I suspect the muscular powers are much greater in what may be called ascending veins, than either descending, or horizontal: and I believe, in general, it is very considerable; for if we look at the back of our hand, and compare their size in a warm day, or before a fire; and in a cold day, they hardly appear to be the same veins. They are not so strong in their coats as the arteries, and their strength is in an inverse proportion to their size in the extremities; and the reason is very obvious. They are more dense in their coats than the arteries, yet in the dead body they seem to admit of the transudation of the blood; for when there is the least degree of putrefaction, we can trace the veins with the eye, on the skin, as if very large, the cellular membrane and the skin being tinged for some way on each side of the vein. In the liver, we find injections escaping the vena cava hepatica, and getting into its substance in a peculiar manner. They have nearly the same elasticity with the arteries.

They are similar to the arteries in their structure, being composed of an elastic, and muscular substance; the elastic in some degree preserving a middle state, although not so perfectly as in the arteries. The muscular power adapts the veins to the various circumstances which require the area to be within the middle state, and assists the blood in its motion towards the heart.

The coats of the veins themselves are vascular; although not very much so. The arteries arise from the nearest small ramifying arteries; and the corresponding veins do not terminate in the cavity of the vien to which they belong, but pass off from the body of the vein, and join some others from different parts; and at last terminate in the common trunk, some way higher.

On laying open the jugular vein of a dog, and closing up the wound for some hours, and then opening it, I observed the vessels of this part very distinctly. They were becoming inflamed, therefore turgid; and I could easily distinguish between the arteries and veins, by the colour of the blood in them.

Veins have interruptions in their cavities, called valves. They are thin inelastic membranes, of an exact semilunar form; their unattached edge being cut off straight, not curved, as in those of the arteries; and this is, because there are only two of them, whose circumference adheres to the sides of the vein. They are not placed in a transverse direction, so as to cut the axis of the vein perpendicularly; but obliquely, as the valves at the beginning of the arteries, making a pouch, whose mouth is turned towards the heart. They are attached in pairs, the two making two pouches, whose edges come in contact. In the larger veins of many animals, as the jugular veins of a horse, etc. there are often three valves, as at the beginning of the aortas but not so completely formed: these valves as it were, cut the veins into two at this part. These two valves are not always of equal size. At this part there are always two swellings in this form; but I believe more in the adult, than in the young subject. They are not formed from a doubling of the internal coat, as has been imagined; for the internal coat is elastic; but the valves are rather of a tendinous nature; from this circumstance, together with their shape, and their mode of attachment to the sides of the vein, they always do their office whenever the vein is full, in the same manner as the valves of the arteries. The valves of the veins are chiefly in the extremities, jugular veins, and the veins on the exterior parts of the head; but never in the veins of the brain, heart, lungs, intestines, liver, spleen, nor kidnies.

Where a smaller vein opens into a larger, there is often a valvular structure at the acute angles; but this is not constant.

The veins, taken altogether, are much larger than the arteries; but in the extremities, the veins that attend an artery, are sometimes less. Nevertheless, there are commonly two of them; but besides these, there are superficial ones, which are much larger than those deeply seated. The best way, however, of judging, is by comparing them with the corresponding arteries, where there are no supernumery veins, as in the intestines, kidnies, lungs, brain, etc. we find that they are larger than the arteries; and this too, where a considerable waste has taken place of the arterial blood in the different secretions.

From this circumstance the blood's motion in them is slower; and they allow a greater quantity to be in the body at all times.

There is a greater number of trunks of veins in the body, than of arteries, at least visible veins; for wherever there is an artery, in common there is a vein; and in many places too, one on each side, which sometimes make a kind of plexus round it; besides, there are many veins where there are no corresponding arteries, as on the surface of the body; for in the extremities many of the larger veins pass superficially; but those become fewer and fewer towards the trunk of the body. They are numerous also in the neck of the human subject; but in some of the viscera, as the intestines, the veins and arteries correspond in number very exactly. Dr. Hales, however, in his Staticks says, that he has seen a number of arteries throw their blood into one vein, which, if true, shews that there are more small arteries than veins.

Although veins generally attend the arteries, there are some exceptions, even in corresponding veins, as in the piamater; but they cannot all attend the arteries, there being more superficial veins on the extremities, and neck; but the large trunks do. The supernumerary veins are not so regular as those that attend the arteries, being hardly alike in two people.

The veins may be said, upon the whole, to accompany the arteries; and it is most reasonable that this should be the case, since both perform the same office of conducting the blood, the same course must answer equally in both: this, however, is not universally the case, some veins being intended for particular purposes, as the vena portarum; some forming bodies, as the penis, plexus retcformis, and others varying their course for convenience, as in the brain; the veins of this viscus taking in general a very different course from the arteries, but this is principally in the larger veins of the brain; for the smaller, which are in the substance, accompany the arteries. The intention of this seems to be, that the largest veins, called the sinuses, should be so formed as not to be compressible; probably that there should be as little chance as possible of any stoppage to the circulation of the blood in this part. But in some parts of animals they vary their course from the arteries, where we do not so well see the intention, because it is not the case in others. Thus the veins in the kidnies of the cat kind and hyæna have the veins, in part, passing along the surface in the external membrane, like the sinuses in the brain. Veins seldom or ever take a serpentine course, because a retardment in the blood's motion in them answers no particular purpose in the œconomy of the parts; and the more readily the blood gets to the heart the better. However, the plexuses, although not intended to retard the motion of the blood, answer other purposes not immediately connected with the circulation.

Veins, upon the whole, anastomose more frequently than the arteries, especially by their larger trunks, and more particularly in the extremities; for we often see a canal of communication going between two trunks, and one trunk shall divide into two, and then unite again. Where the veins and the arteries correspond, their anastomoses are nearly the same. I believe they do not anastomose in the lungs or liver; however, the veins corresponding to the arteries, do not always follow this rule; for the veins in the spleen and kidnies anastomose in very large trunks, while the arteries do not at all. This of the larger veins anastomosing more frequently, is because a vein is more easily compressed, and the blood has a ready passage into another; besides, the valves render it more necessary, for when the blood has got past a valve, it cannot take a retrograde course, but may take a lateral: and indeed it is principally in those veins which have valves that we find those large anastomosing branches; by this means the blood gets freely to the heart.

As the area of all the veins is larger than that of the arteries, the blood will move more slowly through them; and this is evident from every observation that can be made. It may be observed in the large superficial veins in the extremities of the living body, and the difference of velocity in the blood flowing from a vein and artery in an operation is very great. The blood, however, moves with a good deal of velocity in a vein: for if we stop the circulation in the beginning of any of the superficial veins of an extremity, and empty the vein above, immediately upon removing the finger the blood will move along the vein faster than the eye can follow it; yet its motion is so slow as to allow the blood to lose its scarlet colour, and acquire the modena red; and this more so as it passes on to the heart.

The blood moves more slowly in the veins than in the arteries, that it may come into the right auricle more slowly; for if the two venæ cavæ were of the same size with the aorta, the blood would have the same velocity in them which the auricle, as it is now constructed, could not have borne: but it may be probable, that the blood is assisted in its passage into the auricle by a kind of vacuum being produced by the decrease of the size of the ventricles in their contraction.

From the number of anastomosing branches, especially by larger trunks, from the blood being liable to temporary obstructions in many places, and also moving with little force, its course becomes often very irregular, and undetermined; much more so than in the arteries.

The first cause of the blood's motion in the vein of a quadruped, is the force of the heart; for I think we must suppose that the heart can, and does carry on simple circulation; because in paralytic limbs, where voluntary muscular action is totally lost, and where, I conceive, the involuntary is very weak, the circulation is continued, although, I believe, with much less velocity than in perfect and sound parts: besides, we have observed, that the arteries continue the motion of the blood in them where the heart either fails to do it, or where an increased motion may be wanted. The arteries, therefore, will assist the heart in propelling the blood through the veins; however, it is assisted by collateral causes. The second cause, is their muscular contraction; which most probably is in the direction of the blood's motion, assisted by lateral pressure of all kinds; because the valves will favour this course wherever they are. However, as the valves are not universal, the motion of the blood in some veins must be carried on without them, and therefore they are not absolutely necessary.

Since we see the veins assuming the office of arteries in the liver of quadrupeds, birds, amphibia, and fish, and much more so in many of the inferior orders of animals, the motion of whose blood is first derived from the heart, we must suppose that veins have considerable power in carrying on the circulation; but the resistance being continually removed at their termination into the heart, will direct and assist the blood's motion in that direction, more especially when influenced by the action of the vessels themselves, or any lateral pressure. In those veins which are accompanied by the arteries; the pulsation of the artery assists in propelling the blood towards the heart; more especially where there are two or more attending an artery.

When treating of the motion of the blood, in the arteries, I observed that its motion was not in an uniform stream, but interruped, which arose from the heart's action; but as it receded from that viscus, that its motion gradually became more uniform, till at last it was nearly a continued stream. However, it is not certain, but an alternate accelerated motion is continued into the veins, immediately from the heart, although it may not be an easy undertaking to ascertain this: for simply observing an accelerated motion in the blood of the veins, more especially the small ones, does not prove that this was an alternate increase immediately from the arteries.

Every artery has a pulsation in itself, immediately from the heart; but a secondary vein, or one that is a third or fourth in order of size cannot, because it has more than one cause acting upon it: for such vein is receiving the impulse of the heart at very different times, owing to the larger trunk receiving blood by a number of smaller veins that come from a variety of parts: so that if the trunk was to receive it by starts from the smaller veins, it would only be a tremor, or confused motion. This is a reason why this cause could produce none in the secondary veins. The fact is, however, that there is a pulsation in the veins;

for when we bleed a patient in the hand, or foot, we evidently see a strong jet, much more in some than in others; and much more here than in the bend of the arm. The query is, Does this arise from the immediate stroke of the heart; or is it by the lateral pressure, occasioned by the swell of the arteries? To ascertain this the better, it is necessary to observe several things: we may remark that the pulsation in the veins is more in some parts than in others: thus I should suppose it was more in the veins of the kidney, spleen, lungs and brain, especially the last, than in many other parts: but this from the lateral swell of the arteries cannot, from the above observations, affect all parts alike; for the veins on the back of the hand being superficial, and not surrounded with vascular parts, could not be affected by arteries: but still it may arise from the lateral swell of the smaller arteries; and this acceleration, given to the blood's motion in the smaller veins, is carried to those on the back of the hand. But I think I have seen the difference in the projection so great, that it hardly could arise from that cause alone: and, indeed, if this was the only cause, we should have it in some degree in every vein; for every vein is so far surrounded as to be in some measure affected from the swell of the arteries of the part: but we certainly do not perceive it in so great a degree in the bend of the arm. The larger veins, near to the heart, have a pulsation which arises from the contraction of the heart preventing the entrance of the blood at that time, and producing a stagnation. This I saw very evidently in a dog whose chest I opened, and produced artificial breathing: but I could not say whether this arose from the contraction of the auricles, ventricles, or both: but the vena cava superior has a contraction in itself, in both dog and cat, and, probably, in the human subject. Even breathing produces a stagnation near the thorax; for during inspiration the veins readily empty themselves; but in expiration there is a degree of stagnation. Coughing, sneezing, or straining, in any way where the thoracic and abdominal muscles are concerned, produces this effect.

I think it is probable, that where there is an universal action of the vascular system, the actions of the arteries and veins is alternate. That when the arteries contract, as in many fevers, the veins rather dilate, more especially the larger.

PART II.

CHAPTER I.

UNION BY THE FIRST INTENTION.

I May obſerve, that all alterations in the natural diſpoſitions of a body are the reſult either of injury or diſeaſe; and, that all deviations from its natural actions ariſe from a new diſpoſition being formed.

Injury is commonly ſimple; diſeaſe more complicated.

The diſpoſitions ariſing from theſe are of three kinds; the firſt, is the diſpoſition of reſtoration in conſequence of ſome immediate miſchief, and is the moſt ſimple.

The ſecond is the diſpoſition ariſing from neceſſity; as for inſtance, that which produces the action of thickening parts, of ulceration, etc.

This is a little more complicated than the former, as it may ariſe both from accident and diſeaſe, and therefore becomes a compound of the two.

The third is the diſpoſition in conſequence of diſeaſe; which is more complicated than either, as diſeaſes are infinite. Yet many local diſeaſes although complex in their natures, are ſo ſimple in their extent, as to allow the removal of the diſeaſed part, becoming when that is done; ſimilar to many accidents.

As diſeaſe is a wrong action of the living parts, the reſtoration to health muſt firſt conſiſt in ſtopping the diſeaſed diſpoſitions and actions, and then in a retrograde motion towards health.

In treating ſyſtematically of ſuch complaints as are the object of ſurgery, we ſhould always begin with the moſt ſimple, and advance gradually to the more complicated, by which means we ſhall be more clearly underſtood.

There are many complaints requiring the attention of a ſurgeon, which cannot be called diſeaſe, becauſe having been produced by ſomething foreign to the body, as in accidents, they are to be conſidered as a violence committed upon it, altering in ſome degree the ſtructure of parts, and conſequently interrupting the natural operations already deſcribed.

The parts ſo hurt not being able to purſue their original or natural mode of action, are obliged to deviate from it; and this deviation will vary according to the nature of the violence, the nature of the part, and the ſtate of the conſtitution at the time.

An alteration in ſtructure requires a new mode of action for its reſtoration; as the act of reſtoration cannot be the ſame with what was natural to the parts before any alteration had taken place.

The alteration of ſtructure by violence, requires only the moſt ſimple change in the natural action of the part to reſtore it; and of courſe the moſt ſimple method of treatment by art, if it be ſuch as to require any aſſiſtance at all; for there are many accidents where none is neceſſary.

It will be proper to obſerve here, that there is a circumſtance attending accidental injury which does not belong to diſeaſe, viz. that the injury done, has in all caſes a tendency to produce both the diſpoſition and the means of cure.

The operations of reſtoration ariſe naturally out of the accident itſelf; for when there is only a mechanical alteration in the ſtructure, the ſtimulus of imperfection taking place, immediately calls forth the action of reſtoration; but this is contrary to what happens in diſeaſe; for diſeaſe is a diſpoſition producing a wrong action, and it muſt continue this wrong action till the diſpoſition is ſtopped, or wears itſelf out; when this ſalutary effect, however, has once taken place, the ſtate of the body becomes ſimilar to that in a ſimple accident, viz. a conſciouſneſs of imperfection is excited, which produces the action of reſtoration.

In injuries arifing from accident, we have hitherto fuppofed that the parts have no tendency to any difeafed action, independent of the accident; for if they have, it is probable that fuch a tendency may be ftronger than the difpofition for reftoration, and in that cafe they will fall into the peculiar difeafed action, as was explained when treating of fufceptibility. Let us take the fcrophula and cancer as examples, and we fhall find, that if a part be hurt, which has a ftrong tendency to fcrophula, it will, moft probably run into the fcrophulus mode of action, in preference to that of reftoration; and therefore, we have many joints, when injured, affuming the fcrophulous action, called white fwelling; or if a woman, beyond thirty years of age, receives a blow on the breaft, it is more likely to acquire the cancerous mode of action, than that of reftoration; which fhould be well diftinguifhed from what is immediately confequent, viz. the inflammation; for on this depends a knowledge of difeafes.

Although accident may be faid to produce an effect on a part (whatever that effect may be) which has a tendency to its own cure, yet there are often not only immediate confequences arifing from that effect, as inflammation; and again, the confequences of this inflammation, as fuppuration; but the bafis of difeafes are alfo frequently laid by it, not by producing them immediately or naturally, but by exciting fome fufceptibility of the conftitution, or of a part, into a difpofition for a difeafe, which may be latent for a confiderable time, and then come into action.

Thus fcrophula, cancer, etc. often arife from accident, even where the parts in confequence of the injury have gone through the immediate and the fecondary ftages of a cure.

Thofe effects of accident which arife from the nature of the parts hurt, may be divided into fuch as take place in found parts, and fuch as effect parts already difeafed. The firft is what I fhall at prefent treat of, the fecond, being connected with difeafe, is not to our prefent purpofe.

The injuries done to found parts, I fhall divide into two forts, according to the effects of the accident.

The firft kind confifts of thofe in which the injured parts do not communicate externally, as concuffions of the whole body, or of particular parts, ftrains, bruifes, and fimple fractures, either of bone or of tendon, which form a large divifion. The fecond confifts of thofe which have an external communication, comprehending wounds of all kinds, and compound fractures.

Bruiſes which have deſtroyed the life of the part, may be conſidered as a third diviſion, partaking, at the beginning, of the nature of the firſt, but finally terminating like the ſecond.

I. OF INJURIES, IN WHICH THERE IS NO EXTERNAL COMMUNICATION.

The injuries of the firſt diviſion in which the parts do not communicate externally, ſeldom inflame; while thoſe of the ſecond commonly both inflame and ſuppurate. The ſame operations, however, very often take place in both, though the order in which they happen is reverſed; the firſt becoming like the ſecond, by inflaming and ſuppurating; and the ſecond being in many caſes, when properly treated, brought back to a reſemblance of the firſt, and united by the firſt intention; by which inflammation and ſuppuration are prevented. But when the life of a part has been deſtroyed by the accident, it muſt neceſſarily ſuppurate; and therefore theſe injuries will be rendered ſimilar, in this reſpect, to thoſe of parts which communicate immediately, and have not been united by the firſt intention.

That injury which in its nature is the moſt ſimple, and yet calls forth the actions of the part to recover from it, is a degree of concuſſion*, where the only effect produced is a debility of the actions or functions of the whole or part, ſimilar to that occaſioned by a bruiſe, in which the continuity of the ſubſtance is not interrupted; in ſuch a ſtate the parts have little to do, but to expand, and reinſtate themſelves in their natural poſition, actions, and feelings; and this is what happens in concuſſion of the brain.

The rupture of a ſmall blood-veſſel is, perhaps, the next in order of ſimplicity; where the continuity of the part is broken, extravaſation takes place, and the blood is diffuſed into the common cellular membrane, into the interſtices

* Here I mean concuſſion as a general term, not confining it to the brain.

of some part, or into a circumscribed cavity. But should the vessel be either very large, or essential to life, such as are femoral, bracheal, or coronary arteries; or should the rupture take place in a vital part, as the brain, or in interstices or cavities belonging to a vital part, as in the cavities of the brain, or pericardium, in all such cases the injury may kill from the extravasation alone, however inconsiderable may be the original mischief.

The operation of restoration in this case, when the vital parts are not concerned or disturbed, consists first in the coagulation of the extravasated blood between the ruptured parts, laying, as it were, the foundation of union, next in closing the ruptured vessel, or in promoting its inosculation, and sometime after in bringing about an absorption of the superfluous extravasated blood. If the vessel close, that effect is produced by the muscular contraction of its coats; but in what way it inosculates, whether by the two orifices when opposed having a mutual attraction, and instead of contracting the two portions of the ruptured vessel elongating, so as to approach each other reciprocally and unite*; or whether a new piece of vessel is formed in the intermediate coagulable lymph, is not easily determined.

Inosculation, however, can only take place where the extent of the parts divided is not great, and the opposite surfaces remain near each other; but even then it is most probable that we must in part ascribe to another mode of union the communication of vessels which takes place be-

* Inosculation is a term commonly used by writers, but whether it was derived from theory or observation is not material. The very few instances where it can be observed, together with the want of accuracy in those who first introduced the term, would incline me to think that it arose from theory, or opinion only. I never could get an opportunity of observing it in all my experiments, and observations on inflammation, except in the coats of the eye In many inflammations of that organ, we find an artery or arteries passing from the tunica conjunctiva to the cornea and ramifyi g on that part. These have been often cut across to prevent the influx of blood; the two ends are seen to shrink, but in a little time they are again perceived to unite, and the circulation to be carried on as before. In this there can be no deception; and to perform, therefore, such an operation effectually, a part of the vessels should be removed.

tween the two divided ſurfaces; for where inoſculation does not, or cannot take place, the union of the ruptured veſſels is produced by the coagulation of the extravaſated blood of this part, which becomes vaſcular.

That the blood becomes vaſcular, is clearly ſhewn in the caſe of the blood extravaſated on the teſticle.

The ſuperfluous extravaſated blood is taken up by the abſorbents, by which means the whole is reinſtated as much as it is in the power of the parts to do it. I may obſerve here, that the power of recovery in the arteries is greater nearly in proportion to the ſmallneſs of their ſize, which is combined with ſeveral cauſes, viz. their diſtance from the heart, their elaſticity, their diviſion into ſmaller branches, and their accumulated diameters becoming larger, which allows them to recover. Secondly, there is an increaſed power within the ſmaller artery itſelf abſtracted from the above circumſtances.

This includes a great variety of caſes, and the moſt ſimple difference which can happen between them will be owing to the magnitude of the ruptured parts, or to a difference in the parts themſelves; or to the magnitude of the injury; or to a difference in the effects. It will comprehend ſimple fractures of all kinds, broken tendons, as is often the caſe with the tendo-achilles; even many injuries of the brain producing extravaſated blood, which is probably the only way in which the brain can be torn when there is no fracture.

Some of theſe will often require art to reinſtate them in the natural poſition, out of which they may have been put by the accident, or by ſome peculiar circumſtance attending the nature of the part, as we ſee in a fracture of the patella, or broken tendon, where the upper part being too far pulled up by the muſcles, it muſt be reinſtated by the hand of the ſurgeon, to bring the parts into a ſituation more favourable to their recovery.

But extravaſations, even from the moſt ſimple accidents, are often ſo ſituated as to obſtruct the actions of life; as for inſtance, in that affection of the brain, which is called apoplexy. The ſame thing happens in extravaſations into the pericardium, or into any of the other vital parts, where little can be done, although much is wanted. In many other parts, where the actions of life cannot be affected, yet the extravaſations are often too conſiderable to allow the parts to go through their proper modes of reſtoration.

The quantity of extravaſated blood being often ſo large as to diſtend the parts, and form a kind of tumor, called ecchymoſis, of which I ſhall now treat.

The extravaſated blood in ſuch caſes being the only viſible complaint, to remove it is the cure, which may be effected by abſorption; or, if neceſſary, by an operation.

An ecchymoſis we may conſider as of two kinds, one in which the blood coagulates when extravaſated, the other where it remains fluid; but this diſtinction makes little difference in the diſeaſe itſelf, and of courſe little in the mode of treatment; it ſhould be obſerved, however, that the firſt kind, for the moſt part, terminates well; while the ſecond ſometimes inflames and ſuppurates.

When theſe injuries get well by the abſorption of the blood, the cure is gradual, and often takes a conſiderable time; but if the tumors become leſs and do not inflame, they ſhould be allowed to go on to perform their own cure; and even where inflammation takes place, that ſhould be permitted to advance to ſuppuration, and the tumors to threaten burſting before they are opened by art, or what I believe would be ſtill better practice, they ſhould be left to open of themſelves.

In ſome inſtances, a blow the cauſe of the ecchymoſis, may have injured the ſuperficial parts or ſkin ſo much as to produce inflammation; and under ſuch circumſtances I ſhould recommend the caſe to be treated as an inflammation ariſing from any other cauſe, without paying attention to the blood underneath. It often happens that the blow has deadened the ſkin over this blood, which deadened part, as is uſual in ſuch caſes, muſt, in a certain time, afterwards ſeparate from the living.

Where this has taken place, and the extravaſated blood has coagulated, it has often been found to remain in the cavity, as a mere extraneous body, without acting, and without even allowing the ſtimulus of an expoſed ſurface, or of an imperfect cavity to take place. The edges of the ſkin all round ſhewing the diſpoſition to contract over this blood, as if it was a living part to be preſerved, nothing has ſeemed to be wanting to finiſh the cure but the blood being alive with due powers of action.

In theſe caſes the common practice has been to ſcoop out the blood and diſtend the internal ſurface with warm dreſſings to ſtimulate it to inflammation, etc. and a ſore being the conſequence of this method it goes on as ſores commonly do. But in other caſes where the opening leading to the coagulated blood has been very ſmall, I have ſeen that without any other means being uſed the blood has been gradually ſqueezed out of the orifice by the contraction of the ſurrounding parts, till the whole cavity became ſo much contracted as to contain no more than what ſeemed to ſerve as a bond of union to the parts; and thus the cure has been completed without further trouble. The following caſe was treated in this way.

CASE.

Mrs. B—t fell backwards and pitched upon a pail which was behind her, and the left labium pudendi ſtruck againſt its handle with the whole weight of her body.

Within five minutes after the accident, the bruiſed part ſwelled to as great degree as the ſkin would allow; from which ſudden appearance of the ſwelling, and feeling of fluctuation, I concluded that blood had been extravaſated by the rupture of ſome ſmall artery. I bled her, and deſired a poultice to be applied to the part, in order to keep the ſkin as eaſy as poſſible under ſuch diſtention.

Believing the tumor to ariſe from extravaſated blood, I did not chuſe to open it, that the bleeding might be ſooner ſtopped by the preſſure of the extravaſated blood againſt the ſides of the cavity. Some hours after the accident the ſkin burſt, and a good deal of blood came away. On examining the wound I found the opening of conſiderable ſize, leading into a cavity as large as the egg of a gooſe, and filled with coagulated blood, which I did not remove for the reaſons given above, that it might aſſiſt in ſtopping the veſſels which were ſtill bleeding. The poultice was continued, the bleeding gradually became leſs; and every time I examined the part, I found the cavity diminiſhed, but ſtill filled with coagulated blood, which continued to be puſhed out of the wound, and after ſome time a ſlough came off from the bruiſed ſkin, which enlarged the ſize of the wound. About a fortnight after the accident the parts were all ſo much collapſed, as to have forced out the blood entirely, and there ſeemed only a ſuperficial ſore, not above an inch long and half an inch wide. What may it be ſuppoſed would have been the conſequence, if I had enlarged the opening, ſcooped out the blood and dreſſed the part with lint, or any other application I might think proper?

The effect of ſuch treatment would certainly have been a large ſore, nearly of the ſame ſize with the cavity; and the ſides of the cavity would have inflamed and ſuppurated. Is there not reaſon to believe that the coagulated blood, by remaining in the wound, prevented inflammation over the whole ſurface, and allowed the parts to contract to their natural poſition, ſo as to leave no other ſore than that where the ſkin had burſt and ſloughed?

This practice ſhould be generally followed in ſuch caſes of ecchymoſis.

The ſecond ſpecies of ecchymoſis is that in which the blood has not coagulated but remains fluid. This caſe, although it alſo frequently occurs, does not always terminate ſo well as the former, nor allow of ſuch a ſalutary termination, where an opening has been made, either by the accident, or by art; for then ſuppuration will be produced all over the cavity; more caution is, therefore, neceſſary to prevent an opening. It has often the appearance of an incyſted tumor; but being an immediate conſequence of ſome accident upon the part, its nature becomes readily underſtood, though ſometimes from its ſituation it has the ſymptoms of an aneuriſm attending it; neither does the cauſe of it contradict this idea.

If formed over a large artery the tumor will be attended with a pulſation; but when from this cauſe it cannot be made to ſubſide by preſſure, yet it is not, therefore, to be ſuppoſed harmleſs, as in fact it requires to be treated with great caution.

If the pulſation ſhould ariſe from the real influx of blood, this will ſoon be ſhewn by the increaſe of the tumor, and will lead to the proper treatment, viz. opening it and ſtopping the bleeding veſſel. This ſeldom happens from contuſion, the kind of accident deſtroying in ſome degree the free exit of the blood out of the artery; and if the tumor ſhould not increaſe after a certain period, even if there be a pretty evident pulſation, we may then be certain that it aſſumes this ſymptom from ſome neighbouring artery or arteries. The ecchymoſis which is produced on the head of a child during birth, has ſometimes a pulſation, ariſing from that of the brain, as the ſutures are ſtill open; and every tumor of the ſcalp, whether from a blow or any other cauſe, may be miſtaken for aneuriſm, if it appears before the fontinelle be clofed, and fhould it be opened without proper examination, may difconcert the ignorant furgeon.

That the blood does not coagulate in this fpecies of ecchymofis, muft arife from fome peculiar mode of action in the veffels, occafioned by the effects of the injury: for I apprehend that in fuch cafes, the blood dies in the act of extravafation, in the fame manner as the blood of the menftrual difcharge whenever it is effufed.

The ecchymofis which we have mentioned, as happening very commonly to children in the birth, particularly under the fcalp, requires nothing to be done; as by waiting with patience, the whole will in general be abforbed.

Although this is commonly the event in new born infants, yet ecchymofis does not terminate alike favourably in other cafes, the tumor often remaining for a confiderable time without undergoing any change, and after months, fometimes difappearing, but at other times inflaming and fuppurating.

When an extravafation of blood takes place between the fcalp and head, in confequence of a blow, which is very common, and continues fluid, we find a kind of ridge all round the bag, and by preffing all round the edge of the bag, the finger finks, fo as to give diftinctly, (we conceive) the feel of a depreffed bone; but this feeling of a depreffion following the edge of the ecchymofis all round, is a proof that it cannot be depreffion of the bone; becaufe no depreffion could be fo regular, nor would any depreffion be of the fame extent with the ecchymofis. The edge of the fcalp furrounding the ecchymofis feems to be raifed, and I believe it is; if fo, then fomething fimilar to the adhefive inflammation muft have taken place to fet bounds to the extent of the bag, and to hinder the blood from getting into the cellular membrane.

It might perhaps be the beft practice to make a fmall opening into fuch tumors with a lancet, and by letting out the blood get the fides of the cavity to heal by the firft intention. When the parts inflame and fuppurate, the cafe is to be treated as an abfcefs.

This fometimes difappears by refolution: but this being feldom permitted, the ecchymofis is reduced either to the ftate of a frefh wound, which is allowed to fuppurate, or an abfcefs; for furgeons are induced to open early, by feeing an inflammation, and feeling a fluctuation, two ftrong motives when every circumſtance is not well attended to; but in ſuch caſes I ſhould wait till I obſerved evident ſigns of ſuppuration, viz. the thinning of the ſkin over the matter, and pointing of the contents, which are the only true marks of the formation of the matter, as well as of its coming near the ſkin.

If the blow ſhould have deadened a part of the ſkin, then a ſeparation of the ſlough will take place, and expoſes this cavity ſo as to produce ſuppuration. And this is to be conſidered as a ſtep ſtill farther removed from the moſt ſimple ſpecies of injury, than where the blood coagulates.

I am not able, under ſuch circumſtances, decidedly to ſay which is the beſt practice, whether to leave the ſlough to ſeparate, or to make a ſmall opening and allow the blood to eſcape ſlowly from the cavity.

In both kinds of ecchymoſis, when inflammation has taken place in the ſkin from the violence, if it has not advanced to ſuppuration, the object of the ſurgeon ſhould be to bring about the reſolution of the tumor; when he finds there is no further increaſe of the tumor, he may conclude that reſolution is beginning to take place; which being clearly aſcertained, he is then to aſſiſt in exciting the abſorbents to do their duty, in order to take up the extravaſated blood. I believe the beſt exciting power is preſſure, which if urged beyond the point of eaſe, ſets the abſorbents of the parts to work, for the purpoſe of removing the ſubſtance which preſſes, or the part that is preſſed: but moſt commonly the body preſſing, if it be ſubject to the laws (or powers) of abſorption; and in this caſe the extraneous ſubſtance preſſing on the inner ſurface of the cavity, is the extravaſated blood which we wiſh to have removed.

The following caſes explain this.

A lady fell and ſtruck her ſhin againſt a ſtone, a conſiderable ecchymoſis came on almoſt immediately, and the ſkin over it inflamed to a conſiderable degree. The blood had not coagulated, there was therefore a perceptible fluctuation underneath, and her phyſician recommended an opening to be made. I was ſent for, and on examining the part, was rather of opinion, from the ſurface being a regular curve, and no part pointing, that matter had not formed; I therefore recommended patience; the ſubſiding of the inflammation, and the application of ſuch preſſure as ſhe could bear without uneaſineſs, cauſed the whole tumor to be abſorbed.

A man was brought into St. George's Hoſpital whoſe thigh had been run over by the wheel of a cart; a very large enchymoſis was formed on its inſide, and a conſiderable inflammation of the ſkin had taken place. The blood had not coagulated, therefore a fluctuation could eaſily be felt; but as there was no appearance of pointing, ſimilar to that of matter coming to the ſkin, I was in hopes that ſuppuration was not coming on; and although the inflammation was conſiderable, I ſuppoſed that it might ariſe rather from the violence of the accident than from the extravaſation: I waited therefore the event; ſaw the inflammation gradually go off, and as that ſubſided I obſerved the tumor decay, although it was very ſlow in its decreaſe: I then directed a ſlight compreſs to be applied, after which the tumor evidently diminiſhed much faſter than before, till the whole was abſorbed.

The union by the firſt intention uſually takes place ſo ſoon after the injury, that it may be ſaid to be almoſt immediate; for when the blood has coagulated in ſuch a ſituation as to adhere to both ſurfaces, and ſo as to keep them together, it may be ſaid that the union is begun. It is not, however, immediately ſecure from mechanical violence, and the blood itſelf by loſing its power of retaining life, may likewiſe be rendered unfit to preſerve the communication with the adheſing ſurface, (by which it is connected with the body at large) and thus the union be of courſe prevented. If there be no ſuch impediment, then the union of the parts may be very quick; but it will be in ſome degree according to the quantity of extravaſated blood interpoſed; for if that be large, the whole blood will not become vaſcular, but the ſurface only which is in contact with ſurrounding parts, and the reſt will be abſorbed as in the enchymoſis. Where the quantity is ſmall, as in a ſlight wound without laceration, and where all the divided ſurfaces can be brought into almoſt abſolute contact, their union will be firm in twenty-four hours, as happens in a hair-lip, or wounds of the ſcalp.

Although under ſuch circumſtances the blood ſeems to change into a ſolid form very quickly, yet when the ſituation of the wound particularly ſubjects the parts to mechanical violence, we ſhould not truſt to this union being completed in ſo ſhort a time.

In the hair-lip, for inſtance, perhaps forty-eight hours may be required to make it perfectly ſecure, and except when the ſtitches by producing ulceration might make ſcars, there can be no harm in allowing ſuch parts even a longer time for their union. But in wounds of the ſcalp, this caution is not neceſſary; and indeed in ſuch caſes it is ſcarcely required to make ſtitches at all.

In caſes of accidental injury, whether they be in themſelves ſlight or conſiderable, in whatever ſituation or part they may have happened, if the ſalutary proceſſes, above deſcribed, go on readily, no other effect of injury, or irritation, or pain, in conſequence of nature's operations is felt. No univerſal ſympathy or fever takes place, except what ariſes from the mere injury done, but all is quiet as if nothing had happened. This is ſometimes the caſe even in a ſimple fracture of the bones of the leg, in fiſſures of the ſkull, etc. However, the magnitude of the accident often produces effects which are alarming, and more particularly when they happen to parts eſſential to life. Theſe effects are often the cauſe of much danger, the conſtitution becoming affected according to the nature and importance of the parts injured. Thus concuſſion and extravaſation affecting the brain, muſt likewiſe affect the conſtitution, from its natural action and influence on the body being diminiſhed, increaſed, or otherwiſe diſturbed. The ſame thing happens from an injury done to any other vital part of the body, and the effects will be according to the uſe of ſuch parts, or the influence which they have on the ſyſtem.

However, theſe immediate and ſalutary operations do not always take place ſimply, for they are often altered by other circumſtances; as the accident ſometimes becomes the cauſe of irritation, and produces another operation of the parts, called inflammation, which is often of ſingular ſervice, by increaſing the power of union in the broken parts.

This inflammation will generally be in proportion to the degree of injury done, the nature of the parts injured, and the ſtate of the conſtitution at the time, which in other words, is in proportion to what is requiſite for the firſt powers of union. But it ſometimes happens, that inflammation goes further than is required, and produces a variety of actions ſucceeding each other in regular progreſſion. This may occaſionally be obſerved in certain ſimple fractures, in which the extravaſated blood acting as an extraneous body, becomes the cauſe of the ſuppurative inflammation; and the ſimple is in this way brought to a ſtate reſembling the compound fracture. The inflammation, however, does not extend over all the lacerated parts, as when they are expoſed at the time of the injury, many of theſe having united by the firſt intention.

We may here obſerve, that accident of the moſt ſimple kind may produce effects which do not allow the common operations of nature to take place, as when a large blood-veſſel is broken, or when a fractured rib penetrates into the lungs, or a compreſſion of the brain ariſes from a fracture of the ſkull. But none of theſe accidents admit of the modes of cure above-mentioned, as they each require particular treatment, and therefore are not to our preſent purpoſe.

II. OF INJURIES WHERE THE WOUND COMMUNICATES EXTERNALLY.

THE ſecond diviſion of injury ariſing from accident, is where the ruptured parts communicate externally, producing effects different from the former. Theſe may be divided into two kinds, viz. wounds made by a ſharp cutting inſtrument, and contuſions producing death in the parts injured. Wounds are ſubject to as great a variety as any thing in ſurgery.

A wound is a breach made in the continuity of the ſolids of a part, beginning moſt commonly on the external ſurface, and proceeding inwards; although ſometimes its directions is from the inſide outwards, as in compound fractures. A gun-ſhot wound may be ſaid to partake of both circumſtances, as it paſſes through a part: wounds often admit of the ſame mode of cure with accidents which do not communicate externally, but then it requires the art of the ſurgeon to place them in the ſame ſituation, or under the ſame circumſtances.

A wound is either ſimple or compound; the ſimple is what I have now to explain, and is of ſuch a nature as to admit of union by the firſt intention. Of this deſcription we may likewife confider wounds which are the confequence of certain furgical operations.

The form of the inftrument by which wounds have been inflicted will alfo make a difference in their nature; for if it be fharp it will make a clean cut wound; if obtufe in its fhape, a bruifed one, and may alfo deaden a part, and the parts may likewife be torn after having been cut; all of which varieties will render a different treatment neceffary towards effecting a cure.

In the moft fimple cafes of wounds, a number of bloodveffels being divided, there is an effufion of blood, which efcaping by the wound, the internal parts are left expofed, efpecially the cellular membrane; and thefe if not brought into contact with correfponding living parts immediately, or by means of the coagulated blood, will inflame and fuppurate. Accidents of this kind differ from thofe of the firft divifion by communicating externally, a circumftance which makes them often require very different modes of treatment. In cafes where parts have been forced out of their natural fituation, they fhould be reduced, that when cured they may anfwer their natural purpofes, as in fracture, diflocation, &c.

Wounds admit of three modes of treatment, arifing from their fize, fituation, and the nature of the parts wounded. One mode is artificial, two are natural, in which laft the conftitution is allowed to perform the cure in its own way, which will be explained when we fpeak of fcabbing.

Thefe being different from the former, and from each other, it might be thought that I fhould have confidered them firft as being natural proceffes; but the firft can be put into the fame ftate with the two others, and therefore ought to precede them. For this purpofe art muft be employed by the furgeon to bring the feparated furfaces in contact; that by retaining them there till union fhall have taken place, the injury may be removed from the ftate of an expofed wound.

This treatment of frefh wounds with a view to cure them by the firft intention, is equally proper after many operations, as in accidental injuries. Inftances of this often occur after diffecting out tumors, fcalping when no fracture is found, and when trepanning has not been performed; and it has been put in practice even where the trepan has been applied. It has been employed alſo after amputations; in ſhort, wherever a clean cut wound is made in ſound parts and when the ſurfaces can be brought into contact, or where there is ſufficient ſkin to cover the part, this practice may, and ſhould be followed.

In no caſe, however, of a breach of continuity, can we entirely prevent the parts from retaining the appearance of a wound, for the breach in the ſkin will more or leſs remain, and the blood will coagulate, become dry, and form a ſcab. But this operation of nature reduces the injury to the ſtate of a mere ſuperficial wound, and the blood which is continued from the ſcab to the more deeply ſeated parts, retaining its living principle, juſt as the natural parts do at the bottom of a ſuperficial wound, the ſkin is formed under this ſcab in the one caſe as in the other; yet if the ſcab ſhould either irritate, or a part underneath loſe its uniting powers, then inflammation, and even ſometimes ſuppuration, may be produced. It is often, however, only inflammation that is produced; the ſcab here preventing the further progreſs of miſchief in the ſame manner as the ſcabbing of the pus on a ſore prevents the proceſs of ſuppuration, which becomes one of the uſes of pus.

In many of the caſes in which we mean to produce union by the firſt intention, it is not neceſſary to be very nice in ſpunging out the blood, with a view to make the two ſurfaces of the fleſh come entirely into contact, the blood itſelf anſwering a ſimilar purpoſe. In ſeveral caſes, having brought the two portions of looſe ſkin together, I have ſeen the two cut edges unite almoſt immediately, and though the cavity underneath was diſtended with blood yet it did well, the tumor gradually decreaſing as the blood was abſorbed; this is to be conſidered in the ſame light as an ecchymoſis.

When the portion of ſkin is not ſufficient to cover the whole wound, and the cut edges cannot be brought together, ſtill the ſkin ſhould be made to cover as much as it can, in order to diminiſh the ſize of the parts that muſt otherwiſe ſuppurate and form a ſore; as in conſequence of this mode of treatment, the living extravaſated blood is confined in the wound, and coagulating there, unites the two ſurfaces together.

The mouths of the veſſels are ſoon ſhut, either by inoſculation, or their own power of contraction, and by the blood becoming vaſcular, as in the former ſtated caſe of union by the firſt intention; and if there ſhould be any ſuperfluous extravaſated blood, we know that it will be afterwards abſorbed.

The blood being alive, this uniting medium becomes immediately a part of ourſelves, and the parts not being offended by it, no irritation is produced. The red particles are abſorbed, and nothing but the coagulating lymph is retained, which being the true living bond of union, afterwards becomes vaſcular, nervous, etc.

This mode of treatment by art, though an imitation of the former, can ſeldom be ſuppoſed equally complete; perhaps we ought not to expect it to be ſo in any caſe, as there are circumſtances often attending the artificial mode of treating wounds, which do not occur in the natural. The ligature uſed for tying a blood-veſſel leaves an extraneous body in the wound*; a part deprived of life by the inſtrument, etc. will become an extraneous ſubſtance, and the ſurfaces cannot always be brought into contact, ſo as to allow a perfect union to take place. In ſuch caſes, union is prevented by the blood loſing in part its living principle, eſpecially in thoſe parts next to the external ſurface; and perhaps the art employed by the ſurgeon himſelf may aſſiſt in changing the original ſtate of the wound, as the paſſing of needles and ligatures muſt always produce ſuppuration through the whole paſſage.

Theſe ſubſtances ſo circumſtanced, moſt probably become the cauſe of irritation, and conſequently of inflamtion. But if the poſition of the parts be ſuch as in any ſort to allow of union, although not readily, the inflammation will go no further than the firſt ſtage, and will even give aſſiſtance to the firſt mode of union.

The poſſibility of effecting a cure by this method is probably limited to ſome certain diſtance of time after the wound has been received, though that ſpace may admit of ſome latitude; perhaps the ſooner it is done the better; but while the blood continues to be extravaſated it certainly may be attempted upon our firſt principles of union.

* If ſuch a wound has a depending angle, and the veſſels ſhould even be tied nearer the upper angle than the lower, yet I would adviſe to bring the looſe end of the thread out of the wound at the lower, for by that means the matter will flow much more eaſily.

Where the former bond of union is loſt in a part, to produce a new one a ſecondary operation takes place, namely, inflammation; and if this is likewiſe loſt, then a third mode of union will ariſe, which is by means of granulation.

If the divided parts are allowed to remain till the mouths of the divided veſſels be entirely ſhut, inflammation will inevitably follow, and will furniſh the ſame materials for union which are contained in extravaſated blood, by throwing out the coagulated lymph; ſo that union may ſtill take place, though ſome time later after the diviſion of the parts. This inflammation I have called the adheſive; and the inflammation that precedes ſuppuration, I have called the ſuppurative inflammation. If the parts, however, continue too long aſunder, ſuppuration muſt follow, and pus is unfriendly to union. We may here obſerve, that ſuppuration takes place on expoſed ſurfaces, with a much leſs degree of inflammation and in much leſs time than on thoſe which are not expoſed, and from their not being oppoſed by living ſurfaces, which tend to bring on the adheſive ſtate, they continue it much longer.

Whether this coagulating lymph iſſues from the half cloſed mouths of the veſſels which were cut, or from the ſurface of the opened cells, is not eaſily determined; but moſt probably it is from the latter, as it comes on about the time that the ſwelling of the ſurrounding parts begins to appear. There is reaſon to ſuppoſe it to be the ſame kind of diſcharge with that which cauſes the ſwelling, and which is continued through the whole courſe of this ſtage of inflammation; for on examining the dreſſings of ſuch wounds as are allowed to ſuppurate, ſeveral days after the wounds have been made, the lint is generally adhering to the ſurface by means of the coagulating lymph; the ſuppuration not having yet ſufficiently taken place to looſen it.

When theſe operations are completed in due order, the ſimple operations of the animal are entirely confined to the part, neither the mind nor the conſtitution ſeeming in ſuch caſes to be at all affected, except that there is a feeling of tenderneſs in the part. But whatever theſe ſenſations may be, they ariſe entirely from the injury done, and not from the operation of union, unleſs when the ſuppurative inflammation comes on.

The inflammation often runs ſo high, even where the parts have been brought into contact, as to deſtroy, by its violence, that union which the extravaſated juices were intended to produce, the conſequence of which is ſuppuration at laſt.

Is it by this exceſs of inflammation that the extravaſated juices loſe their living principle, and become as it were extraneous bodies? or is it not poſſible, that in theſe caſes the inflammation may be the effect rather than the cauſe of the loſs of the living principle, by the blood firſt loſing its living principle, and inflammation ariſing from it as a conſequence?

The time requiſite to complete this union will be nearly the ſame as that of the firſt intention; and probably ſooner if there be no particular tendency to ſuppuration; but if there be, union may be ſuſpended ſome time longer, for here the uniting medium will be thrown out in larger quantity, and where the union is moſt eaſily effected, there is leſs of this medium; when two ſurfaces unite by inflammation, they are commonly in contact, or elſe moſt probably union from this cauſe would not ſo readily take place. We ſhall find in the deſcription of the adheſive inflammation, that the union of two ſides of a circumſcribed cavity is very ſoon effected, and ſoon becomes ſtrong.

There is another mode of union, which, although upon the ſame principle, yet differs with regard to the parts which are to be united.

I have hitherto explained union as taking place only in the diviſion of correſponding parts of the ſame living body, but it is equally poſſible to unite different parts of the ſame, or of different bodies, by bringing them into contact under certain circumſtances. There is ſeldom occaſion for ſuch practice; but accident, or rather want of attention, has in ſome caſes been the cauſe of union taking place between different parts of the body. The chin has been united to the breaſt, the tongue to the lips or cheek, etc. and when this happens it has commonly been through the medium of granulations. The attempt to unite parts of two different bodies, has only been recommended by Taliacotius. The moſt extraordinary of all the circumſtances reſpecting union, is by removing a part of one body and afterwards uniting it to ſome part of another, where on one ſide there can be no aſſiſtance given to the union, as the divided or ſeparated part is hardly able to do more than preſerve its own living principle, and accept of the union.

The poſſibility of this ſpecies of union ſhews how ſtrong the uniting power muſt be; by it the ſpurs of the young cock can be made to grow on his comb, or on that of another cock; and its teſticles, after having been removed, may be made to unite to the inſide of any cavity of an animal.

Teeth, after having been drawn and inſerted into the ſockets of another perſon, unite to the new ſocket, which is called tranſplanting. Ingrafting and inoculating of trees ſucceed upon the ſame principle*.

* That the living principles in two bodies which have a perfect affinity to one another, ſhould not only be a preſervative, but a cauſe of union is evident; but even in bodies which appear foreign to one another, the ſtimulus of an extraneous body is not produced where union is not intended, and cannot take place, although we ſhould at firſt ſuppoſe that the extraneous ſtimulus would be given, and ſuppuration ſucceed.

This is verified by the eggs of many inſects, which are laid under the ſkin of different animals producing only the adheſive inflammation in the ſurrounding parts; by which the ſkin is thickened and a nidus is formed for the eggs.

The Guinea worm, called vena medeneſis, is alſo a ſtriking inſtance of this; for while the animal is endowed with the living principle, it gives but little trouble, yet if killed, gives the ſtimulus of an extraneous body, which produces ſuppuration through its whole length.

Other inſtances of the ſame ſort are:

The æſtrum bovis, which lays its eggs in the backs of cattle.

The æſtrum tarendi, which lays its eggs in the back of the rein deer.

The æſtrum naſale, which lays its eggs in the noſes of rein deer.

The æſtrum hæmorrhoidale, which lays its eggs in the rectum of horſes.

The æſtrum ovis, which lays its eggs in the noſe and frontal ſinuſes of ruminating animals, particularly ſheep.

The little inſect in Mexico, called migna which lays its eggs under the ſkin; and laſtly the cheggars, which get in the feet of animals.

III. PRACTICAL OBSERVATIONS RESPECTING UNION BY THE FIRST INTENTION.

It is with a view to this principle of union, that it has been recommended to bring the ſides (or lips) of wounds together; but as the natural elaſticity of the parts makes them recede, it has been found neceſſary to employ art for that purpoſe. This neceſſity at firſt ſuggeſted the practice of ſewing wounds, and afterwards gave riſe to various inventions in order to anſwer this end, ſuch as bandages, ſticking-plaſters, and ligatures. Among theſe, the bandage commonly called the uniting bandage, is preferable to all the reſt, where it can be employed; but its application is very confined, from being only adapted to parts where a roller can be uſed. A piece of ſticking-plaſter, which has been called the dry ſuture, is more general in its application than the uniting bandage, and is therefore preferable to it on many occaſions.

I can hardly ſuppoſe a wound, in any ſituation, where it may not be applied, excepting penetrating wounds, where we wiſh the inner portion of the wound to be cloſed equally with the outer, as in the caſes of hair-lip. But even in ſuch wounds, if the parts are thick, and the wound not large, the ſides will ſeldom recede ſo far as to make any other means neceſſary. The dry ſuture has an advantage over ſtitches, by bringing a larger ſurface of the wound together, by not inflaming the parts to which it is applied, and by neither producing in them ſuppuration or ulceration, which ſtitches always do. When parts, therefore, can be brought together, and eſpecially where ſome force is required for that purpoſe, from the ſkin not being in large quantity, the ſticking-plaſter is certainly the beſt application. This happens frequently to be the caſe after removal of tumors, in amputation, or where the ſides of the wound are only to be brought together at one end, as in the hair-lip; and I think the difference between Mr. Sharp's croſs ſtitch, after amputation, as recommended in his Critical Enquiries, and Mr. Aliſon's practice, ſhews ſtrongly the ſuperiority of the ſticking plaſter (or dry ſuture). In thoſe parts of the body where the ſkin recedes more than in others, this treatment becomes moſt neceſſary; and as the ſcalp probably recedes as little as any, it is therefore seldom necessary to apply any thing in wounds of that part; the practice will certainly answer best in superficial wounds, because the bottom is in these more within its influence.

The sticking-plasters should be laid on in stripes, and these should be at small distances from each other, viz. about a quarter of an inch at most, if the part requires close confinement; but when it does not, they may be at greater distances. This precaution becomes more necessary if the bleeding is not quite stopped, there should be passages left for the exit of blood, as its accumulation might prevent the union, although this does not always happen. If any extraneous body, such as a ligature, should have been left in the wound, suppuration will take place, and the matter should be allowed to vent at some of those openings, or spaces, between the slips of plaster. I have known a very considerable abscess formed in consequence of this precaution being neglected, by which the whole of the recently united parts has been separated.

The interrupted suture, which has generally been recommended in large wounds, is still in use, but seldom proves equal to the intention. This we may reckon to be the only one that deserves the name of suture; it was formerly used, but is now in a great measure laid aside in practice, not from the impropriety of uniting parts by this process, but from the ineffectual mode of attempting it. In what manner better methods could be contrived, I have not been able to suggest. It is to be understood that the above methods of bringing wounded parts together, in order to unite, are only to be put in practice in such cases as will admit of it; for if there was a method known, which in all cases would bring the wounded surfaces into contact, it would in many instances be improper, as some wounds are attended with contusion, by which the parts have been more or less deadened; in such cases, as was formerly observed, union cannot take place according to our first principle, and therefore it is improper to attempt it.

In many wounds which are not attended with contusion, when we either know, or suspect, that extraneous bodies have been introduced into the wound, union by the first intention should not be attempted, but they should be allowed to suppurate, in order that the extraneous matter may be expelled. Wounds which are attended with laceration, although free from contusion, cannot always be united by the firſt intention, becauſe it muſt frequently be impoſſible to bring the external parts, or ſkin, ſo much in contact, as to prevent that inflammation which is naturally produced by expoſure. But even in caſes of ſimple laceration, where the external influence is but ſlight, or can be prevented, (as we obſerved in treating of the compound ſimple fracture) we find that union by the firſt intention often takes place; the blood which fills up the interſtices of the lacerated parts having prevented the ſtimulus of imperfection in them, and preventing ſuppuration, may afterwards be abſorbed.

Many operations may be ſo performed as to admit of parts uniting by the firſt intention; but the practice ſhould be adopted with great circumſpection; the mode of operating with that view, ſhould, in all caſes, be a ſecondary, and not a firſt, conſideration, which it has unluckily been too often among ſurgeons. In caſes of cancer, it is a moſt dangerous attempt at refinement in ſurgery.

In the union of wounded parts by the firſt intention, it is hardly or never poſſible to bring them ſo cloſe together at the expoſed edges, as to unite them perfectly by theſe means; ſuch edges are therefore obliged to take another method of healing. If kept moiſt, they will inflame as deep between the cut ſurfaces as the blood fails in the union, and there ſuppurate and granulate; but if the blood is allowed to dry and form a ſcab between, and along the cut edges, then inflammation and ſuppuration of thoſe edges will be prevented, and this will complete the union, as will be deſcribed by and by.

As thoſe effects of accidental injury, which can be cured by the firſt intention, call up none of the power of the conſtitution to aſſiſt in the reparation, it is not the leaſt affected or diſturbed by them; the parts are united by the extravaſated blood alone, which was thrown out by the injury, either from the divided veſſels, or in conſequence of inflammation, without a ſingle action taking place, even in the part itſelf, except the cloſing, or inoſculation of the veſſels, for the flowing of the blood is to be conſidered as entirely mechanical. Even in caſes where a ſmall degree of inflammation comes on, it is merely a local action, and ſo inconſiderable, that the conſtitution is not affected by it; becauſe it is an operation to which the powers belonging to the parts themſelves are fully equal. The inflammation may produce a ſmall degree of pain, but the operation of union gives no ſenſation of any kind whatever.

The firſt and great requiſite for the reſtoration of injured parts, is reſt, as it allows that action, which is neceſſary for repairing injured parts, to go on without interruption, and as injuries often excite more action than is required, reſt becomes ſtill more neceſſary. But reſt may be thought to conſiſt merely in abſtaining from bodily exerciſe ; this will in general be proper, as moſt parts of the body will be affected either immediately, as being engaged in the action itſelf, or intermediately by ſome connection with the injured parts. Thus, if the injury be in the limbs, and not ſuch as to prevent walking together, ſtill perſons ſhould not be allowed to walk ; and we find from the want of this caution, complaints in thoſe parts are commonly longer in recovering than in others ; for by keeping the limbs at reſt, the whole progreſſive motion is ſtopped, a thing more diſagreeable to the mind than any prevention of motion in the body. If an arm be injured, it is not ſo, the want of its uſe is not ſo diſtreſſing to the patient, becauſe he can enjoy locomotion, and may have no objection to keeping his hands quiet. Reſt is often admitted from neceſſity, as in the fracture of a leg, but ſeldom where motion is only an inconvenience. But it muſt appear, that the rupture of a veſſel requires union as well as the fracture of a bone, although the veſſel having more powers of reſtoration within itſelf than the bone, and having leſs occaſional diſturbance from other powers, eſpecially of fractures of the loweſt extremities, yet the reſt ſhould be proportioned to the miſchief which would follow from the want of it ; and this will vary according to the ſituation of parts. The ſame principle of reſt ſhould apply to every injury, although this is not often allowed to be the caſe. Thus where an injury produces inability to move a part, eſpecially if in a joint, it is from fear of the loſs of motion, not only allowed to be moved by its own muſcles, which would be the moſt proper mode, if motion at all was neceſſary, but is moved by the ſurgeon, or by his direction, who, not ſatisfied with mechanical violence, has recourſe to ſtimulants, as warm applications, in order to rouſe up the internal action of the parts, and at the very time when every thing ſhould be kept quiet till reſtoration of the injury has taken place. In many parts of the body this practice is not ſo injurous as in others, in which it may be attended with very ſerious conſequences. Thus when a man has ſuffered a concuſſion of the brain, and perhaps a blood-veſſel has given way, the mind is deranged, becoming either defective or too acute, and if theſe ſymptoms ſhould continue but a little while, the medical aſſiſtant applies bliſters to remove the effect, either forgetting, or not rightly judging the cauſe. This is even carried further, we hardly ſee a man taken with all the ſigns of an apoplexy, where a paralyſis in ſome part takes place, or hemiplegia *, but that he is immediately attacked with cordials, ſtimulants, electricity, etc. Upon a ſuppoſition that it is nervous, debility, etc. the poor body is alſo tortured, becauſe it cannot act, the brain not being in a condition to influence the voluntary muſcles; we might with exactly the ſame propriety ſtimulate the fingers when their muſcles were torn to pieces. I muſt own I never ſaw one of them which had not an extravaſation of blood in the brain when opened, excepting one, who died of a gouty affection in the brain, with ſymptoms ſimilar to apoplexy†. Such a caſe, moſt probably, would require a very different mode of treatment, therefore when it happens to be a gouty man, bliſters, to the head, feet, etc. would probably be the beſt practice; but ſurely this would not be the proper practice in a rupture of a veſſel; we ought to bleed at once very largely, eſpecially from the temporal artery, till the patient begins to ſhew ſigns of recovery, and to continue it till he might begin to become faintiſh. We ſhould give ſaline purges freely, to diminiſh impetus and promote abſorption; then great quietneſs ſhould be enjoined, and as little exerciſe of the body as poſſible, and eſpecially to avoid coughing and ſneezing. Plain food ſhould be directed, and but little of it; nor will ſuch caſes ever allow of being

* It may be obſerved here, that the only difference between an apoplexy and hemiplegia is in degree, for they both ariſe from extravaſations of blood.

† For many years I have been particularly attentive to thoſe who have been attacked with a paralitic ſtroke, forming a hemiplegia. I have watched them while alive, that I might have an opportunity to open them when dead; and in all I found an injury done to the brain, in conſequence of the extravaſation of blood. I have examined them at all ſtages, when it was recent, ſome of weeks ſtanding, others of months, and a few years, in which I ſaw the progreſs of reparation.

rouſed to action, when as much recovered in their texture as nature can accompliſh, to the ſame degree that other parts will admit of or even require.

Theſe obſervations lead us to conſider the means of relief, for, beſides reſt, it often happens that the parts can be relieved from the ſecondary conſequences of the injury, ſuch as inflamations, etc. But this leads to conſtitutional and local treatment, and will be included in the hiſtory of inflammation.

I have already mentioned that when the ſalutary effects above deſcribed take place, the conſtitution is not in the leaſt effected, yet it is proper in all caſes where much miſchief might ariſe from a failure, to pay a little attention to the conſtitution. The patient ſhould eat plain food, drink weak liquors, and have the body kept open; this treatment with reſt ſuitable to the caſe, will in many inſtances prevent evils that might otherwiſe occur and prove troubleſome.

IV. OF SCABING.

The operations which I have deſcribed prevent inflamation, eſpecially that ſort of it which produces ſuppuration; but even where the parts are not brought together, ſo as to admit of union by the firſt intention, nature is always endeavouring to produce the ſame effect. The blood which is thrown out in conſequence of the accident, and which would have united ſurfaces brought into contact, is in part allowed to eſcape, but by its coagulation on the ſurface a portion is there retained, which drying and forming a ſcab*, becomes an obſtacle to ſuppuration. The inflamation may be greater than where union can be effected, but not nearly ſo great as when ſuppuration takes place.

* A ſcab may be defined firſt, dried blood on a wound, dried pus on a ſore, a ſlough from whatever cauſe allowed to dry, mucus, from an inflamed ſurface, as in the noſe.

The blood lying on the fresh surface, although not now alive, and therefore not fitted for union with the living parts underneath, yet precludes the necessity of any further discharge as a covering to the exposed surface, which is one of the uses of pus.

This might be considered as the first mode of healing a wound or sore, for it appears to be the natural one, requiring no art; and in the state of parts beforementioned, the complete union is in some degree indebted to this mode of healing, by uniting the edges that were not or could not be brought into close contract, by means of a scab; proper attention to this has, I believe, been too much neglected.

Many wounds ought to be allowed to scab, in which this process is now prevented; and this arises, I believe, from the conceit of surgeons, who think themselves possessed of powers superior to nature, and therefore have introduced the practice of making sores of all wounds: a scab however must always be on a surface, it is only a superficial wound, or on superficial parts of deeper wounds, that scabs can form.

How far this practice may be extended, I do not know, but there are cases in which it should be discouraged, as where deep seated extraneous bodies have been introduced, as in gun-shot wounds, or where deeper seated parts have been filled; but it will answer extremely well, where the superficies only is deprived of life.

Superficial hurts are very common, on parts opposite and near to some bone, as on the head, shin-bone, fingers, etc. but more especially on the shin. In all such cases it is better to let them scab, if they seem inclined, or will admit of it; and if that should not succeed, they can but suppurate at last, and no harm is done.

In many deep seated wounds, where all the parts have remained in contact, those underneath will unite much better if the surface be allowed to scab. Some compound fractures (more especially where the external wound is very small) should be allowed to heal in the same way; for by permitting the blood to scab upon the wound, either by itself, or when soaked into lint, the parts underneath will unite, the blood under the scab will become vascular, and the union will be complete, even where the parts are not in contact.

How far this practice may be extended is not yet ascertained. A small wound doing well under this treatment is a common case, and some examples of large wounds are mentioned, though these do not so generally succeed; but I do not know that there is any danger in the attempt. In many cases, therefore, which seem doubtful, where the external contusion is not very great, or not continued of the same size as in the deeper seated parts, it may be tried.

In some of those cases which have been allowed to scab, the parts injured have appeared ready to go into inflammation; a red circle has been seen all round, produced by the irritation of the scab. Suppuration takes place underneath the scab, and the pus makes its escape from under its edges: but even in such cases, I should be cautious of treating it as a suppurating sore: I should allow it to go on, and ocasionally press the scab in order to squeeze out the pus; for it very often happens that the red circle surrounding the scab becomes of a dusky brown, which is the best sign of resolution, the suppuration diminishes, and the whole does well. But if inflammation should proceed farther and seem to be increased by the mode of treatment, it must not be urged further; the scab should be poulticed in order to soften it, that it may come off easily, and it should afterwards be treated according to the nature of the sore.

This practice succeeds wonderfully well in cases where we find applications of all kinds disagree with the skin. A person shall get a blow on the shin, which shall probably deaden a part, a poultice is then often applied, that poultice brings out pimples on the surrounding skin, these pimples increase and become sores of some breadth, the poultice is increased in breadth to cover them, new pimples arise, and so on, that I have seen a whole leg full of those sores.

In such, I always allow the wound to scab, and to accomplish this, the best way is to take off the dressings in the morning, and put on trowsers, without stockings, and by the evening the parts are scabbed; or we may powder them with lapis calam: or chalk finely powdered, and desire the patient to go bed, for the first night, with the trowsers on; where the sore has been only one, I have made a circular pad, and bound that on till the scab was formed.

The mode of aſſiſting the cure of wounds by permitting a ſcab to form is likewiſe applicable, in ſome caſes, to that ſpecies of accident where the parts have not only been lacerated, but deprived of life. If the deadened ſurface is not allowed to dry or ſcab, it muſt ſeparate from the living parts, by which means theſe will be expoſed, and ſuppuration brought on; but if the whole can be made to dry, the parts underneath the ſlough will cicatrize, and the dried ſlough will at laſt drop off. I have ſeen this take place after the application of a cauſtic, and many other ſloughs. Where this can be effected, it is the beſt practice, as it will preclude inflammation and ſuppuration, which, in moſt caſes ſhould be avoided if poſſible.

I have treated many caſes in this way, and the living parts underneath have formed a ſkin as the ſlough ſeparated. This will more readily take place where the cutis is not deprived of life through its whole ſubſtance; for it has a much ſtronger diſpoſition and powers to reſtore itſelf than the cellular membrane has to form a new cutis; indeed the ſkin formed upon entire new fleſh is very different from the original cutis; therefore as the ſkin is the part moſt liable to theſe accidents, we have the beſt chance of ſucceeding in this way when the cutis alone is injured.

This practice is the very beſt for burns or ſcalds, after the inflammation has either been conſiderably prevented, or ſubdued, by proper applications or by time, for which there probably are more remidies than for an inflammation ariſing from any other cauſe, as if there was ſomething ſpecific in ſuch cauſes. Whatever will abate an inflammation ariſing from accident, will have the ſame effect upon a ſcald or a burn; and from the diverſities of applications, we have opportunities of knowing the beſt. Oil was long an application, but which has no virtue; ſpirits has alſo been long applied, and with very good effect. The common application, which is a ſoap made with lime water and oil, ſeemed to anſwer better; and now vinegar is ſtrongly recommended, and I think with juſtice, as far as I have ſeen.

Cold leſſens all inflamations, and is a very good application where it can be applied, but it cannot be applied ſo univerſally as many others: however, cold has this diſadvantage, that the pain, although removed while under the application, occurs with double force when it is removed, much more than from any of the applications, and the reaſon is evident, for as the warmth returns, the pain is increaſed by the warmth, even in ſound parts; on the contrary, it is recommended, that when a part is burnt to hold it to the fire as hot and as long as it can be held, which undoubtedly leſſens the ſucceeding inflammation, and ſoon gives eaſe. This I have often ſeen, and probably it can only be accounted for on the principle of producing the act of contraction in the veſſels.

I have taken a bucket of cold ſpring water with me, when I have made an attempt on a waſp's neſt, and put my hand into it, after having been ſtung, and while my hand was in the water I felt no pain, but when I took it out, the pain was greater than when I put it in. This is not the caſe with other applications, for their ſpecific virtues are not counteracted by any natural circumſtance attending the body, and then they can be applied with a continuance to any part where the ſkin is thin. The bliſters commonly break, and ſo much the better, as the application can come in contact with the inflamed ſurface, but on the hand, foot, fingers, and toes, eſpecially in working people, and thoſe who walk much, the bliſters ſeldom break of themſelves; they ſhould be pricked with a needle to take off the tenſion.

When the inflammation has gone through its ſtages, then the parts ſhould be allowed to dry. This in many parts is very awkward, as when a large ſurface of the body is ſcalded, for expoſure is neceſſary, and in ſome parts it is almoſt impoſſible, as behind the ears, armpits, etc. To keep the cloths from ſticking to the parts, it is neceſſary to powder it with ſome inoffenſive powder, ſuch as lapis calaminaris, very fine powdered chalk; this does not hinder evaporation, the principle of ſcabbing; and if the diſcharge ſhould be ſo much at firſt as to moiſten the firſt powdering, then ſtrew more over the whole, till it forms a hard cruſt.

This is hardly neceſſary on the face, but it will rather dry ſooner by being at firſt powdered. In ſuch caſes nature will go on infinitely farther than if the parts had been diſturbed by our applications.

V. ACCIDENTS ATTENDED WITH DEATH IN A SUPERFICIAL PART.

In the foregoing account of injuries done to the body, and of the modes of reſtoration, we have been ſo far from conſidering inflammation as one of them, that hitherto it has been inculcated to guard againſt it with the utmoſt care.

It ſometimes, however, takes place, and is one of the modes of reſtoration when the methods abovementioned fail, as well as a mode of reſtoring parts under diſeaſe, we ſhall therefore proceed to explain its principle; but as there are accidents already mentioned, which often advance to ſuppuration, I ſhall now treat of them.

Among the diviſions of accidents, one is where death is produced in the injured parts, and where inflammation and ſuppuration muſt take place, in conſequence of the dead parts which ſeparate not being within the power of the former treatment to produce a cure; but it ſhould be remembered, that the inflammation, which is the forerunner of ſuppuration in ſuch caſes, is not nearly ſo great as even the inflammation ariſing from a wound that ſuppurates. In many accidents, ſuch as bruiſes, the ſkin preſerves its living powers, while the cellular membrane underneath has become dead; this will afterwards produce an abſceſs, and muſt be treated as abſceſſes commonly are, remembering that, in the preſent caſe, the abſceſs, after being opened, will be later in acquiring the healing diſpoſition than abſceſſes are commonly; the dead cellular membrane muſt ſeparate, which will come away like wet dirty lint.

It ſometimes happens, that in one part, the ſkin; in another, the cellular membrane only ſhall become dead; and in ſuch caſes, I have often obſerved that the bruiſed ſkin ſloughs much ſooner than the cellular membrane; an abſceſs, therefore, is frequently forming under the ſound ſkin while the other parts are healing, a circumſtance which often diſappoints both the patient and ſurgeon.

When the wound, or the dead part, is conſiderable, it is probable the treatment will, in general, be very proper, becauſe the degree of miſchief calling up the attention of the furgeon, and producing acquiefcence in the patient, he will be induced to fubmit to whatever may be thought neceffary. The beft application, at firft, will probably be a poultice, which fhould be either fimple or medicated, according to the nature of the fucceeding inflammation, and continued either till the inflammation has fubfided, and fuppuration come on fufficient to keep the parts moift, or till the flough has entirely feparated, when the fore may be dreffed according to its particular difpofition. But fuch accidents as have a fuperficial part killed, when the flough would readily feparate, and the part fuppurate kindly, are often treated improperly at firft, by the patients themfelves applying Friar's balfam, or fome fuch medicines; but thefe not being within the power of fcabbing, inflammation comes on and alarms the patient, a poultice is then commonly applied, which removes the firft dreffing, and the flough appears, which gives a difagreeable appearance to the wound, and it is fuppofed to be a foul fore. From fuch an idea various methods are employed, and the application of red precipitate, etc. but with no good effect: and the patient becomes fretted from a fore, apparently fo trifling, being fo difficult to heal; but it is impoffible that fuch a fore can heal, while there is a flough to feparate. It is, therefore, the furgeon's bufinefs to inform himfelf of the nature of the complaint, to explain it to his patient, who will then become better fatisfied, and lefs uneafy about his own fituation. When this piece of flough comes away, the fore will put on an appearance according to the nature of the conftitution, or of the part, and is to be treated accordingly.

CHAPTER II.

FUNDAMENTAL PRINCIPLES OF INFLAMMATION.

AN animal in perfect health is to be confidered as a perfect machine, no part of it appearing naturally weaker than another, yet this is not ftrictly true; but ftill if no relative action, with regard to external matter, was to take place, the machine would, in itfelf, be tolerably perfect for its own actions. As the animal, however, is employed upon common matter, and therefore liable to accidents, which interrupt the natural operations, it becomes abfolutely neceffary for its continuance, that it fhould poffefs, within itfelf, the power of repair; we find it accordingly endowed with powers of repair upon many fuch occafions; but where parts give way from their own natural actions, this mifchief cannot be repaired; becaufe, if they are not able to fuftain their own actions, they cannot recover when difeafed or injured. It is found that fome ftructures of parts more readily give way than others, and confequently are much longer in repair, either when difeafed or injured by accident. We alfo find that different fituations, of fimilar parts, give them advantages or difadvantages, with regard to their powers of reftoration. This is principally known from injuries being done to them, or in confequence of thofe injuries from the attack of a difeafe.

It is alfo fhewn in the common actions of the body, or parts, of which, in health, we have comparative trials. We never can know what a thing is incapable of doing till it gives way, which giving way is either a difeafe, or productive of it: nor can we know the powers of reftoration in the part till tried.

As a proof that parts cannot always be proportioned to the action or powers applied, which have no action within themfelves, but are only acted upon by external force, we adduce the inftances of a broken patella, or broken tendo achillis, or a thickening of the valves of the heart. In the firft, however, there is commonly another power fuperadded befides fimply the actions of the parts, viz. the body falling and being ftopped at once. In the valves of the aorta, however, and the valvula mitralis, we have the beft examples, for they become thickened from the actions of the parts themfelves; while no fuch effect takes place in the valves of the pulmonary artery, even an anuerifm proves the fame.

Where there is a difference in ftructure, there are comparative powers to refift the confequences of actions, attended with injury, fuch as their admitting more or lefs readily of thickening, ulceration, or mortifications and their comparative powers of reftoration. When we compare the powers of reftoration in mufcle, nerve, cellular membrane, ligament, tendon, bone, etc. with each other, they are found to be very different. Mufcles, fkin, and probably nerves, poffefs the greateft powers of that kind; and the cellular membrane, ligament, tendon, bone, etc. the leaft, and are, in this refpect, pretty equal among themfelves. How far elaftic ligaments have powers of refiftance and repair, I do not know, but I fhould fuppofe they had them in a very confiderable degree, from the veffels not giving way fo readily as in many of the others.

Their comparative powers become pretty evident in moft of their difeafes, but chiefly, I think, in mortification. As mortification is the moft fimple effect of debility, it gives the comparative powers of parts in the moft fimple manner. We find that mufcles, fkin, and often bloodveffels, ftand their ground, while they are deprived of their connecting membranes which has either floughed off, or ulcerated; tendons likewife flough off as far as thefe mufcles, and ftop there.

I have alfo obferved, that difference in the fituation of fimilar ftructures in the body makes a material difference both in the powers of refiftance to injuries, and of reparation when injuries have taken place. This difference feems to arife in proportion to the diftance of the parts from the heart, or fource of the circulation. Thus we fee mufcles, fkin, etc. becoming more readily difeafed in the legs than any where elfe, and more flow in their progrefs towards a cure; but this is not wholly to be laid to the charge of fituation or diftance from the fource of the circulation, fome portion of it is to be attributed to pofition, the legs being depending parts, and thofe parts which are moft diftinct happen alfo to be the moft dependent*. We find an horizontal pofition affift in the repair of fuch parts, but even then they are not equal in their powers to parts fituated about the cheft; the difference therefore is principally to be attributed to fituation, or diftance from the heart. The fame difeafe that fhewed the comparative powers between the mufcle and tendon, fhews alfo that they are equally affected by pofition; thus we fee ulceration and mortification taking place in the lower extremity, as fuch, more readily and with lefs powers of repair, than happens in parts near the cheft.

This is ftill more the cafe if the perfon be tall. This is feen by changing a limb from a horizontal pofition, in which it was eafy to a dependent one, wherein it feels pain; becaufe the new pofition increafes the length of the column of blood in the veins. I am inclined to believe that the retardation of the cure is more owing to a ftagnation of the blood in the veins, from the length of the column, than from a deficiency of the motion of the blood in the arteries. As the readinefs of a part to fall into difeafe, and its backwardnefs to admit of cure, arifes from pofition, it is in fome degree compenfated by reft and a change of the pofition.

Thefe differences in the ftructure, fituation, and pofition of parts in the body, make, I believe, but little difference in the progrefs of fpecific difeafes; the venereal difeafe, however, certainly does not make fuch progrefs in bone, tendon, etc, as in the fkin, nor does the cure advance fo rapidly in thofe parts; but both thefe effects may be attributed to another caufe, which is, that bones and tendons are more deeply feated. I believe, however, that pofition makes no difference in the difeafe itfelf, although it may have fome influence upon the power of cure, and perhaps in all fpecific difeafes, in the progrefs towards a cure; for a venereal fore is always approaching nearer and nearer to the nature of a common fore, and therefore is more and more readily influenced by what influences a common fore.

* We find in moft authors the whole laid to this, which I fhall more fully difcufs in the hiftory of opinions.

But in difeafes, for which there is at prefent no cure, as the cancer, I believe it makes no difference where it is fituated, or in what it is placed, except in the cafe of fuch parts as have a tendency to fuch difeafes, which no one of the parts abovementioned has more than another.

I have fo far confidered, in the general way, the comparative powers of different ftructures, of different fituations, and of different pofitions in fome parts of the body when affected by difeafe. Difeafe is the only circumftance which expofes thefe principles to our view, but to fee how far the fame principle was carried in natural operations, of which the moft remarkable is the growth of parts, I made feveral experiments on fowls. The firft was the common experiment of tranfplanting the fpur of a young chicken from its leg to its comb, in which experiment I always found that the fpur on the comb, when it took root, grew much fafter and became much larger than that left on the leg. This I attributed to the greater power of action in the comb than in the leg, although they are pretty nearly at equal diftances from the fource of the circulation; but probably pofition alfo favoured it, as there was no ftagnation in the veins of the head. In the power of producing fuch effects in difeafe, as well as in the growth of parts, I was then defirous to know the comparative degrees between the male and the female. I wifhed alfo to afcertain if the parts peculiar to the male could grow on the female, and if the parts of a female, on the contrary, would grow on a male.

Although I had formerly tranfplanted the tefticles of a cock into the abdomen of a hen, and they had fometimes taken root there, but not frequently, and then had never come to perfection, yet the experiment could not, from this caufe, anfwer fully the intended purpofe; there is I believe, a natural reafon to believe it could not, and the experiment was therefore difregarded*. I took the fpur from the leg of a young cock, and placed it in the fituation of the fpur in the leg of a hen chicken, it took root, the chicken grew to a hen, but at firft no fpur grew, while the fpur that was left on the other leg of the cock, grew as ufual.

This experiment I have repeated feveral times, in the fame fummer with the fame effects, which led me to con-

* Vide book on Teeth.

ceive that the ſpur of a cock would not grow upon a hen, and that they were, therefore, to be conſidered as diſtinct animals, having very diſtinct powers. In order to aſcertain this, I took the ſpurs of hen chickens and placed them on the legs of young cocks. I found that thoſe which took root, grew nearly as faſt, and to as large a ſize as the natural ſpur on the other leg, which appeared to be a contradiction to my other experiments. Upon another examination of my hens, however, I found that the ſpurs had grown conſiderably, although they had taken ſeveral years to do it; for I found that the ſame quantity of growth in the ſpur of the cock, while on the cock during one year, was as much as that of the cock's ſpur on the hen in the courſe of three or four years, or as three or four to one; whereas the growth of the hen's ſpur on the cock was to that of the proper ſpur of the cock as two to one. Theſe experiments ſhew that there is an inequality of powers in different parts of the ſame animal, and that the legs have much leſs than the comb; they alſo ſhew that there is a material difference in the powers of the male and the female. The ſpurs of a cock were found to poſſeſs powers beyond thoſe of a hen, while at the ſame time, the one animal as a whole, has more powers than the other; yet when I apply theſe principles to the powers of cure in local diſeaſes of the two ſexes in the human race, I can hardly ſay that I have obſerved any difference. It is to be obſerved, however, that women commonly live a much more temperate life than men, which certainly muſt have conſiderable influence both with regard to reſiſting and curing diſeaſes.

In all complicated animals, among which man is the moſt complex, the parts are compoſed of different ſtructures, and we find that in ſuch animals the powers of action of thoſe different ſtructures within themſelves are very different; when they are therefore excited to any common action, the varieties produced ſhould be well known and particularly attended to. Beſides, every ſimilar ſtructure in different animals does not always act in the ſame manner. Thus we cannot make a horſe vomit; nor can we give many ſpecific diſeaſes, which attack the human ſubject, to any other animal, more particularly the morbid poiſons. The mode, therefore, of action in one animal does not implicitly direct to the mode of action in another; nor does the ſame ſtructure in the ſame animal always act in the ſame way at all times: it acts at various times in a way ſimilar to the ſame ſtructure in various animals; and beſides, the ſame ſtructure varies its action in different ſituations in the ſame animal. Beſides, the exterior actions of life make a very material difference in the internal actions of animals, or in the excitement of diſeaſe, either univerſally or locally; for there are parts which cannot bear one mode of life, while there are other parts which cannot bear another. Parts and mode of life being in oppoſition with each other. A great many of theſe varieties depends upon the difference in the natural ſtrength and weakneſs of the parts; but as thoſe vary very conſiderably in different habits, ſo the varieties are increaſed; and likewiſe, as many occurrences in life produce the principle of ſtrength or weakneſs, we have thoſe varieties ſtill more increaſed, as well as diſeaſe.

Theſe obſervations, as heads, I ſhall treat more fully, but not as my principle ſubject, attending to them only ſo far as they are connected with inflammation, and may illuſtrate the varieties in that action.

I. OF THE DIFFERENT CAUSES WHICH INCREASE AND DIMINISH THE SUSCEPTIBILITY FOR INFLAMMATION EITHER IN THE WHOLE BODY OR IN PARTS.

Susceptibility for inflammation may be ſaid to have two cauſes, the one original, the other acquired. The original conſtitutes a part of the animal œconomy, and it is probably inexplicable.

Of the acquired it is probable that climate, and modes of life, may tend conſiderably either to diminiſh or increaſe the ſuſceptibility for inflammation.

The influence, however, of climate may not be ſo great as it commonly appears to be, for it is generally accompanied by modes of life that are not ſuited to others; and if we conſider how much leſs pernicious many climates are now than they were formerly, ariſing from the mode of living being different, we may be led to allow leſs influence to climate; and on the other hand, if we confider how difeafe becomes multiplied and varied in the fame climate, we fhall fee that climate alone is not attended with fo much variety as may have been fuppofed.

It is obferved by fome of the ableft phyficains of this day, that the fever called inflammatory, is now not fo common in this country as it was formerly reprefented to have been; that it is now feldom that in fevers they are obliged to have recourfe to the lancet, at leaft to that excefs which is defcribed by authors in former times. They are now more obliged to have recourfe to cordials than evacuations, and indeed the difeafe called the putrid fever, and putrid fore throat, are but of late date. I remember when the laft was called, Fothergill's fore throat, becaufe he firft publifhed upon it, and altered the mode of practice. I remember when practitioners uniformly bled in putrid fevers; but figns of debility and want of fuccefs made them alter their practice.

Whether the fame difference takes place in inflammation I do not know, but I fufpect that it does in fome degree, for I am inclined to believe that fever and inflammation are very nearly allied, that is, that either will be according to the conftitution, which is not the cafe with fpecific difeafes, excepting in their common modes of action, which confift either in fever or inflammation; but I believe we have much lefs occafion for evacuations in inflammation than there were formerly, the lancet, therefore, in inflammation, and alfo purgatives, are much more laid afide. How far climate varies the conftitution fo as to alter the nature of difeafes, I do not at prefent know; but it would appear from Dr. Blane's account, that inflammation is hardly a difeafe in the Weft Indies.

How far an alteration in the mode of life is the caufe of this difference, I will not pretend to fay, but certainly the way of life is very much altered. We certainly live now more fully than they did formerly. We may be faid to live above par. At the full ftretch of living, therefore, when difeafe attacks us, our powers cannot be excited further, and we fink, fo as to require being fupported and kept up to that mode of life to which we have been accuftomed.

A kind of conftant ftate and variety of mind may often alter conftitutions fo much as to alter the mode of difeafed action, which is much more common in fome countries than others. We may be pretty certain that this ſtate of mind often produces inflammation of the gout.

Probably there is but little power in art to concert the ſuſceptibility of inflammation; however, if the ſuſceptibility of the body be ſimilar to that of the mind it ought to be in ſome degree corrected by art. The mind is corrected by reaſon, together with habit, but the body can only have the laſt employed upon it; it might be made leſs ſuſceptible by the immediate cauſes coming ſlowly upon it, or by avoiding thoſe cauſes and even acting in diametrical oppoſition to them; this will at leaſt anſwer in the acquired ſuſceptibilities. The acquired ſuſceptibility for inflammation, or indeed for any other diſeaſe as it is acquired by art or habit, may be leſſened ſimply by a ceſſation of thoſe habits; and if the habit is of any particular kind, which is always aſcertainable, then the habit of the contrary is to be uſed, which muſt alſo be aſcertainable.

Strength and weakneſs are the oppoſites of each other, and therefore muſt have very different effects in diſeaſe. They have very different powers in reſiſting diſeaſe in their mode of action, and alſo their readineſs to terminate that action.

Strength, probably, under every circumſtance, produces good effects, or at leaſt it is always more in the power of management, by art, than weakneſs; I can conceive, however, that too much ſtrength might act with too much power, becoming unmanageable under diſeaſe that excites action.

In inflammation, when the conſtitution is ſtrong, then it will be commonly the moſt manageable, for ſtrength leſſens irritability: but in every kind of conſtitution, inflammation will be the moſt manageable where the power and the action are pretty well proportioned; but as every part of the body has not equal ſtrength, theſe proportions cannot be the ſame in every part of the ſame conſtitution. According to this idea of ſtrength, the following parts, viz. muſcles, cellular membrane, and ſkin, and more ſo in proportion as they are nearer to the ſource of the circulation, will be moſt manageable in inflammation and its conſequences, becauſe they are ſtronger in their powers of action than the other parts of the body.

The other parts, as bone, tendon, ligament, etc. fall into an inflammation which is leſs in the power of art to manage, becaufe, though the conftitution is good, yet they have lefs powers within themfelves, and therefore are attended with the feeling of their own weaknefs; and I believe they affect the conftitution more readily than the former, becaufe the conftitution is more affected by local difeafe, when the parts have lefs power within themfelves of doing well; and the effects, if bad on the conftitution, reflect a backwardnefs on the little powers they have. Strength and weaknefs of the conftitution, or of parts, are fynonymous terms with a greater or lefs quantity of animal life, or living principle joined with powers of action.

The inflammation, if in vital parts, will be ftill lefs manageable, for although the parts themfelves may have very ftrong powers, yet the conftitution, and the natural operations of univerfal health, become fo much affected, that no falutary effect can fo readily take place, and therefore the difeafe becomes lefs manageable.

If the vital part is the ftomach, or fuch as the ftomach readily fympathifes with, inflammation, in fuch parts, will be ftill lefs manageable, for no operation can go on well, either in the ftomach or in other parts, where the vifcus is affected, as the powers of reftoration become weaker than ever.

In weak conftitutions, although the inflammation be in parts which admit of the moft falutary operations, in the time of the difeafe, and in fituations the moft favourable to reftoration after difeafe, yet the operations of inflammation are proportionably more backward, as to their falutary effects, in fuch conftitutions, and more or lefs according to the nature of the parts affected, which I fhall now confider more fully.

II. EFFECTS OF STRENGTH OR WEAKNESS OF CONSTITUTION, AND OF PARTS, WHILE UNDER INFLAMMATION.

WHATEVER is to be the confequence of injuries, efpecially inflammation, is produced much more readily in a ftrong conftitution than in a weak one. A wound, for inftance, made upon a perfon of an healthy conftitution, and ſound parts, will unite almoſt at once; it admits readily of an union by the firſt intention. A greater ſtrength of conſtitution and of parts, admits of reſolution, while in the adheſive ſtate of inflammation, very readily, and therefore tends much to prevent the ſuppurative inflammation from taking place, for it gives a better diſpoſition to heal by the adheſive; ſo that the union of parts by the firſt intention, the inflammation and reſolution, as well as the readineſs to change from the one to the other, according as the preceding, is prevented, depends equally upon the ſtrength and health of conſtitution and parts inflamed. We may alſo obſerve, that a greater ſtrength and ſoundneſs of the conſtitution, or parts inflamed, when the inflammation has got beyond the ſtage of reſolution, and has aſſumed the diſpoſition for ſuppuration, haſtens on inflammation and ſuppuration, and alſo brings it ſoon to a termination, while, at the ſame time, the matter is brought more quickly to the ſkin by ulceration,

Whatever, therefore, is the ſtep which nature is to take, whenever an injury is done, or a neceſſity for inflammation has taken place, it is performed with readineſs and facility in ſtrong conſtitutions and parts.

Weakneſs of conſtitution and weakneſs of parts, are ſuppoſed to be the immediate cauſe of moſt tedious or chronic diſeaſes. It appears to be often uſed as a general term, as have alſo nervous, bilious, to denote any thing for which we cannot well account, and to which, I am certain, there has been affixed no preciſe meaning. Every action that is not acute, eſpecially a mild continuation of ſome of the ſymptoms of a former violent diſeaſe, is called weakneſs. Thus a gleet is called a weakneſs, diarrhœa is called a weakneſs, ſiour albus is called a weakneſs; none of which I conceive ſimply to ariſe from weakneſs; for I believe that weakneſs ſeldom or ever becomes an immediate cauſe of diſeaſe, or action of any kind; but it often becomes the prediſpoſing cauſe of diſeaſe, many diſeaſes not taking place, except where weakneſs is an attendant, as agues, ſcrophula, nervous, etc. none of which are ſimple weakneſs; and it may continue many diſeaſes when they have already taken place. This is, I think, very evident in many diſeaſes which would terminate well if there was ſtrength in the conſtitution to perform the right actions. However, where there is a ſtrong ſuſceptibility for any one diseafe, in which weaknefs might alfo become a predifpofing caufe, I can believe that, in fuch cafes, weaknefs, efpecially if fuddenly brought on, may become an immediate caufe of that difeafe; as, for inftance, a man may, from a wound, or any other caufe, have a ftrong tendency to a locked jaw; if you bleed that man freely, it is a thoufand to one but that a locked jaw comes on: weaknefs produces a confcioufnefs of its own want of powers, or incapacity, which produces increafed action, that even proceeds the length of unnatural actions, called nervous. Thefe effects are no lefs vifible in acute difeafes in fuch conftitutions, which include accidents, or violence, of all kinds; for they run into too violent action, which is not of a falutary kind, and therefore may be called unnatural difeafed action.

When a wound is made in a perfon of a weak habit, there is a great backwardnefs in the two cut furfaces to unite by the firft intention, therefore inflammation takes place if there be ftrength of conftitution to produce it, which is not always the cafe; fo that in fuch habits inflammation is more likely to be a confequence; but this does not arife from a greater readinefs to inflammation in the habit, but from a want of power and difpofition to heal, which renders inflammation neceffary; however, in this cafe the want of powers or difpofition to unite may partly depend upon a different principle from that of weak parts or folids; it is probable that the blood of people of weak habits is weak in its living principle, which it therefore very foon lofes upon extravafation, fo as to become unfit for a bond of union, by which it degenerates into an extraneous body, and therefore the fuppurative inflammation muft take place if there be ftrength to produce it.

In weak habits and difeafed parts, inflammation is flow in any of its falutary effects, and is hardly capable of either producing the adhefive or fuppurative inflammation; if they fhould take place, it is but imperfectly, and the furrounding inflamed parts of the fuppurating furfaces are hardly capable of refolution, but continue inflamed; we even find in many conftitutions, where the animal powers are very much weakened, that inftead of their readily running into inflammation, it is hardly poffible to promote it, even from a breach of continuity in the folids, which, in moft other cafes, is fureft of being followed by inflammation: fuch conftitutions are in general thofe which are dropfical: I have feen feveral cafes, where the power has been fo weak, that the wound, after tapping, has not united by the firft intention, nor has even acquired the adhefive ftate of inflammation, and has admitted water to pafs through it from the abdomen for feveral weeks without the peritoneal inflammation being excited. In the fame dropfical habits, I have feen fcarifications in the legs or feet not inflame, fo that the cells were not united, but continue to difcharge the water for many weeks. In fuch cafes of extreme weaknefs, this total want of inflammation would appear to be a falutary effect; for in many dropfical cafes, where the parts have powers to inflame, but not fufficient to go through the different ftages of the inflammation, and at laft refolve, as in healthy conftitutions, the inflammation generally produces a total lofs of animal powers, and the parts mortifies, which often produces death in the whole, fo that in fuch cafes the parts only act to deftroy themfelves*. As a further proof that debility is often the caufe of increafed inflammation, in confequence of any violence, and often the caufe of mortification, is plainly fhewn in Mr. Dick's account of dropfies among the troops in the Eaft Indies, Edin. Med. Com. In the firft year of the attack in any man, he durft not venture to fcarify the legs, but when they were attacked with the fame difeafe the year following, which was often the cafe, whenever he attempted to fcarify the legs, a violent inflammation and mortification were the confequence. He was in this fecond attack obliged to have recourfe to ftrengtheners; and we may obferve that, in the cafe of tapping, if the conftitution is irritable, the cavity of the abdomen commonly feels the effect, and inflammation of the peritoneum, and death is the confequence.

As the effect which this inflammation has upon the conftitution is by fympathy, it muft be in proportion to the readinefs with which the conftitution affumes that action. This fufceptibility is ftronger in fome conftitutions than in others; and every conftitution is more fufceptible of fympathy with fome parts of the body than with others.

The kind of conftitution which is leaft affected by this inflammation, is that which is in general moft healthy, where fympathy hardly takes place; this happens to be the cafe with fuch conftitutions as can moft readily perform

* Vide paper on the Recovery of drowned People.

all the different operations with eafe; and when the parts inflamed are able to manage their own bufinefs, they thereby affect the conftitution lefs; for we fhall find, that a conftitution may be affected by a local difeafe, merely becaufe it is beyond the power of the part to cure itfelf.

But it is to be obferved, that conftitutions in full vigor, or which have not been in the fmalleft degree accuftomed to local difeafe, take the alarm much more readily than thofe which are not in fuch full health, or which have been accuftomed with local difeafe. Thus, if a man in perfect health gets a very bad compound fracture in the leg, or has his leg taken off, either for this fracture or in confequence of any other accident, he ftands a much worfe chance of recovery than one who has been accuftomed to a local difeafe: even the man with the compound fracture will do much better, if his leg is not taken off, till the firft fymptoms are over; or at leaft we may be certain that the fymptoms arifing from the amputation will not be nearly fo great as thofe that arife at firft from the fracture, or would have arifen from the immediate amputation. This would appear to be a contradiction to the above pofition; but upon an accurate inveftigation I think it may be accounted for; for firft, I do not look upon full health, as the beft condition to refift difeafe; difeafe is a ftate of body which requires a medium; health brooks difeafe ill, and full health is often above par; perfons in full health are too often at the full ftretch of action, and cannot bear an increafe, efpecially when difeafed; and as I before obferved, it is a new impreffion on the conftitution, and till it be in fome degree accuftomed to local difeafe, it is lefs able to bear fuch as is violent; befides, the removal of a difeafed part which the conftitution has been accuftomed to, and which is rather fretting the conftitution, is adding lefs violence than the removal of a found part in perfect harmony with the conftitution; the difference, however, is not wholly owing to that caufe, for the circumftance of a conftitution being accuftomed to a mode of life, etc. which it is to continue, makes a confiderable difference.

III. OF PARTS OF THE BODY MOST SUSCEPTIBLE OF THE THREE DIFFERENT INFLAMMATIONS TO BE TREATED OF.

All parts of the body are ſuſceptible of inflammation, although not all equally ſo; nor will all parts of the body admit readily of the three different kinds of inflammation I mean to treat of; ſome parts admitting readily of one only, others of two, and others of all the three; which difference appears to be according to the ſituation of the inflamed parts in the body, and alſo the nature of the parts inflamed. The cellular membrane the firſt. The cellular membrane free from the adipoſe, appears to be more ſuſceptible of the adheſive inflammation, than the adipoſe membrane, and much more readily paſſes into the ſuppurative. Whether this ariſes from ſurfaces inflaming more readily than other parts, I will not pretend to ſay. Thus we ſee that the cellular membrane connecting parts together as muſcles, and the cellular membrane connecting the adipoſe to muſcles, eaſily inflames and runs readily into ſuppuration, and, as it were, ſeparates the muſcles from their lateral conexion, and even ſeparates the adipoſe from the muſcles, while the ſkin and adipoſe membrane ſhall only be highly inflamed, and the matter ſo formed muſt produce ulceration through all this adipoſe membrane, to get to the ſkin, and then through the ſkin, in which laſt mentioned parts it is much more tedious; ulceration, therefore, does not ſo readily take place in thoſe parts as it does in the common connecting membrane. Muſcles, nerves, and blood-veſſels, are parts which nature wiſhes to retain, and the adipoſe membrane contains a ſubſtance which is properly no part of the animal, viz. oil; it may therefore be more difficult for this part to be abſorbed than what are properly the parts of the animal itſelf.

As a deficiency in the power to heal becomes a ſtimulus, or an incitement to inflammation, we find that ſimilar parts, in proportion as they are removed from the ſource of the cirulation, ſuch as the lower extremities, are more ready to inflame than others not ſo circumſtanced; and what adds to this backwardneſs is their being depending parts, which adds to the incitement.

The deeper ſeated parts of the body, and more eſpecially the vital, very readily admit of the adheſive inflammation, which is proved by diſections; for we hardly ever open a human ſubject where there are not in the circumſcribed cavities conſiderable adheſions: and moſt probably many in the common cellular membrane, if they were equally viſible.

The deeper ſeated parts, however, do not in common ſo readily paſs into the ſuppurative inflammation; and this readineſs to accept of the adheſive, moſt probably becomes a cauſe why the ſuppurative inflammation does not ſo readily take place.

But if the inflammation comes on at once, with great violence, it would appear to paſs almoſt at once over the adheſive, immediately to the ſuppurative action; or perhaps where it may appear to have done this, there may be an eryſepelatous diſpoſition; for although it is not the diſpoſition of the eryſepelatous inflammation to ſuppurate, yet it has a greater backwardneſs to produce adheſions. This effect we often find take place in the abdomen, in the thorax, etc. and I have already mentioned that I ſuſpect the eryſepelatous inflammation does, in ſome degree, reverſe the common rules of the common inflammation, by being more ready to ſuppurate in deep ſeated parts than in the ſuperficial, and extend much farther towards the centre of the body.

I ſuſpect too, that the coverings of the brain, viz. pia and dura-mater, have ſomething of this diſpoſition. They appear to ſuppurate very readily, or with very little inflammation; for from a ſlight blow on the head, we find theſe membranes much oftener ſuppurate than we ſhould from a ſimilar blow on the ſhin-bone; for inſtance, a blow on this bone will only produce ſuppuration on the external ſurface, very ſeldom in its internal cavity; but a blow on the head that ſhall not even produce the adheſive inflammation in the ſcalp, ſhall make thoſe membranes ſuppurate.

Inflammation, wherever ſituated, is always more violent on that ſide of the point of inflammation next to the external ſurface.

This effect we often find take place in the abdomen, in the thorax, etc. and I have already mentioned that I suspect inflammation, wherever situated, if there be a continuity of parts between it and the external surface, will be greater on that side next to the external surface of the part, than towards the centre of the part.

This also equally takes place in inflammations, although close to the different outlets of the body, and is probably most easily demonstrated in them. Thus, for instance, if an inflammation comes on in the socket of a tooth at its root, inflammation will not take place on the inside of the jaw, but towards the outside; and if it is beyond the union of the lips with the gum, it will attack the skin over the inflamed part, while all the internal parts, such as the gums on both sides, but principally on the inside. The tongue if in the lower jaw, shall be perfectly sound.

If an inflammation attacks the cellular membrane on the outside of the gut near the anus, although the gut is in contact with the inflamed part, yet the inflammation extends to the skin of the buttock, while the gut remains pretty free from inflammation.

If an inflammation attacks the peritonæum covering an intestine, and if adhesions between it and the peritonæum lining the abdomen are a consequence, the inflammation immediately passes through the abdominal muscles towards the skin, while the proper coats of the intestines shall in most cases remain sound; however, this is not always the case, although much more commonly so than the reverse: we see the same thing in the obstruction of the natural passage of the tears called fistula lacrymalis, for there the sack and skin ulcerate on the inner angle of the eye, while the the inside of the nose defends itself by becoming thicker; so much so in many cases as to stop the cavity of the nose, and unite with the septum, which has been the cause of the failure of the operation for the fistula lacrymalis. We even find, that if an abscess forms in a frontal sinus from an obstruction in its duct, that the matter makes its way through the frontal bone externally, instead of getting into the nose.

The same observations are applicable to abscesses in the antrum, which are common cases; and indeed, if we observe accurately, we shall find that nature rather defends such parts as are either deeper seated, or on the inside of outlets, as will be explained hereafter.

The fpecific qualities in difeafes alfo tend more rapidly to the fkin than to the deeper feated parts, except the cancer; although even in this difeafe the progrefs towards the fuperficies is more quick than its progrefs toward the center. The venereal has fomething of the fame difpofition with the cancer, although not fo much. In fhort, this is a law in nature, and it probably is upon the fame principle by which vegetables always approach the furface of the earth. That this is a general principle in vegetation requires no illuftration, but what is the immediate caufe is not fo eafily determined. I conceive it might be the light, not warmth, for the ground is often warmer than the air, or furface, into which vegetables are often growing. To afcertain this, as far as I could, by experiment, I took a tub, about eighteen inches deep, and about two wide, and filled it with fine mould, in which I planted fome beans and peas; their eyes were placed in various directions, and over the furface was fpread a clofe mafhed net. The mouth of this tub was turned down, was raifed about three feet from the ground, and was fufpended between two pofts. Round the tub, and over its bottom, which was uppermoft, were placed wet ftraw, mats, etc. to take off any influence the fun or air might have upon its contents, and a fmall hole was bored in its bottom, to which was fixed a fmall long tube that came through the ftraw. This was intended for pouring fome water, if I found the earth get dry, into the tub. Under the mouth of the tub I placed looking glaffes in fuch a way that the light was thrown upon the mouth of the tub, or furface of the earth. The weather was fine; fo that through the whole day there was the reflection of the light from the looking glaffes upon the furface of the mould, which was much more powerful than day-light without the direct rays of the fun. This I continued till I conceived that the beans and peas had grown fome length, but not finding their tops coming down through the furface of the mould, I examined the contents of the tub, and found that they had all grown upwards towards the bottom of the tub, and that in thofe whofe eyes had been placed downwards the young fhoot had turned round fo as to rife up. As one experiment leads to another, I wifhed to fee how a bean would grow if kept in conftant rotatory motion. For this purpofe I put fome earth in a bafket, having the fhape of a cylinder, and about a foot diameter, with the two ends of wood for greater ftrength, through the centre of which I fixed an axis or ſpindle; in the earth I planted a bean, about half way between the ſurface and axis, with its eye to the ſurface. The baſket was laid acroſs the mouth of a large tub, with the ends of the ſpindle reſting on the edges of the tub, which were fitted to one another ſo as to allow of eaſy motion. Round the baſket was rolled ſome ſmall cord, to the end of which was ſuſpended a box, water tight; into this was put lead, ſo as almoſt to make it ſink in water, and which was ſufficient to turn the baſket round in the open air. This large tub was filled with water, and the box placed upon it, and the ſpindle with the baſket placed acroſs the mouth of the tub; a very ſmall hole was boared at the lower end of the tub, which allowed the water to eſcape, but very ſlowly; as the water ſunk in the tub the box deſcended, and as the box deſcended the baſket was turned round. This tub took about twelve hours in emptying, and during that time the ſpindle with the baſket, only turned about one and an half. The tub was repeatedly filled, and when I conceived the bean might have grown ſome inches, if it had grown at all, I examined it, and found it had grown as much as if it had been planted in the common ground, but it had no particular direction but that of paſſing in a ſtraight line from the bean, which was at firſt towards the circumference, the direction in which it was planted; but in its courſe it had met with a ſmall ſtone, which had turned it into the direction of the axis, and it had gone on in a ſtraight line in that direction. Here, as there was no fixed inducement to grow in any one direction, the bean grew in a ſtraight line, in that direction given it by chance.

This circumſtance of the deeper ſeated parts not ſo readily taking on the ſuppurative inflammation as thoſe which are ſuperficial, is ſhewn in caſes where extraneous bodies irritate any parts; for we find that extraneous bodies are in general capable of producing inflammation, but if theſe extraneous bodies are deeply ſeated, they may remain for years without doing more than producing the adheſive inflammation, by which means they are incloſed in a cyſt, and only give ſome uneaſineſs; or if they are ſuch as can be made to change their ſituation by the actions of the body upon them, as pins and needles, or from gravity, as is the caſe ſometimes with bullets, then the parts through which they paſs ſeem not to be much altered or diſturbed* : but if the ſame body was nearer to the ſkin it would produce ſuppuration. This is proved by the caſes that have occurred of people ſwallowing pins, needles, &c. they have been found to travel almoſt over the whole body, without producing any effect, except in ſome ſituations exciting ſome ſenſation ; but when they have come near to the ſkin, the very ſame ſubſtance has generally produced ſuppuration. This principle ſhews itſelf very remarkably in the cattle which feed in bleach fields ; there is not one of theſe killed without having their ſtomachs, etc. ſtuck full of pins, and no ſeeming inconvenience takes place, for they appear to be healthy, and fatten as readily as other cattle. However, it is to be remarked that theſe pins are not found in the fourth or digeſting ſtomach, therefore do not give that diſturbance to the conſtitution that might be expected. It is probable that theſe caſes of pins, etc. owe their want of power in producing ſuppuration, not entirely to ſituation, but in ſome degree to the nature of the ſubſtance, metals perhaps not having the power of irritation beyond the adheſive, for when the adheſive has taken place, the part appears to be ſatisfied.

This appears alſo to be the caſe with the introduction of glaſs, even in ſuperficial parts ; a piece of glaſs ſhall enter the ſkin juſt deep enough to bury itſelf, inflammation ſhall come on, the wound in the ſkin, if brought together, ſhall heal by the firſt intention, and the inflammation ſhall not exceed the adheſive, but rather degenerate into the diſpoſition for forming a ſack, by which means a ſack is formed round the glaſs, and no diſturbance is given to the irritability of the parts. This was the caſe with Mr. Knight, apothecary, who had a piece of glaſs three-fourths of an inch long run into the palm of his hand, and remained there for ten weeks, without any further inconvenience than retarding the motion of the hand, and ſometimes giving a pricking pain, when the ſack was made to preſs upon the points of the glaſs ; this inſenſibility, however, ariſes from

* This circumſtance of ſuch bodies moving in various directions and not towards the ſurface, is a proof of the truth of my principle, for their motion ariſes from a mechanical cauſe, and is ruled by it ; which ever way it is directed they muſt move, whether by gravitation, as is the caſe with bullets, or by the mechanical preſſure of the part upon the two ends of the pin, which will determine the motion towards the point.

a fack being formed with fuch properties, but it cannot be affigned as a caufe in the cafe of bodies moving as pins. Whether this fact, of external parts affuming the fuppurative inflammation more readily than the internal, arifes from unknown properties in the parts themfelves, or from circumftances which attend fituation, fuch as heat, cold, etc. is not eafily determined; but whatever be the caufe, the effects are good, as many fituations of inflammation, viz. the internal, would prove dangerous, if the parts were always, or often to fuppurate; of two evils, nature choofes the leaft; while on the other hand, when near the external furface, it becomes the leaft evil to produce fuppuration, in order to get rid of the extraneous matter. Accidents may be affigned as one caufe of this frequency upon the external furfaces, but the cafes of pins abovementioned, (which is accident) fhow, that even when it arifes from accident, the parts near the external furface much more readily fuppurate; and in all cafes arifing from the conftitution, or fpontaneous, the external inflammations exceed the internal, in number, violence, and extent.

IV. OF THE TWO PARTS THAT HAVE THE ORDERS OF INFLAMMATION RESPECTING PRIORITY INVERTED.

I FORMERLY divided the furfaces capable of taking on inflammation into two; the firft of thefe was the cellular membrane in general, together with the whole circumfcribed cavities; the fecond was all the outlets in the body, commonly called mucous membranes; for inftance, all the ducts of glands, and the alimentary canal.

The firft order of parts, I have already obferved, generally (if not always) take the adhefive firft in the true inflammation, and then all the three inflammations in fucceffion; for the adhefive is immediately admitted in the cellular membrane and circumfcribed cavities, to exclude, if poffible, fuppuration, where fuppuration, and of courfe ulceration, would prove hurtful.

In the following parts the order of inflammation, with regard to its being adhefive or fuppurative, appears to be inverted; as the ulcerative is a confequence either of the adhefive or of the fuppurative inflammation, it is ruled equally by both. In internal canals *, where adhefions in moft cafes would prove hurtful, the parts run immediately into the fuppurative inflammation, the adhefive inflammation in common being excluded; fuch parts are the internal furfaces of the eyelids, nofe, mouth, trachea, air-cells of the lungs, œfophagus, ftomach, inteftines, pelvis of the kidneys, ureters, bladder, urethra, uterus, vagina, and indeed all the ducts and outlets of the organs of fecretion, which all thefe parts mentioned may be in fome degree reckoned, and which are commonly called mucous membranes. In fuch parts, if the inflammation is but flight, the fuppurative in common takes place, which is almoft immediate, as it is not retarded by the adhefive ftage, which accounts for the quicknefs of fuppuration of thefe parts in many cafes. I have known a violent difcharge of pus come on the furface of the urethra only a few hours after contamination. Thefe facts are fhewn us every day in various inflammations of thofe parts, and particularly in the gonorrhœa, cold in the nofe, lungs, inteftines, etc. The matter from fuch is generally not called true matter, or purulent, but is often fo, if not always, having all the characters of pus; however this will be according to circumftances. Since thofe furfaces are, in general, fecreting furfaces, fuppuration would appear to be only a change in the fecretion; and I think I have vifibly feen, or could vifibly trace, the one change gradually leading into the other: the different parts, therefore, of which the pus is compofed, will not always be in the fame proportion, fo that the matter will feem to vary from true matter, towards that of the common fecretion of the part, and vice verfa. But this does not alter the pofition, for it is common to matter from a fore; and even common to our ordinary fecretions. If this inflammation, which produced fuppuration on thofe furfaces, becomes more violent, or has fomething of the eryfepelatous difpofition, we find that it moves from the

* I make a diftinction between an internal cavity and a canal; they are very different in their conftruction their ufes, and alfo their mode of action in difeafe are very different.

ſuppurative to the adheſive, and throws out the coagulating lymph. I have ſeen this in the inteſtines, often on the inſide of inteſtines that had been ſtrangulated in a hernia. I have been able, alſo, to produce it on the inſide of the vagina of an aſs, by injecting a ſtrong ſolution of corroſive ſublimate. But if of the eryſepelous kind, theſe ſurfaces will take on the adheſive action immediately or at firſt. This is evidently the caſe in what is called the ulcerous ſore throat; I have ſeen it in the trachea, I have ſeen it thrown up from the lungs in branches, I have ſeen it in the pelves of the kidneys, ureters, bladder and urethra.

This is contrary to the mode of action of the eryſepelatous inflammation in the cellular membrane and circumſcribed cavities, for there it hardly produces adheſions, and when it ſuppurates the ſuppuration takes place firſt. The common inflammation and the eryſepelatous would ſeem to change actions ſimilar to the adheſive and the ſuppurative, according as they are changed to places of different diſpoſitions, never acting in the ſame way under the ſame apparent circumſtances, and, therefore, ſomething ſpecifically different. As the adheſive inflammation is commonly excluded from ſuch ſurfaces in the true inflammation, ſo of courſe is the ulcerative in ſuch caſes; for it is in general only as a conſequence of the adheſive and ſuppurative having previouſly taken place, with the confinement of pus, that ulceration becomes neceſſary; for the ulcerative in ſuch caſes is a conſequence of a ſtimulus ariſing from preſſure from within.

In inflammation we ſeldom pay attention to more than the continued and the univerſal ſympathy; how far the contiguous takes place without adheſions, further than ſenſation, I am not certain. I believe it never produces inflammation without them; for we may obſerve, that a teſticle ſhall be conſiderably inflamed, and the ſcrotum not in the leaſt affected. The ſcrotum ſhall even inflame and ſlough off, without the teſticle being affected till death or expoſure takes place in the tunica vaginalis; then it becomes an expoſed or imperfect ſurface, ſimilar to the opening, or application of a cauſtic in the hydrocele; but I know that contiguous ſympathy produces a nervous tenderneſs or ſenſibility, expreſſed by the word ſore.

Thus I have ſeen complaints in the viſcera of the abdomen produce a vaſt tenderneſs in the ſkin of the abdomen; and alſo complaints of the lungs, produce a tenderneſs in the ſkin of the cheſt oppoſite to the complaint. The remote ſympathy ſometimes takes place when particular parts are inflamed.

The continued is that ſympathy which increaſes the inflammatory ſpace, by which means the inflammation ſpreads beyond the irritating point. This becomes more a ſubject of ſurgery than any of the ſympathies, becauſe it increaſes the local complaint, and it takes its peculiarities from the conſtitution at large, as well as from the nature of the parts inflamed; as much can be learned from it in an inflammation as from any other ſymptom.

The univerſal ſympathy, or conſtitutional, is where the whole conſtitution feels the local diſeaſed action.

V. THE NATURAL CAUSE OF THE ADHESIVE INFLAMMATION BEING LIMITED.

As the body is made up of diſſimilar parts, whoſe conſtruction and functions are peculiar to themſelves, yet all tending to the benefit of the whole, we find them alſo keeping themſelves diſtinct in many of their diſeaſes as long as they can; and if it is a diſeaſe ſomewhat peculiar to the part it will be kept in proportion longer confined. Thus a cancer in the breaſt will ſpread faſter in the glandular part of the breaſt than in the ſurrounding parts which may even be in contact with it. A diſeaſe taking place in any part of a lymphatic gland, will communicate its diſeaſe to the whole of that gland much ſooner than to the ſurrounding cellular membrane. Even a diſeaſe common to all parts alike, if it takes place in any diſſimilar part will keep diſtinct at firſt.

Thus an inflammation in a lymphatic gland is not taken up by the ſurrounding cellular membrane, till the inflammation has made ſome conſiderable advancement, and then it begins to inflame. Thus a lymphatic gland ſhall inflame and the ſurrounding parts ſhall not, till other proceſſes beſides inflammation are going on, viz. ſuppuration; this, however, will be more or leſs, according to the conſtitution, for if it has a ſtrong ſuſceptibility for the eryſepelatous, the diſſimilar parts will more readily ſympathize with the ſeat of the diſeaſe.

Thus the inveſting membranes have not this ſympathetic connexion with the parts which they either cover or line, nor have the parts either covering the inveſting membrane, or lined by it, any ſympathizing affection with it in the adheſive ſtages of inflammation. Thus the peritoneum is both a lining and a covering, and ſo is the pleura. If the peritoneum which lines the cavity of the abdomen inflames, its inflammation does not affect the parietes of the abdomen; or if the peritoneum covering any of the viſcera is inflamed, it does not affect the viſcera. Thus the peritoneum ſhall be univerſally inflamed, as in the puerporal fever, yet the parietes of the abdomen and the proper coats of the inteſtines ſhall not be affected; on the other hand, if the parietes of the abdomen, or the proper coats of the inteſtines are inflamed, the peritoneum ſhall not be affected.

The ſame principle will lead to diſtinctions between an inflammation of the lungs and that of the pleura; but I ſuſpect that the reticular or connecting ſubſtance, which joins the air-cells of the lungs, has a greater ſympathetic affection with the air-cells, or reciprocally with each other, than the beforementioned parts; and this may ariſe from the thinneſs of the air-cells. And it is alſo upon the ſame principle that inflammation of the pia-mater is ſeldom continued into the ſubſtance of the brain, although the pia-mater may be in ſome degree conſidered as a continuation of the ſame veſſels.

Contiguity of parts does not communicate inflammation. Thus when an inteſtine is inflamed the inflammation is not communicated to the peritoneum, lining the abdomen, although in contact; but I have already obſerved it produces ſomewhat of a ſoreneſs, even to the external touch; but if continuity by adheſions takes place, then inflammation will be continued from the one into the other.

The ſecond cauſe of the limitation of inflammation is ſimple contact. I have already obſerved, that expoſure of internal ſurfaces becomes an immediate cauſe of inflammation; and when it extends further than the ſurface of expoſure, it is then by continued ſympathy only, and that a whole cavity, if wholly expoſed, will wholly acquire the inflammation; but we may now obſerve, that although a cavity is opened and fo far rendered imperfect, yet fimple contact of its fides renders it perfect again, and fets bounds to the immediate caufe.

To explain this further, we may obferve that there is no fuch thing in an animal as empty fpace, exclufive of outlets or refervoirs, which cannot be reckoned internal or circumfcribed cavities, for they are perfect by not being fuch. Every part of the body is either connected by a continuation of one part into that of another, or by fimple contact.

This takes place equally, either in the common cellular membrane, or in the circumfcribed cavities; for, if a wound is made either into the cellular membrane, or into a circumfcribed cavity, we find that the furfaces of both, beyond the cut edges, are naturally and generally in contact with one another, for without this, union by the firft intention would not take place, either in circumfcribed cavities, or in the common cellular membrane. To explain this pofition, let me fuppofe a cafe.

If we make a wound into the cavity of the belly, and in a found ftate of thofe parts, we fhall find that every vifcus is in contact with fome other vifcus, and that the whole infide of the peritoneum is in contact with the vifcera in genêral; fo that no fpace is unfilled while this contact of parts remains. If this wound is not allowed to heal by the firft intention, ftill we fhall find that no inflammation will take place, or extend further than the attachment of thofe parts to the cut edges; except what is owing to continued fympathy. If this was not the cafe, every part of the fame cavity muft inflame, becaufe every part would be equally imperfect; for if this contact was removed, upon the receiving of the wound, or at any time afterwards, the whole cavity muft inflame, becaufe every part is equally under the fame predicament with regard to expofure. The fame thing would take place in the common cellular membrane, if thofe cells were not (in a natural ftate) in contact. Inflammation, in cafe of wounds, would as readily extend over the furface of each cell, as air does through the cavity of each cell when blown into. Now this fimple and natural contact of natural parts, keeps off the inflammation beyond the cut edges of expofure; and inflammation only takes place at this part, to preferve this contact, as alfo to ferve as a bafis for the future operations. This, I apprehend is upon the principle of contiguous fympathy, two ſurfaces being ſimply in contact, mutually agreeing not to inflame; or perhaps, more properly expreſſed, by being in contact there is a mutual harmony which prevents their being excited to inflammation. This circumſtance is a reaſon why we ſhould not attempt to bring circumſcribed cavities to univerſal ſuppuration, by ſimply opening them, and allowing them to collapſe; for we may be pretty certain, that union only will take place at the expoſed edges of contacts which excludes the general cavity, and which is the reaſon why the operation for the radical cure in the hydrocele often fails. If, on the other hand, this natural contact of parts did not preſerve the whole beyond the cut edges, then we muſt allow, that the cavity is under the ſame predicament with the cut edges; and if the cut edges inflame, ſo muſt the whole.

In caſes of ſpontaneous inflammations of circumſcribed cavities, we find where this contact is completeſt, that the inflammation and its conſequences are the leaſt; for inſtance, in the abdomen, in the caſes of the peritoneal inflammations, the inflammation is the greateſt where the ſurfaces are not ſo well oppoſed to one another, viz. in the angle between any of the two viſcera.

This fact of ſimple contact being ſufficient to exclude the irritation for inflammation, was well illuſtrated in a woman who had the Ceſarian operation performed upon her, where a wound of eight inches long was made into the cavity of the abdomen to extract the child. After the child was extracted, the wound could not be brought exactly together; therefore ſo far gave riſe to a peritoneal inflammation; but the belly collapſing, and falling on its contents, they all came in contact as before, and the woman living twenty-ſix hours, gave time for the inflammatory irritation to take place. After death it was found, that the inteſtines were united to the peritoneum, all round the wound for about half an inch in breadth, and the ſurface of the inteſtines which lay unattached and expoſed at the bottom of the wound were inflamed, while every other viſcus as well as the peritoneum, beyond the adheſions, were free from inflammation.

Ulceration does not ſeem to obey this law ſo much, and the reaſon is, that ulceration is a ſecond operation, and is preceded by inflammation, ſo that pus is brought equally through every part, if equally ſuſceptible of ulceration, which all parts are not, although not depending upon their being ſimilar or diſſimilar. Thus a muſcle or artery will not ulcerate ſo readily as cellular membrane; but if pus was formed on the inſide of an artery, or in the centre of a muſcle, they would ulcerate very readily, and the ulceration would not ſtop, or remain ſtationary, when it came to the cellular membrane, but would go on; if pus too be formed in a lymphatic gland, ulceration would go on in the parts between it and the external ſurface, as faſt as it did in the gland, if not faſter, becauſe, inflammation would have gone before, and as it were aſſimilated the parts, and all from this cauſe, viz. being equally diſpoſed to ulcerate. The cauſe of the ſpreading of inflammation is ſympathetic; but, the cauſe of ulceration is immediate.

VI. OF INFLAMMATION—ITS STAGES.

I have given the moſt ſimple idea I can form of an injury done to a part, with the natural, immediate, and conſequent means of reſtoration. I have alſo treated of caſes where they become a little more complicated, requiring the aid of art as a ſubſtitute for the ſimplicity of the firſt. The action of the parts is not neceſſary in either of theſe, except that of the blood forming its veſſels and other ſolid parts, and becoming of the nature of the parts in which it is extravaſated. But I took notice that the violence done was often ſo great, or that reſtoration did not take place ſo readily, as in all caſes to exclude irritation; we had, therefore, an action in ſuch caſes taking place in the parts called inflammation. That this action aſſiſted in the reſtoration by producing an extravaſation of the coagulating lymph, which became the ſecond bond of union. I have alſo ſtated what may be called the natural tendency to inflammation, to ſerve as a kind of leading principle. We ſhall find that inflammation may ariſe from very different cauſes, and often without any apparent cauſe, and that its operations are far more extenſive than ſimply the act of producing union in parts divided by violence; for it more commonly produces union in whole parts or in natural ſeparations, ſuch as the common cellular membrane, large circumſcribed cavities, joints, etc. becauſe ſuch ſurfaces are not naturally diſpoſed to unite, but only in conſequence of ſome uncommon action being produced; and although theſe adheſions are unnatural, yet that tendency of the parts to admit of this union becomes a ſpecies of cure. It is in conſequence of the parts taking on, in ſome degree, the ſame mode of action which divided parts do when brought in contact, that in ſuch caſes ſuppuration is precluded. As inflammation often ariſes from diſeaſe, its ſalutary purpoſes are in many inſtances not ſo evident, although they may finally take effect ; as it likewiſe takes place in diſeaſe, or becomes the ultimate in diſeaſe where it did not begin it, as in the ſcrofula, cancer, etc, and ſome indolent tumors ; on theſe accounts too its ſalutary purpoſes are ſometimes not obvious. However, upon the whole, as inflammation is an action produced for the reſtoration of the moſt ſimple injury in ſound parts, which goes beyond the power of union by the firſt intention, we muſt look upon it in ſuch inſtances, as one of the moſt ſimple operations in nature, whatever it may be when ariſing from diſeaſe, or in diſeaſed parts. Inflammation is to be conſidered only as a diſturbed ſtate of parts, which requires a new but ſalutary mode of action to reſtore them to that ſtate wherein a natural mode of action alone is neceſſary : from ſuch a view of the ſubject, therefore, inflammation in itſelf is not to be conſidered as a diſeaſe, but as a ſalutary operation, conſequent either to ſome violence or ſome diſeaſe. But this ſame operation can and does vary ; it is often carried much further even in ſound parts, than to accompliſh union, producing a very different effect, and forming a very different ſpecies of diſcharge from the former ; inſtead of uniting and confining the parts, rather ſeparating and expoſing them, which proceſs is called ſuppuration, and varies with circumſtances. However, even this in ſound parts leads to cure, although in another or ſecondary way ; and in diſeaſe, where it can alter the diſeaſed mode of action, it likewiſe leads to a cure ; but where it cannot accompliſh that ſalutary purpoſe, as in the cancer, ſcrofula, venereal diſeaſe, etc. it does miſchief.

This operation of the body, termed inflammation, requires our greateſt attention, for it is one of the moſt common and moſt extenſive in its effects of any in the animal body ; it is both very extenſive in its cauſes, and it becomes itſelf the cauſe of many local effects, both ſalutary and diſeaſed.

It has its different ſtages in which it produces more immediately its different effects, which are local; ſuch as adheſions, ſuppuration, and ulceration, and often death in the part inflamed, together with ſecondary complaints which are univerſal, as fever, nervous affections; and when in parts that cannot heal, or in conſtitutions which are too weak, the hectic fever, next diſſolution, or univerſal death. However, by its forming thoſe adheſions, it often precludes the neceſſity of ſuppuration; and alſo entirely prevents many local diſeaſes where probably ſuppuration would be the conſequence, if ſuch adheſions had not taken place, with all the train of conſequences of ſuppuration, ſuch as abſceſſes, fiſtulæ, diſeaſed bones, etc. which are prevented by it. It is alſo one of the modes of action in many ſpecific diſeaſes, and in morbid affections proceeding from poiſons.

Inflammation is not only occaſionally the cauſe of diſeaſes, but it is often a mode of cure, ſince it frequently produces a reſolution of indurated parts, by changing the diſeaſed action into a ſalutary one, if capable of reſolution.

By theſe extenſive powers inflammation becomes the firſt principle in ſurgery. In one point of view it may be conſidered as a diſeaſe in itſelf where it takes place without any viſible cauſe; and it may be looked upon as an increaſe of the miſchief, when it is a conſequence of ſome injury; but in either caſe it is a ſign of powers, and of neceſſary powers; for if a part under the influence of ſuch irritation as ſhould naturally excite inflammation, had either no powers or diſpoſition to exert them, the conſequences would be much worſe, for mortification would probably take place. I intend at preſent to conſider the moſt common cauſes and effects of inflammation, together with the end propoſed by nature, in producing it, and the uſe to which it can be applied in ſurgery.

It becomes therefore neceſſary, firſt to begin with deſcribing its moſt ſimple forms, together with its general effects, and then to particularize as I proceed.

Inflammation has ſeveral well marked local peculiarities by which it is diſtinguiſhed.

I ſhall call by the name of inflammation whatever produces the following local effects, viz. pain, ſwelling, and rednefs, in a given time, and thefe dependent on or the effects of one immediate caufe.

Inflammation appears capable of arifing from three caufes which may be called remote.

First, from fome accidental force applied to a part, making a wound or bruife which cannot recover itfelf, unlefs by inflammation. Such violence at leaft is naturally capable of exciting it.

Secondly, from fome irritation which does not deftroy the texture of parts, but fimply the natural actions, as many irritations, fuch as preffure, friction, heat, cold, blifters, pungent applications, and often fevers of every kind.

Thirdly, From a particular difpofition in parts themfelves, as boils arifing fpontaneoufly without the conftitution having been preconcerned, fo little fo, as to have given the idea that fuch inflammations were healthy. Each of thefe will be of a kind peculiar to the conftitution; but from whatever caufe inflammation arifes, it appears to be nearly the fame in all, for in all it is an effect intended to bring about a reinftatement of the parts nearly to their natural functions.

Inflammation may firft be divided into two kinds as firft principles, viz. the healthy and the unhealthy.

The healthy probably confifts only of one kind, not being divifible but into its different ftages, and is that which will always attend an healthy conftitution or part, is rather to be confidered as a reftorative action than a difeafed one, and would rather appear to be an effect of a ftimulus than an irritation. The unhealthy admits of vaft variety, (difeafes being almoft numberlefs) and is that which always attends an unhealthy conftitution or part, and will be according to the kind of health in that conftitution or part, but principally according to the conftitution; however, many parts naturally have a tendency to run into inflammations of particular kinds. Moft of thefe arifing from the nature of the conftitution, are, I conceive, in moft cafes, if not in all, called, although erroneoufly, the eryfepelatus inflammation; which will be further taken notice of.

The fimple act of inflammation cannot be called fpecific, for it is an uniform or fimple action in itfelf; but it may have peculiarities or fpecific actions fuperadded.

Inflammation is either fingle or compound; it may be called fingle when it has only one mode of action in the part inflamed, as in its firft ftages; compound, when attended with another mode of action, or when it produces other effects.

Inflammation is capable of producing three different effects, viz. adhefion of the parts inflamed, fuppuration in the parts, and ulceration of thofe parts; which I have called the adhefive, the fuppurative, and the ulcerative inflammation; the laft or ulcerative, is properly fpeaking, only a fecondary effect of inflammation, not being performed by the fame veffels; however it is poffible it may keep up inflammation, as it always keeps up a fpecies of violence, viz. a deftruction of the parts.

The two firft do not take place in the fame veffels, at the fame time, but fucceed one another, although all the three effects may exift at the fame time in the different parts of the fame inflammation.

I have placed the adhefive firft in order, although it is not always fo, for with the refpect to the priority of thofe three actions of inflammation, it depends principally upon the nature of the parts, together with the degrees of violence of the inflammation.

To explain this more fully, we fhall firft divide the body, refpecting inflammation, into two parts, viz. the cellular membrane, or the body in general, together with the circumfcribed cavities as belonging to the firft; and then all the outlets of the body, as the fecond. We fhall treat of each according to the nature of the parts, and of the inflammation joined, and obferve their effects, which will fhow that the common effects of one, as to priority, may be changed into thofe of the others and become fecond or third, according to the nature of the parts, the inflammaation, and its degree of violence.

We may obferve that inflamation, but more efpecially the fupperative, in the firft order of parts, more readily takes place nearer to the furface of the body than in parts more deeply feated, and as a proof of this obfervation, it has been formerly obferved that tumors, and even extraneous bodies, will make their way from fome deeper-feated part to the fkin, but no inflammation fhall take place till they arrive near the fkin; but this circumftance will be more fully defcribed when I treat on fuppuration.

It does not feem neceffary that both furfaces which are to be united fhould be in a ftate of inflamation for the purpofe of effecting an union; it appears only neceffary that one fhould be in fuch a ftate, which is to furnifh the materials, viz. to throw out the coagulating lymph, and the oppofite uninflamed furface fhould be in a ftate of inflammation, to admit of union; for I juft obferved, that extravafated blood produces an union without inflammation; and we often find adhefions of parts which can hardly be called inflamed.

Thus a trufs applied to a rupture will produce adhefions as has been obferved, although it may fit very eafily.

In defcribing inflammation it will be found that the principal theory of inflammation will be introduced in the adhefive ftages; for in the firft ftated parts it appears only preparatory to the fuppurative either in preventing or promoting it.

When inflammation takes place in the firft order of parts, it is commonly the adhefive, but it will be according to circumftances whether the fuppurative or the ulcerative follows firft. That either the one or the other fhould follow, feems to rife in many cafes from an increafe of the inflammation; but it fometimes happens that the fuppurative takes place almoft immediately, and probably from two caufes; the firft is, the intenfity of the inflammation, its exceeding the adhefive almoft immediately; the fecond, an inflammation of a different kind, where the adhefive makes no part of the inflammation, and fuppuration takes place in the firft inftance. I fufpect that the eryfepelatous inflammation has very little of the adhefive in its nature, and therefore probably thefe inflammations are in fome degree of this nature, and go into fuppuration without adhefions. In fome cafes ulcerations muft take place prior to fuppuration, as when an inflammation happens on a furface, viz. the fkin, as for inftance, in a chancre, and with fuch violence as is neceffary for fuppuration to take place, then ulceration muft begin firft, fo as to expofe internal furfaces for fuppuration; but in the parts of the fecond order, viz. internal canals or duct, it is the fuppurative inflammation which moft readily takes place firft; but if carried further the adhefive follows, as will be more fully explained hereafter. When it is an inflammation of the firft order of parts, the fuppurative fucceeds the adhefive, and the ulcerative may be faid to be an action fuperadded to the fuppurative, arifing out of effects produced by the firft, now becoming new caufes, the fuppurative naturally taking place in the time of the firft, and the ulcerative in confequence of the fuppurative, which has called forth the action of another fyftem of veffels, the abforbents; all of which may be reckoned as three different modes of action arifing from the firft irritation or caufe.

The adhefive, as alfo the fuppurative inflammation, either in the firft or fecond orders of parts, with their varieties, may have a principle fuperadded, which does not in the leaft alter their inflammatory mode of action, which ftill continues to go on. This principle is fome fpecific difpofition, from fcrophula, or poifons, as the venereal, fmall-pox, etc.

Thefe three different modes of action, viz. the adhefive, the fupperative, and the ulcerative, when carried on perfectly, are generally the effects of a good conftitution, feldom attending the unhealthy; they are what I would call common inflammation.

I have already obferved that common inflammation either takes place in parts that conftitute the largeft part of an animal, which are all the circumfcribed cavities, all the cellular membrane, and the fubftance of every part, the two laft of which are the moft univerfal; or upon internal canals or outlets, which are, in common, only excretory ducts.

That whatever has a tendency to difcharge any extraneous matter, whether already exifting, as matter already formed, or a ball lodged, etc. or only preparatory to its formation fuch as inflammation that has a difpofition to fuppurate, the inflammation is always greateft and extends fartheft on that fide next to the fkin; for inftance, fuppofe a man fhot in the thigh, the ball paffes through to within an inch or two of the oppofite fide; the ball has not deadened any part for an inch or two of the laft part of its paffage fo as to allow this part to unite, we fhall find if that ball excites inflammation, it will not be along its paffage where we fhould (without knowing the principle) have moftly expected it, but the inflammation will commence on that fide next to the oppofite fkin that has not in the leaft been hurt. If a ball paffes quite through, a piece of cloth is carried in, and lies in the middle between the two orifices; if the paffage is pretty fuperficial, fay only an inch diftant from the fkin where the cloth lies, but which is two or three inches from either orifice, we fhall find that the inflammation, for its exit will not lead to either orifice, but directly acrofs to the fkin.

As the adhefive inflammation precedes the fuppurative in every part of the body, except the outlets, as was obferved, and the fuppurative commonly precedes the ulcerative, excepting on an external furface, the propriety of following, likewife, this order of nature in treating of them will appear evident, efpecially as each fucceeding inflammation is in fome meafure illuftrated by that which has gone before.

VII. OF THE DIFFERENT DEGREES, AND DIFFERENT KINDS OF INFLAMMATION.

INFLAMMATION will in general be in proportion to the exciting caufe, (in which may be included the mifchief done), the conftitution and the nature of the part; in all which, as there is great variety, fo muft there be in the inflammations. The degrees of inflammation will be more in the adhefive than in the fuppurative, for the adhefive may have all the degrees of violence between the moft flight inflammation and fuppurations; but the fuppurative is a more fixed or determined quantity, for when got to a certain point, it takes a new action, and inflammation ceafes; however, we have not always inflammation producing fuppuration when it has arrived to a certain degree of violence, for in fome it often goes beyond that point which would produce it in others, and in fuch cafes there is no difpofition for fuppuration, and it feems to become ftationary, for neither has it any difpofition for refolution.

Spontaneous inflammations which are to fuppurate, are more violent than thofe inflammations arifing in confequence of an operation or accident, which alfo muft produce fuppuration; and thofe inflammations from either operations or accidents, if they have not produced death in the part operated upon, are more violent, and of greater extent than thofe where death in the part has been produced.

The inflammation of a boil or abfcefs is more violent, and commonly more extenfive than that in confequence of a cut, or even an amputation of a leg. The inflammation in confequence of a cut or amputation of a leg, will be more violent than that from a gun-fhot wound, or from the application of a cauftic, which produces death in the part, and even although more parts have been deftroyed by thefe means; neither do fpecific difeafes, except the gout, produce fo violent inflammation, nor are they commonnly fo painful as what I have called the common inflammation.

It may appear not to be an eafy matter to account for all thofe differences; however it is poffible that in the fpontaneous inflammation there is more occafion for inflammation than fuppuration; the inflammation being the only action which is neceffary to produce the ultimate effect, as for inftance, in the gout; in this difeafe the inflammation is the only thing neceffary for its action, and the inflammation runs much higher than many others do which produce fuppuration*.

The fpontaneous inflammation arifes often from difeafe, which probably makes the parts more fufceptible of inflammation.

When inflammation arifes from the irritation of death in a part, let the caufe of that effect be what it will, whether mechanical, as in bruifes, gun-fhot wounds, etc. or by chemical means, as cauftic, etc. the inflammation is late in coming on, and in comparifon with the others gentle when come on.

However, in many bruifes, even where the death of parts has taken place, we have inflammation quick and violent, but then the living parts have alfo fuffered, and have fuffered much more than if fimply wounded.

In many bruifes we alfo have inflammations quick and violent, even where death has been produced in a part; but then death does not take place in all the hurt parts, as in many gun-fhot wounds, fuch as thofe attended with fractured bones, in which the furrounding parts were only hurt fo far as to bring on irritation and not death.

If cauftics do not act with vigour, they will irritate fo as to bring on the inflammation fooner than if they had killed the part quickly.

* It is a curious circumftance in the gout, that although it is attended with all the common effects of the adhefive inflammation, as confiderable fwelling, etc. which fwelling muft arife from extravafation of the coagulating lymph; yet, adhefions do not feem to be the intention, for none are produced; the lymph is in general taken up, and chalk-ftone or tophaceous matter put in its place.

Irritating ſubſtances, when of no ſpecific kind, produce inflammation ſooner than other viſible cauſes of inflammation. If of a ſpecific kind, then the time, ſort, and violence, will be according to that kind.

But irritating applications muſt be continued for ſome time to produce violent inflammation.

Theſe differences are eaſily accounted for; quick death does not irritate the part killed, and the contiguous living part, not being itſelf hurt, is only irritated to get rid of the dead part.

A wound is a quick irritation of a living part, ſo that it inflames more readily, and more violently, according to the quantity of irritation; but that cannot be of long ſtanding, as nature ſets about procuring relief. But when irritating ſubſtances are applied, the part inflames quickly, according to their power of irritation; and if they are continued, nature is not allowed to relieve herſelf, but is conſtantly teazed, by which means the inflammation becomes alſo violent.

I need hardly mention, that fever is often the cauſe of local inflammation. We ſee this happen every day.

Theſe cauſes, and of courſe the inflammation, are of two kinds, one which may be called accidental, as inflammation ariſing in conſequence of common fever; the others are more determined, depending upon the ſpecies of a fever, which may be called ſpecific, as the ſmall-pox, chicken-pox, etc. Theſe inflammations in conſequence of fever, are commonly ſuppoſed to be critical; but I very much doubt the truth of this opinion. The ſmall-pox and chicken-pox are, perhaps, the ſtrongeſt inſtances of an appearance in proof of this opinion; and, perhaps, the meaſles, as a critical inflammation, might be produced as another; but, I believe, that it is peculiar to theſe diſeaſes to form inflammation and ſores. We muſt allow, however, it is not abſolutely neceſſary, even in them, that abſceſſes ſhould be formed, viz. the pock to leſſen or carry off the fever. For the ſpecific fever in them cannot exiſt beyond a certain time, even although no eruption appears.

But I think that in the caſes of the ſmall-pox, chicken-pox, and the meaſles, theſe diſeaſes often prove the contrary to that which is ſuppoſed to be the caſe; for we have large abſceſſes as often formed after thoſe diſeaſes as after any other, which are commonly ſuppoſed to be the ſettling of the fever in this part, but which are equally accidental with thofe from common fever, and therefore we cannot fuppofe that thofe abfceffes are critical in fuch difeafes, becaufe they are either common abfceffes, or fcrophulous; for no one difeafe can have two diftinct and different critical inflammations. In further confirmation of my opinion, thofe inflammations are found to be not in the leaft of the nature of the difeafe which produces them, fo little fo in moft cafes, as to be truly fpecific of another kind, viz. the fcrophulous. Now we certainly find it difficult to conceive one univerfal fpecific difeafe, as the fmall-pox, etc. producing a local one of another fpecific difpofition to cure the firft, or terminating in another difeafe, whofe mode of action is totally different; and the more fo when we fee that the fame local difeafes can and do arife from every kind of fever. To afcertain this fact, therefore, we are to look out for that difpofition, or that mode of action common to all fevers which are capable of producing this effect, with the difpofition of the conftitution, or of the part at the time, and we fhall find that this kind of inflammation depends upon the conftitution and part at the time, and not upon any peculiarity in the fever, as is alfo the cafe with the fmall-pox eruptions, viz. they partake of the conftitution.

This common principle in fever, of producing local inflammation, is the fimple fever itfelf, abftracted from every peculiarity. A fever in all cafes or of all kinds, is a difturbed action, like inflammation itfelf, which may be joined with any fpecific mode of action, and this difturbed action will always be according to the conftitution, even when joined with any fpecific quality. The inflammatory fever is, perhaps, the moft fimple, becaufe it is a fimple fever on a conftitution having no peculiarity of difpofition. The putrid fever (as it is called) is perhaps no more than the fame fever upon a conftitution that has a peculiarity of action under that difturbance, and therefore it proceeds according to that peculiarity.

This is well illuftrated in fpecific difeafes; for inftance, in the fmall-pox. The fmall-pox produces a fever, viz. a difturbed action, joined with the fpecific, and although this action is produced by the fame poifon in two different perfons, yet the one fhall be the true inflammatory, and the other the putrid, the eryfepelatous, etc. Now the fame poison can have but one mode of irritating, abstracted from its poisonous quality, and this one mode produces fever; and it also can have but one mode of irritating in respect of its poisonous quality, but that fever abstracted from its poisonous quality will be according to the nature of the constitution at the time, the poison being capable of producing nothing but a fever joined with its specific poison, and that specific quality takes place equally on every kind of constitution, the poison itself having no power of affecting the constitution in one person differently from that of another, it can only act in a greater or less degree, according to the susceptibility of the person for such irritation.

Now since every fever, whether common or specific, is equally capable of producing local inflammation, which may be carried the length of suppuration; and as it cannot with any degree of reason be called critical in specific fevers, we have no reason for supposing that those suppurations are critical in the common fever, or in those fevers, which are of no specific kind.

It was a leading doctrine of Boerhaave, that inflammation consisted in an obstruction of the minute vessels, in consequence of too great a spissitude of the fluids, and his practice consisted in seeking for attenuants; but this theory seems to be almost entirely exploded.

This was certainly too confined an idea of all the causes of inflammation, and reduced all inflammations to one species. The only distinction between inflammations, must have arisen from the nature of the obstruction, if there could be any; but this could never account for the action of many specific diseases and poisons.

It was also too mechanical. If they had said that any obstruction to the natural actions of a part which could stop the blood's motion in it, became a cause of inflammation, they would not have been so materially wrong as to a possible cause of inflammation.

It has been as much laboured on the other hand, to shew that the cause cannot on any occasion be obstruction in the blood's motion through the small vessels; but I will venture to say, that any cause which can obstruct the motion of the blood, for a given time, will become the cause of inflammation, for either the cause of the obstruction itself or the blood being retained in the smaller vessels for a certain time, will either irritate or unite the parts, or where it irritates will throw the veſſels into ſuch actions as naturally ariſe out of an extraneous irritating cauſe, but not an increaſed motion of the blood behind, to drive on the obſtructed blood through theſe veſſels, as has been ſuppoſed. It will excite that action which in the end produces ſuppuration, in order to get rid of the extraneous matter, which was the cauſe of the obſtruction; ſuch as preſſure on external parts, or the obſtructing matter itſelf, which is to be reckoned extraneous. But though pure inflammation is rather an effort of nature than a diſeaſe, yet it always implies diſeaſe or diſturbance, in as much as there muſt be a previous morbid or diſturbed ſtate to make ſuch effort neceſſary.

All inflammations attended with diſeaſe have ſome ſpecific quality which ſimple inflammation has not; and in ſuch caſes it is the ſpecific quality which is the diſeaſe, and not the inflammation; for ſuch conſtitutions or parts as are capable of falling into the true adheſive and ſuppurative inflammation, are to be looked upon as the moſt healthy, and the freeſt from diſeaſes of all kinds. Indeed, even where there is a ſpecific quality, it often can hardly be called diſeaſe; for in the ſmall-pox, where the diſorder goes through its different operations well, it is exactly ſimilar to common healthy inflammation; for if ſuch an irritation as above deſcribed were to attack a conſtitution or parts, in another ſtate than that of health, we ſhould then not have either the adheſive, or ſuppurative inflammation taking place, but moſt probably ſome other, ſuch as the eryſepelatous or ſcrophulous, according to the nature of the conſtitution or parts at the time.

This ſtate of health in a conſtitution is ſo remarkable, that we ſee in the time of the ſymptomatic fever, when nature would ſeem to be univerſally diſturbed, a kindly or benign inflammation going on, and kindly ſuppuration; which ſhews that this fever has no ſpecific tendency to wrong action, the conſtitution being only diſturbed by ſympathizing with a local injury, but not capable of giving or reflecting back upon the part inflamed, a diſeaſed diſpoſition or action.

And this is ſo remarkable, that ſuch inflammations as ſeem to affect the conſtitution by ſympathy only, which is commonly either from extent, quantity, or the ſeat of it being a part eſſential to or connected with parts belonging to life, go on as kindly as they do in a ſmall inflammation, as a boil, which does not affect the conſtitution in the leaſt. Indeed fever is a good ſymptom when equal to the injury and of the ſame kind with the local affection, when that kind is good.

Let us take an amputation of a leg as an example, which produces ſomething more than a diſturbed conſtitution, for there is a great loſs of a ſubſtance to that conſtitution, which, abſtracted from the violence, would probably produce conſiderable effects till the conſtitution became accuſtomed to the loſs; but even with all this loſs we often find that a healthy inflammation ſhall come upon the ſtump, and a kindly ſuppuration take place while the ſymptomatic fever laſts; in many caſes alſo it ſtill keeps its ground even when affected by many ſpecific irritations which are foreign to it; and nearly in the ſame manner as when affected by a common irritation, which will only rouſe that conſtitution into action, but not alter it, having only the ſpecific difference added, ſo that the parts will go readily through the adheſive or ſuppurative inflammation; the ſpecific being only an attendant on this healthy action; this we ſee plainly to be the caſe in the healthy ſmall-pox, and the lues venerea in its firſt ſtages. But on the contrary, if the conſtitution is ſuch at the time as would readily fall into an unhealthy inflammation, from common irritation or accidental violence, then it will alſo fall into that ſtate, when irritated by a ſpecific irritation foreign to the conſtitution, ſuch as the ſmall-pox, which in this caſe will run into the confluent kind.

There are many conſtitutions which have a tendency to ſpecific diſeaſes, that when injured by fever, or any conſtitutional complaint, readily produce the ſpecific inflammation in ſuch parts of the body as have the greateſt ſuſceptibility for any ſpecific action; or if ſuch parts are affected by any local violence, the parts affected will go through the healthy adheſive inflammation, nor will they enter into the healthy ſuppurative inflammation, but will fall into the ſpecific inflammation peculiar to the habit; ſuch is the caſe with an eryſepelatous habit. Or if a ſpecific inflammation has already taken place, any violence done to it, when already begun, will increaſe that diſpoſition, and action, which we plainly ſee to be the caſe with the ſcrophula; becauſe this diſeaſe can and often does ariſe from ſuch a cauſe alone. Beſides the conſtitution producing ſuch effects, there are many parts of the body have a greater tendency to some specific disease than the constitution in general; which particular parts will fall into these specific inflammations more readily than others, either upon the constitution being affected, or a violence committed upon themselves; for instance, many parts of the body have a greater tendency to fall into the scrophula than others, and these will fall into that mode of action when injured, either by means of the constitution, or from accident; except the constitutional complaint is such as to be a specific for the scrophula, which I can easily conceive it may; in the cancer also, if the disease has previously taken place, then the tendency of an injury is to exasperate and increase it.

But there are specific irritations which do not affect either the part or the constitution, as a common irritation, but affect them in a way peculiar to the irritation, altering at the same time both the parts affected and the constitution, from an healthy state to an unhealthy one of its own kind.

This seems to be the case with the plague, perhaps with the putrid and jail-distempers in a less degree; for whatever be the kind of constitution which they attack, they always reduce that constitution to their own kind; it is not a healthy operation going on, and the specific superadded, as in the healthy small-pox etc. However, even the plague has its degrees of power over a constitution, some being much more easily, and of course more violently, affected than others.

This change in these cases, especially in the first, is often so great, that the constitution hardly ever recovers it, so that the patient dies; which we have observed above, is not the case with many other specific diseases or poisons, as the small-pox, etc. for this disease makes no change in the constitution peculiar to itself.

From what has been said, it must appear, that the irritations which are capable of producing those inflammations may be either simple, as the adhesive, or producing with it other modes of action, as either suppuration or ulceration; and also either of the above modes of action may be joined with some of the specific actions.

Hence we may conclude, that irritations of whatever kind, either produce an inflammation peculiar to the constitution, or the nature of the parts; or, according to the irritating cause, as in the plague; and where it is according to the conftitution, that many fpecific irritations may be added, without altering the nature of the inflammation itfelf, and that they only determine its fituation, extent, duration, etc. according to the fpecific difpofition added, provided the conftitution be healthy; but if the conftitution be unhealthy, whether affected with eryfepelas, putrid fever, or plague, and the fpecific difeafe is fuperadded, it will be a mixture of both, that is, it will be a fpecific inflammation, fet down upon a conftitution of a peculiar kind, which partakes of both, and thofe fpecific properties will not be fo diftinct, or fo well formed, as when they appear in a found conftitution.

If the conftitution has a fufceptibility to be putrid, and the fmall-pox attacks it, the inflammation will be the fmall-pox joined with the putrid mode of action of the conftitution, which will affect the mode of action peculiar to the fmall-pox, and deftroy the fpecific difference of the inflammation belonging to the fmall pox, the puftules will fpread, not fuppurate, and look livid, according to the putrid difpofition.

Thefe conftant effects, peculiar to the conftitution, may be changed from one to the other, juft as the conftitution changes, for the fmall pox may begin upon a healthy conftitution, in which they will be diftinct or circumfcribed; but if the conftitution becomes difeafed, they will fpread; and if the conftitution takes a healthy turn again, they will begin to contract to their fpecific diftance again*.

* The knowledge of thefe facts, is of great fervice in the cure of many fpecific difeafes; for whatever the fpecific difeafe may be, we are always to treat the patient in one refpect according to the general nature of the inflammation; and if we have a fpecific remedy, we are alfo to join that with the other; but if we have not a fpecific remedy, we are then only to take up the difeafe according to the conftitution.

Let us illuftrate the foregoing propofitions by example. The firft cafe is explained by the venereal difeafe in the form of chancre; the venereal matter produces an inflammation and ulceration according to the nature of the fpecific difeafe, and the conftitution; if the conftitution is perfectly healthy, then the effects are the fuppurative and fpecific difeafe joined; the limits of both are confined according to the conftitution and the nature of the fpecific difeafe. For the inflammation and ulceration never extend beyond the fpecific affection; but if the conftitution is fuch as readily to fall into the eryfepelatous, then it becomes

Many people are much more ſuſceptible of inflammation than others, even of the common kind, and thoſe probably may be reckoned ſimply irritable. In ſuch it is more violent, and in ſuch it is more apt to ſpread, the ſurrounding parts being ready to act or ſympathize with an action to what they are prone; continued ſympathy more readily takes place in ſuch caſes*; but this is not univerſal, for we find many very conſiderable inflammations confined to the part irritated, and in ſuch inſtances continued ſympathy is not great, only the part irritated takes up the action violently.

The term or idea of inflammation may be too general, yet it is probable that it may form a genus, in which there is a number of ſpecies, or it may be more confined in its claſſification, and be reckoned a ſpecies containing ſeveral varieties. Theſe are, however, ſo connected among them-

the eryſepelatous and ſpecific joined; and although the extent of the ſpecific affection is limited, that of the eryſepelatous is not; the conſequence of which is, that it ſpreads over the whole prepuce and often the whole ſkin of the penis.

In this diſeaſe, under ſuch circumſtances, we are led to the method of cure; for although we have a medicine for the venereal inflammation, yet bark is to be given for the eryſepelatous, the quantity to be given is according to the predominancy of the one or the other. The effects of this practice are very ſtriking; for as the eryſepelatous inflammation leſſens it becomes more confined in its limits, and, as it were, drawn into the original point; and when it becomes truly ſuppurative, and venereal, its limits then are brought within the ſpecific diſtance.

The ſecond caſe is explained by the ſmall-pox. The various matter in healthy conſtitutions produces the ſuppurative and ſpecific inflammations, the ſpecific is limited, and directs the ſuppurative; but if the eryſepelatous comes on, the ſuppurative ceaſes it then ſpreads along the ſurface, uniting inflammation with inflammation, and producing the confluent ſmall-pox.

We have no ſpecific remedy for the ſmall pox, nor can we readily have any for a diſeaſe which cures itſelf; our buſineſs then is to cure the eryſepelatous, if poſſible, and leave the conſtitution to cure the ſpecific.

* This one might illuſtrate by a piece of paper being either dry or damp; if dry, then ink will not ſpread, it will be confined to its point, but if damp, it will ſpread being attracted by the ſurrounding damp to which it has an affinity.

ſelves, that we cannot juſtly underſtand any one of the ſpecies or varieties without forming ſome idea of the whole, by which means, when treating of any one, we can better contraſt it with the others, which gives us a clearer idea both of the one we are treating of, and of the whole. So far as it appears to be neceſſary to take notice of the different inflammations, as illuſtrative, they may be comprehended in five diviſions: although, I muſt own that if we take in all the ſpecific diſeaſes which produce inflammation, ſuch as the venereal diſeaſe in its different forms, the gout, etc. they may be without number; however, many of them produce very much the ſame appearance and effect with thoſe which are of no ſpecific kind. The ſpecific is of no particular kind, but only the cauſe, and the ſpecific effect is a ſomething ſuperadded. The preſent, viz. the adheſive, with its different effects, as ſuppuration, I ſhall conſider as one. The œdematous, which comes neareſt to the adheſive, forms a ſecond diviſion. The eryſepelatous, the carbuncle, and that which leads immediately to mortification, form a third. There is another inflammation very like chilblains, which is not very lively and often in blotches, ſome the breadth of a ſhilling, others of the breadth of half a crown, and even broader, etc. This inflammation certainly ariſes from irritable debility; the blotches look more of a copper-colour, and the ſkin over them is often diſeaſed. All, except the firſt, have a kind of affinity to each other; although I think the œdematous has the leaſt affinity to the three laſt, and many vary ſo as to make it difficult to ſay to which ſpecies the varieties belong. There are a great many other inflammations, but which ariſe from ſome ſpecific cauſe, as the gout, ſcrophula, etc. or poiſons; but as theſe do not explain, or illuſtrate by contraſt, the adheſive or ſuppurative inflammation, I ſhall not give the outlines of them here, except juſt to mention the particulars of the gout, as an inflammation.

The action of the complete gout, has all the characters (while it laſts) of the true inflammation, and which may be called the inflammatory action of the gout; but it has many ſingularities attending it, which attend no other inflammation, and which of courſe become ſome of its ſpecific characters.

The inflammation of the gout is very different from the adheſives and ſuppurative in its ſenſation. It ſeldom throbs;

it is a pricking, cutting, and darting pain; befides which, there is a pain that feels as if the inflamed parts were all moving, and in that motion there was pain; therefore the action, which is the caufe of the pain, muft be very different, and is moft probably from the action of the veffels, not from their diftention, as in the fuppurative inflammation.

It probably comes on more quickly than any other. Its violence is probably greater. In duration it is probably the moft uncertain; and its going off is quicker than of any other inflammation. Its fhifting from one part of the body to another, is probably in fome degree peculiar to itfelf; and it leaves parts in a ftate which no other inflammation does. Without entering further into the nature of this difeafe than faying it is an act of the conftitution, I fhall defcribe fome of its vifible effects, which of courfe can only be obferved when it falls on an external part, and when it does, it is moft commonly on an extremity, more efpecially on the lower, but fometimes on the upper, and ftill more commonly on the extreme parts of the extremity in either the upper or the lower; and its principal feat in the extremity is a joint. When it falls on internal parts, it is moft commonly the ftomach, which is only fuppofed by its effects or fymptoms; from its being transferred, and from the mode of relief. It attacks alfo the brain, producing delirium, giddinefs, the lofs of the natural and accuftomed feel of the body, inceffant fleepinefs, etc, which is alfo known by the above circumftances. When it falls on other parts, either externally or internally, it is not fo much determined on what part, it is moft apt to fall. It fometimes falls either on the lungs or mufcles of refpiration, the throat, tefticles, urethra, producing a difcharge, etc. on the anus, forming piles; which can only be known to be gout by collateral circumftances.

Why the extremities, the ftomach, and brain, fhould be fimilar in fufceptibility to take the gouty action from the conftitution, is not eafily accounted for. I fhould be inclined to fuppofe that its effects on the ftomach or brain are not fimilar to thofe on the extremity, or probably it does not advance fo far in its effects there, becaufe in that cafe it would certainly kill. Its effects on the extremities are, I believe, always more or lefs an inflammation, or at leaft it has the common vifible or fenfible effects of inflammation.

It is moſt probably what may be called a true ſpecific inflammation, for it produces the ſame immediate effects in every conſtitution, therefore does not produce an inflammation according to the conſtitution, having the ſpecific action added, ſimilar to poiſons, but from its nature it produces nearly the ſame effects in every conſtitution. I have ſeen conſtitutions whoſe extremities were attacked with the œdematous inflammation, attended with a purpliſh appearance; violent pain in ſuch caſes comes on, which create, ſome apprehenſions of a tendency to mortification; upon looking at the part, we may ſuſpect ſuppuration, the inflammation to appearance being of that kind; but may think it odd that ſuch healthy inflammation and ſuppuration ſhould take place in the midſt of inflammation of ſo contrary a kind, but ſhall find no ſuppuration; the inflammation ſhall continue its period and then leave the extremities in a much better ſtate than it found them. Although the inflammatory action of the gout is attended with great pain, yet I think it is not ſo tender as the true inflammation is; a part may be violently inflamed, and yet it may be handled or ſqueezed, the nerves are not in ſuch a ſtate of irritation, its conſequent effects are very different from that of the true inflammation, for inſtead of entire reſolution, it gives the diſpoſition to the inflamed parts to fill the joint or whatever parts have been affected, as for inſtance, the cellular membrane with chalk.

However, chalk is not neceſſarily an effect of the gouty inflammation; for in a gouty habit we have chalk formed where there never had been any gouty inflammation, yet it is ſingular it ſhould attack ſuch diſſimilar parts as the ſkin, ligaments, etc. It has not only no tendency to ſuppuration, as an immediate effect of inflammation, but it leaves the parts in a ſtate not eaſily excited to inflammation; the chalk ſhall remain for years without producing inflammation, and ſeldom produces it at all, but from quantity; and when the interior ſurfaces are expoſed, they hardly take on common inflammation and ſuppuration, healing more readily than a ſore of the ſame magnitude from any other cauſe; even a joint ſhall be expoſed, yet common inflammation ſhall not come on, nor ſhall it ſuppurate, only a watery fluid ſhall come out, bringing with it the chalk occaſionally, and it ſhall heal up kindly. It is probable that the gout is not always an act of the conſtitution, but that parts may be ſo ſuſceptible, or rather diſpoſed for this action, that they may immediately run into it when deranged: if this notion be well founded, then it may be a queſtion, whether this local affection relieves the conſtitution for the time from any ſuſceptibility for ſuch an action?

It may be diſputed, whether the following are all inflammations or not. They often riſe from the ſame cauſes; accident, for inſtance, produces all of them. They have certainly many characters in common, although not always the ſame reſult. The veſſels becoming inlarged, there is an extravaſation, pain, and a ſeparation of the cuticle, but ſeldom a formation of matter, although there ſometimes is, which happens when they have at firſt more of the adheſive ſtate; and there is a circumſtance which I think is common to them, namely, a red ſtreak paſſing from the inflamed part, generally towards the trunk, although not always in this direction. In common language they are called eryſepelatous, although very different; the eryſepelatous being one of the beſt marked inflammations of any. I do not mean to treat of theſe but in a general way, not even when conſidering the method of cure. It is probable there is no ſpecific diſtinction between any of theſe inflammations but what ariſes from the conſtitution or the parts, for we find them all proceeding from what may be called the ſame accidental cauſe, which therefore cannot produce any thing ſpecific; the diſtinctions in the mode of action of the inflamed parts being occaſioned by a peculiarity in the conſtitution, or the nature of the part itſelf, but probably in the conſtitution. It has been ſuppoſed that the different ſpecies or varieties of inflammation ariſe from the difference in the nature of the part inflamed; but this is certainly not the caſe; for if it was, we ſhould ſoon be made acquainted with all the different inflammations in the ſame perſon, at the ſame time, and even in the ſame wound; for inſtance, in an amputation of a leg, where we cut through ſkin, cellular membrane, muſcle, tendon, perioſteum, bone, and marrow, the ſkin ſhould give us the inflammation of its kind, the cellular membrane of its kind, the muſcles of theirs, the tendons of theirs, the perioſteum, bone, marrow, etc. of theirs; but we find it is the ſame inflammation in them all; it is the adheſive in them all if the parts are brought together; it is the ſuppurative if parts are expoſed. I ſhall at preſent only take notice of the four laſt, as I mean to treat more fully of the firſt, which cannot be ſo completely underſtood without ſeeing the diſtinctions.

What I would call the œdematous inflammation, is when the extravaſated fluid is water; it has very much the appearance of the adheſive, and probably come the neareſt to it of any, being of a ſcarlet colour; but much more diffuſed. The fluid extravaſated, being principally the ſerum, renders the ſwelling more diffuſed than even the inflammation itſelf; it is very painful, or rather ſore, but there is not ſo much of the throbbing ſenſation as in the adheſive inflammation; it appears to be only on the ſurface, but moſt probably goes much deeper; for in ſuch caſes the extravaſated fluid is in too large quantity to be furniſhed by the cells of the cutis alone; but in this we have not the ſame guide as in the adheſive, viz. the ſwelling and inflammation correſponding with each other. The difference between this inflammation and the adheſive, ariſes, I conceive, from the principle of inflammation acting upon a dropſical diſpoſition, which is always attended with weakneſs; whereas a greater degree of ſtrength would have produced the adheſive inflammation under the ſame cauſe, or irritation; and what makes me conceive this, is, that in many caſes of anaſarcous legs we have exactly this inflammation come on from diſtention, which adds to the extravaſation of the ſerum, as well as in moſt caſes of ſcarifications of œdematous parts to evacuate the water. When inflammation takes place it is much more laſting than the adheſive; and, I believe, ſeldom, or ever produces ſuppuration; but if it ſhould run into this ſtage, it is more general, and the whole cellular membrane in the interſtices of parts is apt to mortify and ſlough, producing very extenſive abſceſſes, which are not circumſcribed.

The eryſepelatous inflammation is very peculiar; and moſt inflammations that are not of the true adheſive and ſuppurative kinds are called ſo, although probably they do not in the leaſt belong to it; and this may ariſe more from the want of terms, than the want of diſcrimination. This inflammation often ariſes ſpontaneouſly, or in conſequence of a low or debilitating fever. It often ariſes from accident, but then it is commonly a ſecondary inflammation, although not always; for the firſt ſhall have gone off, and when ſuppuration was to take place, it ſhall have come kindly on, but afterwards the cryſepelatous ſhall take place.

This may be called a remote inflammation, and is, in this reſpect, ſomewhat ſimilar to the locked jaw.

It is more commonly a cutaneous inflammation than ſituated in the deeper ſeated parts; although in ſome conſtitutions every inflammation, wherever it exiſts, will moſt probably be of this kind; however, the ſkin appears to be moſt ſuſceptible of it, becauſe it will ſpread over a prodigious ſurface of ſkin, while it does not affect even the cellular membrane underneath; at leaſt not commonly. There is an inflammation which attacks internal canals, which is claſſed with the eryſepelatous, but how far it is the ſame I do not know; it is certainly not the ſuppurative; and as almoſt every other inflammation was formerly called eryſepelatous; this has been ſuppoſed to belong to this kind of inflammation. The inflammation I am ſpeaking of is more common to the throat than any other part, often going down the trachea: whatever it is, it may be conſidered in ſome of its effects to be in direct oppoſition to the adheſive and the ſuppurative inflammations; for where the adheſive moſt readily produces adheſions, there the eryſepelatous does not, as in the common cellular membrane; and where the adheſive ſeldom takes place, excepting from extreme violence, there this inflammation (if eryſepelatous) has a tendency to produce adheſions, as in canals or outlets; it alſo oppoſes, in ſome degree, the ſuppurative, in being backward in producing ſuppuration even in thoſe places where ſuppuration moſt readily takes place, ſuch as canals and outlets; for there, as above obſerved, it more readily throws out the coagulating lymph. Whatever the inflammation may be, it is certainly attended with nearly the ſame kind of conſtitutional affection. The fever in both appears to be the ſame, viz. accompanied with debility, langour, etc. The extravaſation in conſequence of the eryſepelatous inflammation is not ſo great as in either the adheſive, or the œdematous; nor is it of that kind which produces adheſions between the parts inflamed, which in this inflammation would commonly be unneceſſary, as it ſeldom produces ſuppuration, but is attended with very bad conſequences when it does. It appears to ſupport itſelf by continued ſympathy, for it commonly begins at a point and ſpreads, while it ſhall be getting well, where it firſt began.

This cannot be merely constitutional, for if it was, the parts already inflamed could not recover, if its increase in new parts arose from the constitution; but it gives the idea that when the parts have once gone through this action that they lose the disposition and become healthy. This property is not peculiar to this inflammation, the ring-worm has this peculiarity, as also many cutaneous ulcers*.

This inflammation is more common in the summer than in the winter, more especialy in hospitals; and I think takes place oftener after wounds on the head than any other. I have often seen it begin round a wound, on the scalp, extending itself over the whole head and face; the eye-lids being very much swelled, the ears thickened, and it has advanced to the neck, shoulders, and body, creeping along both arms, and terminating at the finger ends; that which attacks the body often goes along the body to both thighs, down the legs, and terminates at the ends of the toes; and while this is going on, it is as expeditiously cured behind, and the skin peels off the cured parts; however, this is not always the case, it often stops, and where it proceeds so far, it is commonly becoming milder. This inflammation, when it runs along the skin, has a determined edge, not losing itself gradually and insensibly in the skin beyond, as in the true adhesive, and indeed most of the inflammations; the skin feels as if only a little thickened, and not so pliable; for by passing the finger along the sound skin to the inflamed, we feel an evident difference. The colour of the skin is of a darkish red. When it goes deeper than the skin into the cellular membrance, it often suppurates; but then I suspect it is not the true erysepelatous; for in such cases it commonly produces mortification in the cells, by which air is let loose; this gives a strange feel, neither of fluctuation nor crepitation, and as there are no adhesions the matter finds an easy passage into

* There appears to me two ways of accounting for this; one is, that the whole skin is very susceptible of such action, and readily goes on with it by continued sympathy, and the part having gone through the action, like the small-pox, etc. loses the disposition, and the action ceases.

The other is, that the inflammation is such as to contaminate while it spreads, but when it has once acted it is cured as above observed. If this last be a true solution, then the right practice would be to stop its progress by destroying the parts beyond it.

the common cellular membrane, increafing the fame kind of fuppuration wherever it comes; and as mortification is a confequence of thefe inflammations, putrifaction enfues, and the difcharge becomes very offenfive. Whether this difference in the effect of the inflammation arifes from the nature of the parts, I will not pretend to fay. This effect takes place about the buttocks and fide of the anus oftener than any where elfe; as indeed does common inflammation and fuppuration.

This inflammation commonly begins with fever, lownefs of fpirits, and proftration of ftrength, lofs of appetite, etc. but it commonly does not laft long, and the inflammation fhall fpread even when the fever is gone off, but then it is not fo violent: when it produces fuppuration in the cellular membrane it is often dangerous, both from the difeafe itfelf, and the confequences of the matter diffufing itfelf much farther. This effect frequently takes place when this inflammation attacks the buttocks or parts near the anus, and often proves fatal. In fuch cafes, as the fores feldom ulcerate, they fhould be opened early, for the matter either gets into the cellular membrane from the want of adhefions, or it feparates parts that are only attached, as the periofteum from the bone, mufcles from mufcles etc. whereas the true fuppurative ulcerates brifkly, which, therefore, fhould not be opened early, but allowed to burft.

Many inflammations on the fkin which come to fuppuration, have fomething of the eryfepelatous difpofition, for we fee them increafing the circle of inflammation, the cuticle feparating, matter formed underneath from the cutis, and the fore healing in the centre; they perhaps begin like a pimple, but fpread in that way to the breadth of a fixpence, fhilling, or crown-piece; fuch often take place on the fingers.

The inflammation that produces the carbuncle is of a different nature from any of the former; it is ftationary with refpect to place, and is pretty much circumfcribed, even forming a broad, flat, firm tumour; it begins in the fkin almoft like a pimple, and goes deeper and deeper, fpreading with a broad bafe under the fkin in the cellular membrane; and although confiderably tumified, yet this does not arife from the extravafation of coagulating lymph producing adhefions which are to retain life, for the very cells into which it is extravafated become dead. It produces a fuppuration, but not an abfcefs, fomewhat fimilar to the eryfepelatous when the inflammation paffes into the cellular membrane, for as there are no adhefions, the matter lies in the cells where it was formed, almoft like water in an anafarca; but ftill it is not diffufed through the uninflamed cellular membrane, as in the eryfepelatous, for it appears to extend no further than the inflammation; one would almoft imagine that there was a limitation to the extent, beyond which, this fpecies of inflammation could not go, and at thefe limits the adhefive inflammation took place to confine the matter within the bounds of the carbuncle. A diffufed ulceration on the infide for the exit of the matter takes place, making a number of openings in the fkin; there are generally more carbuncles than one at the fame time, a great number fucceeding each other, which would almoft feem to produce each other in this fucceffion; they are commonly more on the trunk of the body than any where elfe; however, I have feen them on the head, and fometimes on the extremities, although but feldom.

They are more commonly on the pofterior part of the body than the anterior.

This inflammation attacks more beyond the middle age than at it, and very few under it.

It is moft common in thofe that have lived well. I never faw but one patient of this kind in an hofpital. It appears to have fome affinity to the boil; but the boil differs in this refpect, that it has more of the true inflammation, therefore fpreads lefs, and is more peculiar to the young than the old, which may be the reafon why it partakes more of the true inflammation.

As death is produced in a great deal of the cellular membrane, and I believe, in it only, except the fkin giving way, which I believe is by ulceration principally, it becomes a queftion, whether this mortification arifes from the nature of the inflammation, or rather from the matter being confined in the cells of the cellular membrane? I rather fufpect the latter; for I find that if this matter efcapes from thefe cells and comes into uninflamed cells, it produces mortification there. This is like the urine, for whenever the urine efcapes into the cellular membrane it there produces mortification; the colour of the fkin is at firft more vivid than afterwards, for it becomes of a purple colour.

Inflammation often produces mortification or death in the part inflamed. This commonly takes place in old people that are become very much debilitated, and chiefly in the lower extremities. I fufpect it to be fome what fimilar to the carbuncle, viz. principally in thofe who have lived well, although not fo much confined to them as the carbuncle; however, it takes place in the young, where great debility has been produced from difeafe, efpecially thofe difeafes that have debility as a principle, fuch as what are commonly called putrid fevers; but the fituation of thefe is not fo determined, and in fuch, inflammation hardly takes place without an immediate exciting caufe, as the application of blifters, etc. Death in a part fometimes takes place, almoft immediately without inflammation; but this is not to the prefent purpofe. Where mortification fucceeds inflammation in the extremities, efpecially in elderly perfons there is often an early feparation of the cuticle which forms a blifter, filled with a bloody ferum: and we fhall obferve dark brownifh fpots, which confift of extravafated blood in the true cutis, and which fhall at laft blifter, and then the cutis forms a flough.

Such inflammations have little of the adhefive tumefaction in them, but more of the œdematous; are not clear or tranfparent, but rather of a dufky red; as the colour of the inflamed parts fhow fomething of its nature, it is to be obferved that it is different in all thefe inflammations from that of the true adhefive, and as we have reafon to believe that the circulation is quicker in the adhefive inflammation than is natural, and that the colour arifes from this caufe, we may fuppofe that the motion of the blood in thefe is languid, and that it affumes the venal appearance, even in the arteries.

In moft of thefe four inflammations there is an appearance that often arifes, which is a redifh ftreak commonly paffing from the inflamed parts towards the fource of the circulation, but not always in this direction; fometimes juft the contrary; and this is more certain when it happens to take place in an extremity, becaufe there we know the courfe of all the veffels better; but it does not always arife from the part inflamed. I have feen this laft fpecies of inflammation attack the toes, and red ftreaks run up the foot, terminating about the ancle, while there were feveral arifing on the fore part of the leg, juft below the knee.

They often make a net-work on the leg, and are frequently a forerunner, and an attendant on mortification. They feldom go farther than a blufh in the fkin, feldom thicken, but are more of the œdematous kind; however, we fometimes find hard cords running from fores and inflammations, but thefe are commonly deeper feated, and I have fufpected them to be veins; as a proof of this, I have feen the fuperficial veins of the leg have the fkin red over them, fimilar to thofe above defcribed, and the veins have felt hard under the finger. Thefe redifh ftreaks are fuppofed to be abforbents, becoming inflamed by their carrying a ftimutating fluid. I am apt to fuppofe them to be abforbents, but I do not conceive that this effect arifes from abforption. If it arofe from fuch a caufe, it fhould be uniform, the caufe fhould always exift when the effect takes place. It is firft to be obferved, that it only takes place in certain conftitutions, in which abforption, one way or other explains nothing; and I find, upon obfervation, that this effect fhall be coeval with the inflammation where no fuppuration has taken place; I have even feen it arife from accident, prior to the poffibility of inflammation taking place, viz. in the time of the pain arifing from the immediate effects of the accident; this was in the finger, from the prick of a clean needle, which had been for fome time piercing new buck-fkin leather; the glands in the armpit were fore, ficknefs, attended with its ufual fymptoms, fuch as oppreffion, was nearly as immediate. Its direction from the fource of the circulation is another ftrong proof of its not arifing from abforption, and its taking place at fome diftance is alfo a corroboration of the fame opinion. Another ftrong circumftance in favour of this opinion is, that the morbid poifons do not produce this effect, where we know abforption has taken place. Thus the venereal feldom or ever produces it. The hard cord paffing from the prepuce along the upper part of the penis, I do not conceive to be of this kind. In the fmall-pox, after inoculation, it has been obferved, but I imagine it was only in the above-mentioned conftitutions. I could conceive it to arife in the plague, if there was any local difeafe. I am, therefore, rather apt to attribute this appearance to the irritation running along the lymphatics, more efpecially in fuch conftitutions; and as we do not allow the veins to be abforbents;

their being affected muſt be ſuppoſed to ariſe from the ſame cauſe. Whenever we ſee this effect, we may, in ſome degree, form an opinion of the kind of inflammation, and that it is not the moſt favourable.

END OF THE FIRST VOLUME.