Garnett Thomas

Popular Lectures on Zoonomia

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Popular Lectures on Zoonomia / Or The Laws of Animal Life, in Health and Disease:

Содержание

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AN ACCOUNT OF THE LIFE OF THE AUTHOR

DR. GARNETT was born at Casterton, near Kirkby Lonsdale, Westmoreland, on the 21st of April, 1766. During the first fifteen years of his life, he remained with his parents, and was instructed by them in the precepts of the established church of England, from which he drew that scheme of virtue, by which every action of his future life was to be governed. The only school education he received during these early years, was at Barbon, a small village near his native place, to which his father had removed the year after he was born. The school was of so little consequence, that its master changed not less than three times during the space of seven or eight years, and the whole instruction he received, was comprehended in the rudiments of the English grammar, a small portion of Latin, and a little French, together with the general principles of arithmetic. His bodily constitution was from the beginning weak and susceptible; he was unequal to joining in the boisterous amusements of his companions, while from the liveliness of his disposition he could not remain a moment idle. To these circumstances we are, perhaps, to attribute the uncommon progress he made in every branch of knowledge to which he afterwards applied himself.

Whilst a schoolboy, the susceptibility of his mind, and a diffidence of character connected with it, caused him to associate very little with his schoolfellows: he dreaded the displeasure of his preceptor, as the greatest misfortune which could befal him The moment he arrived at home, he set about preparing his lesson for the next day; and as soon as this was accomplished, he amused himself by contriving small pieces of mechanism, which he exhibited with conscious satisfaction to his friends. His temper was warm and enthusiastic; whatever came within the narrow circle of his early knowledge he would attempt to imitate. He saw no difficulties before hand, nor was he discouraged when he met with them. At the early age of eleven years, he had somewhere seen a dial and a quadrant, and was able to imitate these instruments, nay, with the assistance of the latter, and the small knowledge of arithmetic and trigonometry, which he had then obtained, he formally marched out with his younger brother, and rudely attempted to measure the height of a mountain behind his father's house. When he was nearly fifteen years of age, he was, at his earnest desire, put apprentice to the celebrated mathematician, Mr. Dawson, of Sedbergh, who was at that time a surgeon and apothecary. This situation was peculiarly advantageous to him, on account of the great mathematical knowledge of his master, by whom he was instructed in the different branches of this science; and, notwithstanding his constant employment in necessary business, his ardent pursuit of professional information, and his extreme youth, in the course of four years, he became well acquainted with mechanics, hydrostatics, optics, and astronomy. He afterwards applied himself with energy to the study of chemistry, and other subjects, with which it was thought expedient that he should be acquainted, previously to attending the medical lectures in the University of Edinburgh. Strongly impressed with a sense of the value of time, he was indefatigable in the pursuit of knowledge: by a concurrence of fortunate circumstances, his talents had become so flexible, that he succeeded almost equally well in every subject to which he applied himself; but of chemistry he was particularly fond, and from this time it became his favourite study.

During the four years of his apprenticeship, his conduct was in every respect highly commendable; he was assiduous, he was virtuous. His pursuit after general knowledge was restrained to one object only at a time; he had advanced far in the abstruse sciences; his inclination for study was increased: when in the year 1785, he went to Edinburgh with a degree of scientific knowledge, seldom attained by young men beginning the study of medicine. He became a member of the Medical and Physical Societies, where he soon made himself conspicuous, and of the latter of which, he was afterwards president.

Well acquainted with the first principles of natural philosophy, he had considerable advantages over his contemporaries; and his superiority was soon acknowledged. He was not, however, on this account inclined to remit his industry; he attended the lectures of the ablest professors of the day, and more particularly those of Dr. Black, with the most scrupulous punctuality, and endeavoured to elucidate his subject by every collateral information he could obtain. He avoided almost all society; and it is said, he never allowed himself, at this time, more than four hours sleep out of the twenty four. The famous Dr. Brown was then delivering lectures on his new theory of medicine. Dr. Garnett, fired with the enthusiasm of this noted teacher, and struck with the conformity of his theory to the general laws of nature, became one of the most zealous advocates of his doctrine; and from this period, he took, during the remainder of his life, every opportunity of supporting it.

During two summers he returned to Mr. Dawson at Sedbergh, passing the intervening winters in Edinburgh: about this time he wrote the essay, which, in the year 1797, he published under the title of a Lecture on Health, which very neatly and perspicuously explains the fundamental parts of the Brunonian theory of medicine: in September 1788, he published his inaugural dissertation de Visu, and obtained the degree of

M.D. Very soon afterwards he went to London, to pursue his professional studies, which he continued to do with the greatest perseverance: he attended with unceasing diligence the lectures of the most eminent lecturers, and he sought practical knowledge in the chief hospitals of the metropolis with the most ardent zeal; so that whilst he gained information to himself, he set an impressive example to his contemporary medical students, who in the delusive pursuits of a great city, are too apt to neglect the objects their parents had in view in sending them to the capital. Having finished his studies in London, Dr. Garnett, in 1789, returned to his parents. At the time he left London, he had lost none of his ardour; still he continued indefatigable and observant. He had been flattered and respected by his fellow students, and praised by his seniors; and his previous success animated him with the strongest expectation of future advancement. At this time, it is supposed, he wrote the justly admired Treatise on Optics, which is in the Encyclopaedia Britannica. Soon after his establishment as a physician, at Bradford, in Yorkshire, which took place in the year 1790, he began to give private lectures on philosophy and chemistry. He wrote his treatise on the Horley Green Spa; and in a short time, gained a deserved character of ingenuity and skill as a chemist, a physician, and a benevolent member of society. Bradford did not afford scope for his practice as a physician, equal to the sanguine expectations he had formed; and he was induced to change his situation.

In the year 1791, therefore, he removed to Knaresborough, intending to reside at that place during the winter, and at Harrowgate during the summer. This plan he put in execution till the year 1794; his reputation rapidly increased, and his future prospects appeared cheering and bright. He continued to apply himself very closely to chemistry, which was now decidedly his most pleasant and interesting study. He endeavoured to apply his various knowledge to practical purposes, and in many instances was peculiarly successful. No sooner had he arrived at Knaresborough, than anxious to investigate every thing in the neighbourhood, which could at all affect the health of the inhabitants, he began to analyse the Crescent Water at Harrowgate; which he did, with all the accuracy a subject so difficult could admit of; and in 1791, he published his treatise upon it. The same spirit led him, in 1792, to analyse the other mineral waters at the same place of fashionable and general resort, the detail of which he published in the same year. These publications became generally read, and gained him a very extensive reputation. The late Dr. Withering, whose knowledge on these subjects could not be disputed, before he had seen his general analysis of the Harrowgate Waters, said, that "excepting only the few examples given us by Bergman, the analysis of the Crescent Waters was one of the neatest and most satisfactory accounts he had ever read of any mineral water." But his exertions were not confined to professional and scientific pursuits; laudably desirous of advancing knowledge amongst every branch of the community, he formed the plan of a subscription library, which has, since 1791, been of great convenience and utility to the inhabitants of Knaresborough. Far from joining in the opinion which has so much prevailed in modern times, that it was sufficient to aim at general utility, he lost no opportunity of doing good to every member of society. He greatly promoted and encouraged the making of the pleasure grounds and building on the rock, called Fort Montague; and he instructed and assisted the poor man, who is called the Governor, to institute a bank, and to print and issue small bills of the value of a few halfpence, in imitation of the notes of the country bankers, but drawn and signed with a reference of humour to the fort, the flag, the hill, and the cannon. These notes, the nobility and gentry, who during the Harrowgate season crowd to visit this remarkable place, take in exchange for their silver, and by these means the governor, who is a man of gentle and inoffensive manners, has been enabled, with the assistance of his loom, to support himself and a numerous family, and to ameliorate their condition, by giving education to his children.

No station in life escaped his benevolent attentions. In order to benefit John Metcalf, who is perhaps more generally known by the name of Blind Jack of Knaresborough, he assisted him to publish an account of the very singular and remarkable occurrences of his life, during a long series of years, under the heavy affliction of total blindness; by the sale of which, this venerable old man derived a considerable contribution towards his subsistence.

Whilst at Harrowgate, Dr. Garnett obtained the patronage and protection of the Earl of Rosslyn, then Lord Loughborough, who in the year 1794 built a house for him, which for the future Dr. Garnett meant should be his only residence; it was not long however before he discovered that his situation at Harrowgate was but ill calculated to forward his liberal and extended views. At this place he had small opportunities of attaching himself to his favourite sciences; in the winter months he was without literary society, and it was not for his ardent spirit to remain inactive. About this time also, he formed the idea of going to America, where he thought he might live both honourably and profitably as a teacher of chemistry and natural philosophy. All these circumstances were floating in his mind, when in the year 1794, about the end of July, at the instance of a medical friend, who resided in London, he received as boarders into his house, which was kept by his sister, Miss Catharine Grace Cleveland, daughter of the late Mr. Cleveland, of Salisbury Square, Fleet Street, who was recommended to the use of the Harrowgate waters, together with her friend Miss Worboys. To all who were acquainted with the prepossessing exterior of Dr. Garnett, the liveliness of his conversation, the urbanity of his manners, and his general desire of communicating knowledge to whomever he saw desirous of gaining information, it will be no surprise, that a mutual attachment grew up between him and his inmate, Miss Cleveland, a young lady possessing, in all respects, a mind similar to his own, and who must have felt a natural gratification in the zeal with which the company of the person, on whom she had placed her affections, was sought by all ranks resorting to this fashionable watering place, where every one thought himself most fortunate who sat nearest to him at the table, and where he enlivened the circle around him with his conversation, which was not only instructive, but playfully gay, and entertaining, ever striving to amuse, and always successful in his attempts. The Doctor now began to project plans of happiness, which he had only before held in idea. Previous to his visitors leaving Harrowgate, which was towards the latter end of December, he communicated to Miss Cleveland his intention of going to America. At first she hesitated about accompanying him; but finding his resolution fixed, she at length consented. From this time, till the beginning of March 1795, he continued deliberating upon and maturing his plan. He now departed from Harrowgate, and followed the object of his affection to her mother's residence at Hare Hatch, Berks. He was married to her on the 16th of March, and a fortnight afterwards returned to Harrowgate, to dispose of the lease of his house, and his furniture. Having again joined his wife, he then went to London, where he purchased apparatus for his lectures, and after visiting his parents, he proceeded to Liverpool, in order to obtain a passage to America.

Whilst he was thus waiting for the opportunity of a vessel to transport him across the Atlantic, he was solicited by the medical gentlemen at Liverpool, to unpack his apparatus, and give a public course of lectures on chemistry and experimental philosophy. At all times desirous of diffusing the knowledge he had acquired, and eager to fulfil the wishes of his friends, he complied with their request, and entered upon a plan, which in the end completely overturned the scheme he had for several months been contemplating with such ardent hopes of happiness and prosperity. No sooner had he been prevailed upon, than he set about getting every thing ready for his lectures, and after a single week's preparation; he commenced his course. The deep interest he took in his subject, the anxiety he showed to make himself understood, and the enthusiastic hope he constantly expressed of the advancement of science, had a remarkable effect upon his audience; and his lectures were received with the most flattering marks of attention, and excited the most general applause and satisfaction. In a short time, he received a pressing invitation from the most eminent characters at Manchester, to repeat his course in that town. This invitation he accepted, and, encouraged by the success he had just experienced, he postponed the idea of leaving his country. He arrived at Manchester about the middle of January 1796, and began his lectures on the 22nd of that month. Before his arrival, not less than sixty subscribers had put down their names, the more strongly to induce him to comply with their wishes, and many more had promised to do it, as soon as his proposals were published. Notwithstanding he was thus led to expect a large audience, and had procured apartments, which he imagined would be sufficiently spacious for their reception, he was obliged, for want of room, to change them not less than three times during one course. With such success did the career of his philosophical teaching begin, and with such extreme attention and respect was he every where received, that he used afterwards to mention this period, as not only the most profitable, but the most happy of his life. On the 24th of February, his wife was brought to bed of a daughter, the eldest of the two orphans who have now to lament the death of so valuable a parent, to deplore the loss of that independence which his exertions were certain to have raised them, and to rely on a generous public for protection, in testimony of the virtues and merit of their father.

After this time Dr. Garnett repeated nearly the same course of lectures at Warrington and at Lancaster; to both which places he was followed by the same success.

Whilst he was in this manner exerting himself for the general diffusion of knowledge, his fame spread with the delight and instruction he had every where communicated to his audience. The inhabitants of Birmingham wished to have the advantage of his lectures; and he also received a most pressing invitation from Dublin, where a very large subscription had already been formed. It was his intention to have accepted of the latter invitation, but previous to his departure for Ireland (from whence he had even yet some thoughts of emigrating to America) he was informed of the vacancy of the professorship in Anderson's Institution, at Glasgow, by his friend the late Dr. Easton of Manchester, who strongly urged him to become a candidate. As this situation must inevitably destroy all his future prospects, he for a long time hesitated; but Dr. Easton having informed the Managers of the Institution, that there was a possibility of their obtaining a professor, so eminently qualified as Dr. Garnett, they, after making further inquiry concerning him, offered it to him in so handsome a manner, that, although the situation was by no means likely to be productive of so much emolument as the plan of life he had lately been pursuing, he yielded to their proposal, strengthened as it was by the earnest solicitation of Mrs. Garnett, who felt considerable apprehension at the thoughts of going to America, and consented to accept of the professorship.

He began his lectures at Glasgow in November 1796, and a short account of them may be found in his Tour to the Highlands, vol. ii. p. 196. The peculiar clearness with which he was wont to explain the most difficult parts of science, together with the simplicity of the terms he employed, rendered his lectures particularly acceptable to those who had not been initiated in the technical terms, generally used on such occasions. Every thing he delivered might easily be understood by those who had not previously attended to the subject; and of consequence, all who had been disgusted, or frightened by the difficulties they had before met with, or imagined, were eager to receive his instructions; and the audience he obtained, was much more numerous, than either the trustees, or himself, had deemed probable.

When the session was completed, he repaired to Liverpool for the purpose of fulfilling a promise he had formerly given to his friends, to repeat his course of lectures in that town. Mrs. Garnett, in the mean time, remained at Kirkby Lonsdale, where he joined her as soon as his lectures were finished. He spent the latter part of the summer chiefly in botanical pursuits, and returned to Glasgow in the autumn, when he made known his intention of practising as a physician. Fortune continued to favour him, his reputation increased, and he rapidly advanced towards the first professional situation in Glasgow.

In July 1798, he began his Tour to the Highlands, an account of which he published in 1800, and having returned to his duties in the Institution, the success of his lectures suffered no interruption, but whilst he was reaping the benefit due to his industry and his talents, his happiness received a blow, which was irrecoverable, by the loss of his wife, who died in child birth, December the 25th 1798: the infant was preserved. The sentiments of Dr. Garnett on this occasion will be best expressed in his own words, in a letter to Mr. Ort, of Bury in Lancashire.

"Glasgow, January 1st. 1799.

"Oh my dear cousin, little did I expect that I should begin the new year with telling you that I am now deprived of all earthly comforts; yes, the dear companion of my studies, the friend of my heart, the partner of my bosom, is now a piece of cold clay. The senseless earth is closed on that form which was so lately animated by every virtue; and whose only wish was to make me happy.

"Is there any thing, which can now afford me any consolation? Yes, she is not lost, but gone before: but still it is hard to have all our schemes of happiness wrecked: when our bark was within sight of port, when we were promising ourselves more than common felicity, it struck upon a rock: my only treasure went to the bottom, and I am cast ashore, friendless, and deprived of every comfort. My poor, dear love had been as well as usual during the two or three last months, and even on the dreadful evening (christmas eve) she spoke with pleasure of the approaching event. My spirits were elevated to so uncommon a pitch, by the birth of a lovely daughter, that they were by no means prepared for the succeeding scene; and they have been so overwhelmed, that I sometimes hope it may be a dream, out of which I wish to awake. The little infant is well, and I have called it Catharine, a name which must ever be dear to me, and which I wish to be able to apply to some object whom I love; for though it caused the death of my hopes, it is dear to me, as being the last precious relic of her, whom every body who knew her esteemed, and I loved. I must now bid adieu to every comfort, and live only for the sweet babes. Oh! 'tis hard, very hard. "THOMAS GARNETT." "To Mr. Ort, Bury, Lancashire.

The affliction Dr. Garnett experienced on the death of his wife, was never recovered. On all occasions of anxiety which were multiplied upon him, by reason of his exquisite sensibility, he longed for the consolation her society used to afford him; and although his susceptibility to the action of external causes, would not allow him to remain in continued and unalterable gloom and melancholy, yet in solitude, and on the slightest accident, his distress returned, and he despaired of the possibility of ever retrieving his lost happiness. Had it not been for his philosophical pursuits, and the duties of his extensive practice, which kept him almost constantly engaged, it may be doubted, whether he could at this time have sustained the load of sorrow with which he was oppressed.

The circumstances which remain to be mentioned are few. From the death of his wife, Dr. Garnett may be considered as unfortunate; for although a fair prospect opened before him, a series of occurrences took place, which neither his state of mind, nor his constitutional firmness enabled him to support.

At the time of the formation of the Royal Institution of Great Britain, in London, Count Rumford wrote to Dr. Garnett, to whom he was then an entire stranger, inquiring into the nature and economy of Anderson's Institution, Glasgow; the plan of the lectures given, &c. &c.; and after hinting at the opportunities of acquiring reputation in London, he finally proposed that Dr. Garnett should become lecturer of the new Institution. With this proposal, arduous as was the task, to deliver a course of lectures on almost every branch of human attainment, Dr. Garnett complied, relying on his acquirements, and the tried excellence of his nature; and conscious that no difficulty could resist the indefatigable exertions which on other occasions he had so successfully applied. Flattered by the honour and respect he conceived to be paid to his abilities and qualifications; pleased with the prospect of more rapidly accumulating an independence for himself and his children; and animated with the hope of meeting with more frequent opportunities of gratifying his thirst after knowledge, his spirits were again roused, and he looked forward to new objects of interest in the advancement of his favourite pursuits. In the enthusiasm of the moment, he was known to say, that he considered his connexion with the Royal Institution, from which the country had a right to expect so much, as one of the most fortunate occurrences of his life. On the 15th October 1799, he informed a special meeting of the Managers of Anderson's Institution, of his appointment to the Professorship of Philosophy, Chemistry, and Mechanics, in the Royal Institution of Great Britain, and on that account requested permission to resign his situation. The resignation of a man, whom all loved and revered, was reluctantly, though, as tending to his personal advancement, and the promotion of science, unanimously accepted by the meeting; he was congratulated on his new appointment, and thanked for the unremitting attention he had paid to the interests of Anderson's Institution, ever since he had been connected with it. As an instance of the high esteem in which he was held by the trustees, it may be observed, that his successor, Dr. Birkbeck, was elected by a very great majority of votes, principally on account of his recommendation. In November, he pursued his journey to London, leaving his children at Kirkby Lonsdale, under the care of Miss Worboys.

This lady, whose friendship for Mrs. Garnett had induced her to become almost her constant companion, and had even determined her to go with her friend to America, if the Doctor had put his intentions in execution; soon after the death of Mrs. Garnett, had pledged herself, never to desert the children, so long as she could be of any use to them. How faithfully she observes this obligation, all who know her must acknowledge; nor can we, without increased anxiety, reflect upon the situation the poor orphans must have been in without her protection.

Dr. Garnett was received by the Managers of the Royal Institution with attention, civility, and respect. During the winter, the lecture room was crowded with persons of the first distinction and fashion, as well as by those who had individually contributed much to the promotion of science; and although the northern accent, which Dr. Garnett still retained in a slight degree, rendered his voice somewhat inharmonious to an audience in London, his modest and unaffected manner of delivering his opinions, his familiar, and at the same time elegant language, rendered him the object of almost universal kindness and approbation.

The exertions of the winter had in some measure injured his health, and a degree of uncertainty that he saw in his prospects, tended greatly to depress his spirits. He determined, however, to keep his situation at the Institution, in order that he might at a more convenient time be justified to himself in resigning it. In the summer of 1800, he visited his children in

Westmoreland; but his anxiety of mind was not diminished, nor consequently his health improved, by this relaxation from active employment. He walked over the same ground, and viewed the same prospects that he had formerly enjoyed in the company of his wife. He had not resolution to check the impressions as they arose; and thus, instead of being solaced by the beauties which surrounded him, he gave the reins to his melancholy fancy, which, unchecked by any other remembrance, dwelt only on the affection and the virtues of her, whose loss he had ever to deplore; the want of whose society he imagined to be the chief source of his misery. Towards the end of autumn, he returned to the Institution, and in the winter, recommenced his duties as professor. The effect produced upon his lecturing by these and other irritating circumstances was remarkable. Debility of body, as well as uneasiness of mind, incapacitated him for that ardent and energetic pursuit of knowledge, by which he had been so eminently distinguished. His spirited, and at the same time modest method of delivery was changed into one languid and hesitating, that, during this period, occasioned an erroneous judgment to be formed of his abilities as a man of science, and a teacher, by such of his audience as were unacquainted with the cause, or the intrinsic value and merit of the man. At the close of the season, his determination of retiring from the Institution was fixed; and he presented to the Managers his resignation.

It was well known to Dr. Garnett's particular friends, that during the early part of this session, he determined to withdraw himself from the Institution; but the success and advancement of the establishment, which he sanguinely hoped would stand unrivalled in the universe, was so intimately connected with the affections of his mind, that he resolved to forego every personal consideration, rather than risk an inconvenience to the Institution, by ceasing to deliver his lectures in the middle of a course; liberally considering, that the Managers, after the business of the season was over, would have time and opportunity before the ensuing session, to fill the professor's chair with talents competent to the arduous undertaking; a circumstance the Managers afterwards so eminently profited by, with the highest credit to themselves, and advantage to the public, in the nomination of the gentlemen who now fill the situation held by Dr. Garnett, and who discharge its important duties with the most distinguished abilities.

The transactions of the last winter almost completely served to undermine the small strength of constitution he had left; he was constantly harrassed by complaints in the organs of digestion; head ache deprived him of the power of application; his countenance assumed a sallow complexion; the eye which had beamed with animation, retired within its socket, deprived of lustre; melancholy conceptions filled his imagination more habitually, and were excited by slighter causes; at times, they altogether deprived him of the power of exertion; and while he lamented their effect, the contemplation of themselves rendered him the more their prey. At this time, a gloomy day, or the smallest disappointment, gave him inconceivable distress; but he was not altogether incapable of temporary relief, and the few moments of pleasure he seemed to enjoy, would have given reason to believe, that he might once more have recovered, and have long continued to be the delight and instructor of his friends. A more close observation would at the same time have justified the supposition, that the strong and painful emotions of mind he had suffered, had already induced disorders of the bodily system, which were irrecoverable. Before Doctor Garnett had left his situation at Glasgow, he had determined to practice as a physician in London; but from this he was restrained, during the time he was at the Royal Institution. To his former intention he now determined to apply himself, and in addition to the attempt, by giving private lectures, to assure himself of that independency, of which his unfortunate destiny, though with every reasonable expectation before him, had hitherto deprived him.

With this intention, he purchased the lease of a house in Great Marlborough Street; and in the summer of 1801, built a lecture room. He brought his family to town, and once more looked forward with hope. The flattering success he soon met with, and a short residence at Harrowgate in the autumn, contributed to afford a temporary renovation of health and spirits; it was, however, but a short and delusive gleam of prosperity which now dawned upon him; for, confiding too much in his newly increased strength, he exerted himself to a much greater degree than prudence would have suggested. In the course of the following winter, he delivered not less than eight courses of lectures, two on chemistry, two on experimental philosophy, a private course on the same subject, one on mineralogy, and the course to which this sketch is prefixed, which he also delivered in an apartment at Tom's Coffee house, for the convenience of medical students, and others, in the city. Besides these, he commenced two courses on botany, one at Brompton, and the other at his own house; but a return of ill health prevented his concluding them. It was not to be expected, that a constitution so impaired and debilitated, could long support this continued labour of composition and recitation; accordingly he became affected with a consequent disorder, which rapidly exhausted his strength; and, being unable to employ the only probable means of recovering it, he became more incapable of exertion. His spirits however were roused, and he ceased not to use every means of increasing his practice. In the spring of 1802, the office of physician to the St. Mary le Bonne Dispensary happened to be vacant, and he became a candidate; he was more than commonly anxious to obtain this situation. It seemed to him, as if his future good or ill fortune depended altogether upon the event of his canvass, he spared no effort to ensure his success; and accordingly was appointed to the situation in May. His life now drew near a close. Little was he calculated to bear the accumulated labours, and extreme fatigue, to which he was daily exposed. Any benefit which might have resulted from constant and well regulated occupation was frustrated; for whilst he still suffered from the vividness of his conception, representing to him in mournful colours the occurrences of his past life, he became liable to other evils, not less injurious and destructive. The practice of medicine requires both vigorous health of body and firmness of mind. Dr. Garnett, now greatly weakened in body, and not exempt from anxiety of mind, became more and more susceptible to the action of morbific matter. It was not long before he received the contagion of typhous fever, whilst attending a patient, belonging to that very dispensary of which he had been so anxious to become physician. He laboured under the disorder for two or three weeks, and died the 28th of June, 1802; and was buried in the new burial ground of the parish of St. James, Westminster.

Thus was lost to society a man, the ornament of his country, and the general friend of humanity. In his personal attachments, he was warm and zealous. In his religion he was sincere, yet liberal to the professors of contrary doctrines. In his political principles, he saw no end, but the general good of mankind; and, conscious of the infirmity of human judgment, he never failed to make allowances for error. As a philosopher, and a man of science, he was candid, ingenuous, and open to conviction; he never dealt in mystery, or pretended to any secret in art; he was always ready in explanation, and desirous of assisting every person willing to acquire knowledge. Virtue was the basis of all his actions; science never possessed a fairer fabric, nor did society ever sustain a greater loss.

LECTURE I. INTRODUCTION

I AM well aware of the difficulties attending the proper composition of a popular course of lectures on the animal economy, which must be essentially different from those generally delivered in the schools of medicine; because it professes to explain the structure and functions of the living body, to those who are supposed to be unacquainted with the usual preliminary and collateral branches of knowledge. It must be obvious to every one, that it can be by no means an easy task to give in a few lectures, a perspicuous view of so extensive a subject; but I trust that the consideration of this difficulty will readily extend to me your indulgence.

That such a course, if properly conducted, must be interesting, needs scarcely to be observed; for the more we examine the structure and functions of the human body, the more we admire the excellence of the workmanship, and beauty of contrivance, which presents itself in every part, and which continually shows the hand of omniscience. The most ingenious of human inventions, when compared with the animal frame, indicate a poverty of contrivance which cannot fail to humble the pretensions of the sons of men. Surely then there are few who will not feel a desire to become acquainted with subjects so interesting.

But there is another point of view which will place the utility of such inquiries in a still stronger light. We shall afterwards see, that our life is continually supported by the action of a number of substances, by which the body is surrounded, and which are taken into the stomach for its nourishment. On the due action of these depends the pleasant performance of the different functions, or the state of health; without which, riches, honours, and every other gratification, become joyless and insipid.

By understanding the manner in which these powers act, or, in other words, by becoming acquainted with the principles of physiology, we shall be enabled to regulate them, so as, in a great measure, to guard against the numerous ills that flesh is heir to: for it is universally agreed, that by far the greatest part of the diseases to which mankind are subject, have been brought on by intemperance, imprudence, and the neglect of precautions, which often arises from carelessness, but much oftener from ignorance of those precautions.

Physiological ignorance is, undoubtedly, the most abundant source of our sufferings; every person accustomed to the sick must have heard them deplore their ignorance of the necessary consequences of those practises, by which their health has been destroyed: and when men shall be deeply convinced, that the eternal laws of nature have connected pain and decrepitude with one mode of life, and health and vigour with another, they will avoid the former and adhere to the latter.

It is strange, however, to observe that the generality of mankind do not seem to bestow a single thought on the preservation of their health, till it is too late to reap any benefit from their conviction: so that we may say of health, as we do of time, we take no notice of it but by its loss; and feel the value of it when we can no longer think of it but with retrospect and regret.

When we take a view of the human frame, and see how admirably each part is contrived for the performance of its different functions, and even for repairing its own injuries, we might at first sight imagine, that such a structure, unless destroyed by external force, should continue for ever in vigour, and in health: and it is by mournful experience alone that we are convinced of the contrary. The strongest constitution, which never experienced the qualms of sickness, or the torture of disease, and which seems to bid defiance to the enemies of health that surround it, is not proof against the attacks of age. Even in the midst of life we are in death; how many of us have contemplated with admiration the graceful motion of the female form; the eye sparkling with intelligence; the countenance enlivened by wit, or animated by feeling: a single instant is sufficient to dispel the charm: often without apparent cause, sensation and motion cease at once; the body loses its warmth, the eyes their lustre, and the lips and cheeks become livid. These, as Cuvier observes, are but preludes to changes still more hideous. The colour passes successively to a blue, a green, and a black; the flesh absorbs moisture, and while one part of it escapes in pestilential exhalations, the remaining part falls down into a putrid liquid mass. In a short time no part of the body remains, but a few earthy and saline principles; its other elements being dispersed through air, or carried off by water, to form new combinations, and afford food for other animals.

The human body has been defined to be a machine composed of bones and muscles, with their proper appendages, for the purpose of motion, at the instance of its intelligent principle. From this principle, nerves, or instruments of sensation, are likewise detached to the various parts of the body, for such information as may be necessary to determine it to those motions of the body, which may conduce to the happiness of the former, and the preservation of both.

It may perhaps be objected to this definition, that the body consists of other parts besides bones, muscles, and nerves; this is undoubtedly true; but, if we examine more minutely, we shall find that all the other parts, as well as functions of the body, seem only to be subservient to the purposes I have mentioned. For, in the first place, the muscles which are necessary to the motions of the body, are, from the nature of their constitution, subject to continual waste; to repair which waste, some of the other functions have been contrived.

Secondly, most of the other parts and functions of the body, are either necessary to the action of the muscles, or to the operation of the intelligent principle, or both.

Lastly, from the sensibility, and delicate structure, of the muscles and nerves, they require to be defended from external injuries: this is done by membranes, and other contrivances, fitted for the purpose.

To see this more clearly, we shall examine a little more particularly how each of the functions is subservient to the muscular and nervous systems. For this purpose it may be observed, 1st. that the stomach and digestive faculties serve to assimilate the food, or convert it into matter proper to repair the continual waste of solids and fluids. The circulation of the blood besides being absolutely necessary, as we shall afterwards see, to the action of the muscles, distributes the nourishment, thus assimilated and prepared by the stomach, to all parts of the body. The different glands separate liquors from the blood, for useful, but still for subservient purposes. Thus the salivary glands, stomach, pancreas, and liver, separate juices necessary to the proper digestion and assimilation of the food. The kidneys serve to strain off from the blood the useless and superfluous water, salts, &c. which if allowed to remain in the body would be very injurious to it.

We shall afterwards see, that the nerves are not only instruments of sensation, but the origin of motion; it being immediately by their means that the muscles are moved. A certain degree of heat is necessary to keep the blood fluid, and also to the action of the nerves; without either of which, no motion could be performed. Respiration or breathing is so necessary to life, that it cannot exist, even a few minutes, without the exercise of that function; and yet we shall afterwards see, that the ultimate end of respiration is to keep the body in a proper state, for the purposes of muscular motion and sensation.

The skin serves like a sheath to defend the body from injuries; the skull serves the same purpose to the brain, which is the origin of the nerves. The different membranes separate the fibres, muscles, nerves, and various organs of the body, from each other. Hence we see that there is no impropriety, in calling the human body a machine composed of bones and muscles, with their proper appendages, for the purpose of motion, at the instance of its intelligent principle.

In order to show more clearly how each part is subservient to these ends, I shall give a short account of the structure of the human body, but I must premise, that the nature of this course will prevent my entering minutely into anatomical detail. All that can be done is, to give such a general outline of anatomy and physiology, as will furnish individuals with so much knowledge of themselves, as may enable them to guard against habitual sickness.

Among the solid parts of the human frame the bones stand conspicuous. Their use is, to give firmness and shape to the body. Some of them likewise serve as armour, or defense, to guard important parts; thus the skull is admirably contrived to defend the brain; and the spine or backbone is designed, not only to strengthen the body, but to shield that continuation of the brain, called the spinal marrow, from whence originate great numbers of nerves, which pass through convenient openings of this bone, and are distributed to various parts of the body. In the structure of this, as well as every other part, the wisdom of the Creator is manifest. Had it been a single bone, the loins must have been inflexible; to avoid which, it consists of a number of small bones, articulated or joined together with great exactness, which are strengthened by compact ligaments. Hence it becomes capable of various inflections, without injuring the nerves, or diminishing that strength which is so much required.

The whole system of bones, or skeleton, is constructed of several parts, of different shapes and sizes, joining with one another in various manners, and so knit together, as best to answer to the motions which the occasions of the animal may require.

These bones serve as levers for the muscles to act on; which last serve as mechanical powers, to give the machine various motions, at the command of the will.

The muscles are fleshy fibres, attached by their extremities to the bones. When the fibres shorten themselves, the two parts into which the muscle is inserted are brought nearer; and, by this simple contrivance, all the motions of animals are performed, and their bodies carried from one place to another.

Joints are provided with muscles for performing the motions for which they are adapted; every muscle pulling the bone, to which it is attached, in its own particular direction. Hence the muscles may be considered as so many moving forces, as was before hinted; and their strength, the distance of their insertion from the centre of motion, the length of the lever to which they are attached, and the weight connected with it, determine the duration and velocity of the motions which they produce. Upon these different circumstances depend the different kinds of motion performed by various animals, such as the force of their leap, the extent of their flight, the rapidity of their course, and their address in catching their prey.

Most of the muscles act upon the bones, so as to produce the effects of a lever of the third kind, as it is termed by mechanics, where the power acts between the centre of motion and the weight; hence it has a mechanical disadvantage; as an instance of this, the muscle which bends the forearm, is inserted about one eighth or one tenth of the distance from the centre of motion that the hand is, where the weight or resistance is applied; hence the muscle must exert a force eight or ten times greater than the weight to be raised. But this disadvantage is amply compensated by making the limbs move with greater velocity; besides, if room had been given for the muscles to act with greater advantage, the limbs must have been exceedingly deformed and unwieldy.[1]

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[1] [FIGURE] Suppose AC to be a lever, held in equilibrio by the force B and weight W, then the whole momentum exerted at B must be equal to that at W, but the forces will be different. For B x AC = W x AB, and if AC = 10AB, then a force equal to ten times the weight to be raised must be exerted by the muscle. Hence we see, that in the actions of muscles there is a loss of power, from their insertions being nearer the fulcrum than the weight. For example, suppose the deltoid muscle to act and raise a weight of 55 lb.: the weight of the arm is 5 lb., and the distance of its insertion is only 1/3 of the arms length, hence the force exerted must be (55 + 5) x 3 = 180 lb.[FIGURE] But by this contrivance we gain a greater extent of motion, and also a greater velocity, and both with less contraction. Let A be the centre of motion, or articulation; B the

The muscles, in general, at least those which serve for voluntary motion, are balanced by antagonists, by means of which they are kept beyond their natural stretch. When one of two antagonists is contracted by the will, the other relaxes in order to give it play; or at least becomes overpowered by the contraction of the first. Also when one of such muscles happens to be paralytic, the other being no longer balanced, or kept on the stretch, immediately contracts to its natural length, and remains in that situation. The part to which it is fixed will, of course, be affected accordingly. If one of the muscles which move the mouth sideways be destroyed, the other immediately contracting, draws the mouth awry; and in that situation it remains. The same may be observed of the leg, the arm, and other parts. Some muscles assist one another in their action, while others have different actions; according to their shapes, the course of their fibres, and the structure of the parts they move.

According to the shape and nature of the bones to be moved, and of the motions to be performed, the muscles are either long, or short; slender, or bulky; straight, or round. Where a great motion is required, as in the leg, or arm, the muscles are long;

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insertion of a muscle, and AC the length of the lever or bone; then, by a contraction only equal to B_b_, C is carried through C_c_, which is to B_b_ as AC to AB. It is obvious also, that the velocity is greater, since C moves to *c* in the same time as B to *b*.A loss of power is likewise occasioned by the obliquity of the muscular action, and the oblique direction of the fibres.For, in this case, there is a compound of two forces, and a consequent loss of power: for the forces are proportioned to the two sides of a parallelogram, but the effects produced are proportioned only to the diagonal.

where a small motion is necessary, they are short; for a strong motion they are thick, and for a weak one slender.

Some of the muscles are fastened to, and move bones; others cartilages, and others again other muscles, as may best suit the intention to be answered.

With respect to the bones, some are solid and flattened; others hollow and cylindrical. Every cylindrical bone is hollow, or has a cavity containing a great number of cells, filled with an oily marrow. Each of these cells is lined with a fine membrane, which forms the marrow. On this membrane, the blood vessels are spread, which enter the bones obliquely, and generally near their middle; from some branches of these vessels the marrow is secreted; while others enter the internal substance of the bones for their nourishment; and the reason why they enter the bones obliquely is, that they may not weaken them by dividing too many fibres in the same place.

The bones being made hollow, their strength is greatly increased without any addition to their weight; for if they had been formed of the same quantity of matter without any cavities, they would have been much weaker; their strength to resist breaking transversely being proportionate to their diameters, as is evident from mechanics.

All the bones, excepting so much of the teeth as are out of the sockets, and those parts of other bones which are covered with cartilages, are surrounded by a fine membrane, which on the skull is called pericranium, but in other parts periosteum.

This membrane serves for the muscles to slide easily upon, and to hinder them from being lacerated by the hardness and roughness of the bones.

But though the apparatus which I have been describing is admirably contrived for the performance of motion; it would continue for ever inactive, if not animated by the nervous system.

The brain is the seat of the intelligent principle: from this organ, white, soft, and medullary threads, called nerves, are sent off to different parts of the body: some of them proceed immediately from the brain to their destined places, while the greater number, united together, perforate the skull, and enter the cavity of the backbone, forming what we call the spinal marrow, which may be regarded as a continuation of the brain. Portions of the spinal marrow pass through different apertures to all parts of the body.

We are not conscious of the impression of external objects on our body, unless there be a free communication of nerves, between the place where the impression is made and the brain. If a nerve be divided, or have a ligature put round it, sensation is intercepted.

There is perhaps only one sense which is common to all classes of animals, and which exists over every part of the surface of the body; I mean the sense of touch. The seat of this sense is in the extremities of the nerves distributed over the skin; and by means of it we ascertain the resistance of bodies, their figure, and their temperature.

The other senses have been thought to be only more refined modifications of the sense of touch; and the organs of each are placed near the brain on the external surface of the head. The sense of sight, for instance, is seated in the eye; the hearing in the ear; the smell in the internal membrane of the nose; and the taste in the tongue.

The light; the pulses, or vibrations of the air; the effluvia floating in the atmosphere; saline particles, or particles which are soluble in water or saliva, are the substances which act upon these four senses; and the organs which transmit their action to the nerves, are admirably adapted to the respective nature of each. The eye presents to the light a succession of transparent lenses to refract its rays; the ear opposes to the air membranes, fluids, and bones, well fitted to transmit its vibrations; the nostrils, while they afford a passage to the air in its way to the lungs, intercept any odorous particles which it contains, and the tongue is provided with spongy papillae to imbibe the sapid liquors which are the objects of taste.

It is by these organs that we become acquainted with what passes around us; by these we know that a material world exists. We may however observe, that the nervous system, besides making us acquainted with external things, gives us notice of many changes that take place within our own body. Internal pain warns us of the presence of disease; and the disagreeable sensations of hunger, thirst, and fatigue, are signs of the body standing in need of refreshment or repose.

Concerning the manner in which we become acquainted with external things, by means of the senses, we know nothing. Many hypotheses have been offered to explain this: none of them however are the result of experiment and observation. Many philosophers have supposed the universe to be filled with an extremely subtile fluid, which they have termed ethereal; and this hypothesis has been sanctioned by the illustrious authority of Newton. He however merely offered it in the modest form of a query, for the attention of other philosophers; little thinking that it would be made use of to explain phenomena which they did not understand. His query about a subtile elastic fluid pervading the universe, and giving motion and activity to inert masses of matter, and thereby causing the phenomena of attraction, gravitation, and many other appearances in nature, was immediately laid hold of by his followers, as a fact sufficiently supported, because it seemed to have the sanction of so great an authority.

This hypothesis was made use of to explain a great number of phenomena, and the physiologists, whose theories were generally influenced by the prevailing philosophy, eagerly laid hold of it to explain the phenomena of sensation, and muscular motion. When an impression was made upon any part of the external surface of the body, whether it was occasioned by heat, or mechanical impulse, they supposed, that the ether in the extremities of the nerves was set in motion. This motion, from the energy of the ether, is communicated along the nerves to the brain, and there produces such a change as occasions a consciousness of the original impression, and a reference in the mind to the place where it was made. Next they supposed, that the action of the will caused a motion of the ether to be instantly propagated along the nerves that terminate in the fibres of the muscles, which stimulated them to contraction.

Other philosophers imagined, that a tremulous motion was excited in the nerves themselves, by the action of external impulses, like the motions excited in the string of a harp. These motions they supposed to be propagated along the nerves of sense, to the brain, and from thence along the motory nerves, to the muscles.

Before they attempted this explanation of the phenomena, they should have proved the existence of such a fluid, or at least brought forward such circumstances, as rendered its existence credible. But supposing we grant them the hypothesis, it will, in my opinion, not avail much; for it is not easy to conceive how the motion of a subtile fluid, or the vibration of a nerve, can cause sensation.

Nor are the internal senses, as they are generally called, namely, memory, and imagination, any better explained on this supposition; for we cannot conceive how this nervous fluid is stored up and propelled by the will.

After all, I think we must confess, that this subject is still enveloped in obscurity. One observation is worth making, namely, that our sensations have not the smallest resemblance to the substance or impression, which causes them; thus the sensation occasioned by the smell of camphor, possesses not the smallest resemblance to small particles of camphor floating in the atmosphere; a sensation of pain has no similitude whatever to the point of a sword which occasions it; nor has the sensation of sound any resemblance to waves or tremors in the air. In our present state of knowledge, therefore, all that we can say, is, that nature has so formed us, that when an impression is made on any of the organs of sense, it causes a sensation, which forces us to believe in the existence of an external object, though we cannot see any connexion between the sensation and the object which produces it.

But though philosophers were certainly blameable for assuming an unknown cause, to account for various phenomena, yet later experiments would seem to prove that even the conjectures of Newton were not founded on slight grounds. His idea that the diamond was inflammable, has been confirmed by various experiments: and that there exists in nature a subtile fluid, capable of pervading with ease the densest bodies, the phenomena of electricity would seem to show, and some late experiments render it by no means improbable, that this fluid or influence, acts a conspicuous part in the nervous system. That it exists in great quantity in animal bodies, is evident on gently rubbing the back of a cat in the dark; and it would seem that, in some instances, it may be given out or secreted by the nerves. We shall afterwards see that the seat of vision is a delicate expansion of a large nerve which comes from the brain, and is spread out on the bottom of the eye; and flashes of light, or a kind of sparkling, is often seen to dart from the eyes of persons in high health, and possessed of much nervous energy. These luminous flashes are very apparent in the dark in some animals; such as the lion, the lynx, and the cat; and it is difficult to account for this appearance unless we suppose it electrical.

The experiments of Galvani and others, have however proved beyond all doubt, that this fluid, when applied to the nerves and muscles, is capable of exciting various sensations and motions. To produce this fluid by the application of two metals, it is necessary that one of them should be in such a situation, as to be easily oxidable, while the other is prevented from oxidation. If a piece of zinc be put into water, no change will take place; but if a piece of silver be put along with it, the zinc will immediately oxidate, by decomposing the water, and a current of electricity will pass through the silver. If the upper and under surfaces of the tongue be coated with two different metals, one of which is easily oxidable, and these be brought into contact, a sensation is produced resembling taste, which takes place suddenly, like a slight electrical shock. This taste may likewise be produced by applying one part of the metals to the tongue and the other to any part of the body deprived of the cuticle, and bringing them in contact.

The sensation of light may be produced in various ways; such as by applying one metal between the gum and the upper lip, and the other under the tongue; or by putting a silver probe up one of the nostrils, and a piece of zinc upon the tongue; a sensation resembling a very strong flash of light is perceived in the corresponding eye, at the instant of contact.

But the experiments which tend most strongly to prove what I have hinted, are made in the following manner. Lay bare a portion of a great nerve leading to any muscle or limb of an animal, for instance, the leg of a frog separated from the body. Touch the bared nerve with a piece of zinc, and the muscle with a piece of silver, and strong contractions take place the instant these metals are brought into contact. The same effect may be produced by placing a piece of silver on a larger piece of zinc, and putting a worm or a leech on the silver; in moving about, the instant it touches the zinc it is thrown into strong convulsions.

These phenomena have been clearly proved to be electrical; for by a number of pieces of these metals, properly disposed, strong shocks can be given, the electrometer can be affected, a Leyden vial charged, the electric spark seen, and combustible bodies inflamed.

Some animals likewise possess the power of accumulating this influence in a great degree; for instanc the torpedo, and electrical eel, which will both give strong shocks; and if the circuit have a small interruption a spark may be seen, as was shown by Mr. Walsh. On dissecting these fish, Mr. Hunter found an organ very similar to the pile of Volta; it consists of numerous membranaceous columns, filled with plates or pellicles, in the form of thin disks, separated from each other by small intervals, which intervals contain a fluid substance; this organ, like the pile of Volta, is capable of giving repeated shocks, even when surrounded by water.

It is not absolutely necessary to use two metals to produce the galvanic phenomena; for if one side of a metal be made to oxidate, while the other is prevented from oxidation, these appearances will still be produced. It is not indeed necessary to use any metal; for a piece of charcoal, oxidated in the same way, produces galvanism; so does fresh muscular fibre, and perhaps any substance capable of oxidation. The most striking circumstance in galvanism, is, that it accompanies oxidation, and is perhaps never produced without it. But oxidation is always going on in the body by means of respiration and the circulation of the blood. We shall afterwards find reason to believe, that the oxygen, received from the atmosphere by the lungs, is the cause of animal heat, and probably of animal irritability; and it is perhaps not unreasonable to suppose, that the nervous influence or electricity may be separated by the brain, and sent along the nerves, which seem the most powerful conductors of it, to stimulate the muscles to action.

What the nature of the electric fluid is, we are ignorant; some galvanic experiments have led me to suppose that it may be hydrogen, which when combined with caloric appears in the form of gas, but when pure, or perhaps in a different state, may be capable of passing through solid bodies in the form of electricity.

Having given this short view of the human body, considered as a machine composed of bones, muscles, and nerves, I shall proceed to state the different subjects which I shall consider in this course. It is extremely difficult to begin a course like this; for we must either enter abruptly into the middle, or the outset must be in some measure tedious and dry. I have chosen however rather to hazard the latter appellation, with respect to this lecture, than to enter more abruptly into the subject, in order to make it more entertaining. As we proceed, I trust you will feel an increasing interest in the subject; and, I think I may venture to promise, that this will be found the least entertaining lecture in the course. The subjects will be illustrated by experiments, in order to render the deductions more striking.

I shall next proceed to consider the phenomena of respiration, and animal heat; after which I shall explain the circulation of the blood; and the phenomena of digestion and nutrition. I shall then examine, more minutely than has been done in this lecture, the connexion of man with the external world, which will lead to a discussion of the different senses; vision, hearing, smelling, tasting, and feeling.

When these subjects have been discussed as fully as our time will allow, I shall examine, at considerable length, the manner in which the powers that support life, which have been improperly called by physiologists, the nonnaturals, act upon the body. This will naturally lead to a fuller explanation of the system which I have attempted to defend, in my lecture on health. And, after

I have fully explained the laws by which the irritable principle is regulated, I shall proceed to show, how those variations from the healthy state, called diseases, are produced; I shall point out the difference that exists between the debility which is brought on by the diminished action of the powers which support life, and that which results from their too powerful action; I shall then inquire into the nature of diseases of increased excitement; and after having shown how the undue action of the powers which support life, operates in producing disease, I shall endeavour to lay down such rules for the preservation of health, as are the result of reasoning on these subjects, and are also confirmed by experience.

LECTURE II. RESPIRATION

In the last lecture I took a short view of the human body, as a moving machine, regulated by the will. We shall now proceed to examine some of its functions more particularly.

I need not tell any of my audience, how necessary air is to the living body; for every person knows that we cannot live when excluded from this fluid; but, before we can understand the manner in which it acts on the body, we must become acquainted with some of its properties.

That the air is a fluid, consisting of such particles as have little or no cohesion, and which slide easily among each other, and yield to the slightest force, is evident from the ease with which animals breathe it, and move through it. Indeed from its being transparent, and therefore invisible, as well as from its extreme tenuity, and the ease with which bodies move through it, people will scarcely believe that they are living at the bottom of an aerial ocean, like fishes at the bottom of the sea. We become, however, very sensible of it, when it flows rapidly in streams or currents, so as to form what is called a wind, which will sometimes act so violently as to tear up the strongest trees by the roots, and blow down to the ground the best and firmest buildings.

Some may still be inclined to ask, what is this air in which we are said to live? We see nothing; we feel nothing; we find ourselves at liberty to move about in any direction, without any hindrance. Whence then comes the assertion, that we are surrounded by a fluid, called air? When we pour water out of a vessel, it appears to be empty; for our senses do not inform us that any thing occupies the place of the water, for instance, when we pour water out of a vial. But this operation is exactly similar to pouring out mercury from a vial in a jar of water, the water gets in and supplies the place of the mercury; so does the air which supplies the place of the water; and this air will prevent water from rising, or filling a vessel which contains it.

Hence we see that air possesses similar appearances of impenetrability with other matter: for it excludes bodies from the space which itself occupies.

Air being therefore material must have weight; and we shall accordingly find, that a quart of it weighs about fifteen grains. But a quart of water weighs about two pounds; this fluid therefore is nearly a thousand times heavier than air.

But though air is so much lighter than water, yet, because it extends to a considerable height above the surface of the earth, it is evident, that it must press strongly on the surfaces of bodies. It is thought to extend nearly fifty miles above the surface of the earth, and must therefore press heavily on this surface. This may be evinced by different experiments, performed by means of the air pump.

Another property of the air, by which it is distinguished from most other fluids, is its elasticity. It may be compressed into a less space than it naturally occupies, and when the compressing force is removed, it expands to its former bulk, by its spring or elasticity. Indeed it is always compressed into less space than it would naturally occupy, by the weight of the superincumbent air.

The trachea, or windpipe, commences at the further end of the mouth, between the root of the tongue, and the passage into the stomach: its upper part is termed the larynx; it forms the projection in the fore part of the neck, which is more prominent in the male than the female: its opening is called the glottis, and is covered with a small valve, or lid, called the epiglottis, which is open while we breathe, but shuts when we swallow any thing, to prevent its getting into the lungs: sometimes, however, particularly when we attempt to speak at the time we swallow, a small portion of our food or drink gets into the larynx, and excites violent coughing until it is thrown back again.

The windpipe is composed of cartilaginous rings, covered with membrane, which keep it open: after having run downwards for the space of a few inches, it divides into two great branches, each of which is subdivided into a vast number of ramifications, ultimately terminating in little vesicles, which, when distended with air, make up the greatest part of the bulk of the lungs.

The cavity in which the lungs are contained is called the thorax, or chest: and is bounded by the ribs, and backbone or spine, and separated from the abdomen by a muscular membrane, called the diaphragm. The thorax, by the action of the diaphragm and intercostal muscles, is alternately enlarged and diminished. Suppose then the thorax to be in its least state;

if it become larger, a vacuum will be formed, into which the external air will descend by its weight, filling and distending the vesicles of the lungs.

The thorax, thus dilated, is brought back to its former magnitude, principally by the relaxation of the muscles, which distended it, and the natural elasticity of the parts, aided by the contraction of the abdominal muscles; the thorax being thus diminished, a quantity of air is expelled from the lungs. The muscles which distend the thorax beginning again to act, the air reenters; and this alternate dilatation and contraction, is called respiration. The entrance of the air into the lungs, is termed inspiration, and its expulsion, expiration.

To form a more accurate idea of the manner in which respiration is performed, let us suppose this room to be filled with water. On enlarging the thorax, in the manner before mentioned, the water by its weight would rush in, and fill the newly formed void; and, upon the diminution of the capacity of the thorax, a part of this water would be expelled. Just in the same manner the air will alternately enter and be expelled from the lungs by this alternate dilatation and contraction of the thorax.

Respiration is a function of such consequence, that death follows if it is suspended for a few minutes only. By means of this function the blood is elaborated, and rendered fit to nourish the body; by means of it the system is, most probably, supplied with irritability; by means of it the nervous energy is, most likely, conveyed into the body, to be expended in sensation, and muscular motion. It appears, likewise, that in this way, animals are supplied with that heat which preserves their temperatures nearly the same, whatever may be the temperatures of surrounding bodies.

If any number of inanimate bodies, possessed of different degrees of heat, be placed near each other, the heat will begin to pass from the hotter bodies to the colder, till there be an equilibrium of temperature. But this is by no means the case with respect to animated matter; for whatever be the degree of heat peculiar to individual animals, they preserve it, nearly unchanged, in every temperature, provided the temperature be not altogether incompatible with life or health. Thus, we find, from experiments that have been made, that the human body is not only capable of supporting, in certain circumstances, without any material change in its temperature, a degree of heat considerably above that at which water boils; but it likewise maintains its usual temperature, whilst the surrounding medium is several degrees below frost.

It is evident, therefore, that animals neither receive their heat from the bodies which surround them, nor suffer, from the influence of external circumstances, any material alterations in that heat which is peculiar to their nature. These general facts are confirmed and elucidated by many accurate and well authenticated observations, which show, that the degree of heat in the same genus and species of the more perfect animals, continues uniformly the same, whether they be surrounded by mountains of snow, in the neighbourhood of the pole, or exposed to a vertical sun, in the sultry regions of the torrid zone.

This stability and uniformity of animal heat, under such a disparity of external circumstances, and so vast a latitude in the temperature of the ambient air, prove, beyond doubt, that the living body is furnished with a peculiar mechanism, or power of generating, supporting, and regulating its own temperature; and that this is so wisely adapted to the circumstances of its economy, or so dependent upon them, that, whatever be the temperature of the atmosphere, it will have very little influence either in diminishing or increasing that of the animal.

In order that we may see how this effect is produced, we must examine the chemical properties of the air. Previously to this, however, it will be necessary to point out briefly how bodies are affected, with respect to heat, when they change their form.

When a body passes from a state of solidity to that of fluidity, it absorbs a quantity of heat, which becomes chemically combined with it, and insensible to the touch or the thermometer; in the same manner, when it passes from a fluid state to that of vapour or gas, it combines with a still larger quantity of heat, which remains latent in it, so long as it continues in the state of gas, but when it returns to the liquid or solid state, it gives out the heat which was combined with it, which, being set at liberty, flows into the surrounding bodies, and augments their temperature.

This is evinced by the conversion of ice into water, and of water into steam; and by the return of steam into water. It is evinced likewise by the evaporation of ether, and by numberless other experiments.

Modern chemistry has shown that the atmosphere is not a homogeneous fluid, but consists of two elastic fluids, endowed with opposite and different properties.

If a combustible body, for instance a candle, be confined in a given quantity of atmospheric air, it will burn only for a certain time; after it is extinguished, if another combustible body be lighted and immersed in the same air, it will not burn, but will immediately be extinguished.

It has been proved by chemical experiments, that in this instance, the combustible body absorbs that portion of the air which is fitted for combustion, but produces no change on that which is unfit: so that, according to this, the air of the atmosphere consists of two elastic fluids, one of which is capable of supporting combustion, and the other not; and that they exist in the proportion of one part of the former to three of the latter nearly.

These two parts may be separated from each other, and experiments made with them.

Many metals, and particularly manganese, when exposed to the atmosphere, attract the combustible air from it, without touching the other; and it may be procured from these metals by the application of heat, in very great purity.

Because this air is essential to the formation of acids, it has been called by chemists the acidifying principle, or oxygen gas.

On plunging a combustible body into the remaining air, it is instantly extinguished; an animal in the same situation is immediately deprived of life: from this latter circumstance this air has been called azote, or azotic gas. If we take three parts of azote and one of oxygen, and mix them together, we shall form an air in every respect similar to that of the atmosphere.

If I plunge a piece of iron, previously heated, into oxygen gas, it will burn with great brilliancy, the gas will be diminished in quantity, and the iron augmented in weight, and this increase of weight in the metal will be in proportion to the oxygen which has disappeared: at the same time a great quantity of heat is given out. This is the heat which was combined with the oxygen in the state of gas, and which now becomes free, when the oxygen becomes solid and joins with the iron.

The same phenomena take place when phosphorus is burned in oxygen gas; the gas becomes diminished, the phosphorus increased, in weight, and converted into an acid, and a great quantity of heat is given out. The same is the case when charcoal is burned in this gas. In short, in every instance of combustion, the oxygen combines with the combustible body, and at the same time gives out its heat, which supported it in the form of gas. This is the case of the combustion of coal in a common fire, as well as in other cases of combustion; the heat comes from the air, and not from the coal.

When we examine the phenomena of respiration with attention, we shall find them very analogous to those of combustion. A candle will not burn in an exhausted receiver: an animal in the same situation ceases to live.

When a candle is confined in a given quantity of atmospheric air, it will burn only for a certain length of time. On examining the air in which it has been burned, the oxygen is found to be all extracted, nothing remaining but azotic gas, and a quantity of carbonic acid gas, produced by the union of the charcoal of the candle with the oxygen of the atmospheric air.

In the same manner, if an animal be confined in a given quantity of atmospheric air, it will live only a short time; on examining the air in which it has ceased to live, it will be found to have lost its oxygen: what remains being a mixture of azotic and carbonic acid gases.

When a candle is enclosed in a given quantity of pure oxygen gas, it will burn four times as long as in the same quantity of atmospheric air.

In the same manner it has been proved, that an animal will be four times as long in consuming a given quantity of pure oxygen gas, as in rendering unfit for respiration the same quantity of atmospheric air.

Here then we observe a striking similarity between combustion and animal respiration. The ancients seem to have had a more accurate idea of respiration than most of the philosophers who followed them. They supposed that the air contained a principle proper for the support and nourishment of life, which they called pabulum vitae. This idea, which was unconnected with any hypothesis, was followed by systems destitute of foundation. Sometimes it was thought that the air in the lungs incessantly acted as a stimulus or spur to drive on the circulation; sometimes the lungs were considered in the light of a pair of bellows, or fan, to cool the body, which was supposed to be heated by a thousand imaginary causes: and when philosophers were convinced, by experiments, that the bulk of the air was diminished by respiration, they explained it by saying, that the air had lost its spring.

Modern chemistry however enables us to explain the phenomena of respiration in a satisfactory manner.

In order to see this, we shall proceed to examine the changes produced by respiration; firstly, on the air, and secondly, on the blood.

The air which has served for respiration, is found to contain a mixture of azotic and carbonic acid gas, with a small quantity of oxygen gas; and a considerable quantity of water is thrown off from the lungs, in the form of vapour, during respiration.

From a variety of facts, it appears that oxygen gas is decomposed in the lungs during respiration; a part of it unites, as we shall afterwards see, with the iron contained in the blood, and converts it into an oxid; another and greater portion unites with the carbon, brought by the venous blood from all parts of the body to the lungs, and thus forms carbonic acid gas; while another portion of the oxygen unites with the hydrogen, brought in the same manner by the blood, and forms water. Thus then we are able to account for the different products of respiration.

Hence we see, that the explanation of animal heat follows as a simple and beautiful corollary from the theory of combustion; and we may consider respiration as an operation in which oxygen gas is continually passing from the gaseous to the concrete state; it will therefore give out at every instant the heat which it held in combination, and this heat, being conveyed by the circulation of the blood to all parts of the body, is a constant source of heat to the animal.

These facts likewise enable us to explain the reason, why an animal preserves the same temperature, notwithstanding the various changes which occur in the temperature of the surrounding atmosphere. In winter the air is condensed by the cold, the lungs therefore receive a greater quantity of oxygen in the same bulk, and the heat extricated will be proportionally increased. In summer, on the contrary, the air being rarefied by the heat, a less quantity of oxygen will be received by the lungs during each inspiration, and consequently the heat which is extricated must be less.

For the same reason, in northern latitudes, the heat extricated by respiration will be much greater than in the southern. By this simple and beautiful contrivance, nature has moderated the extremes of climate, and enabled the human body to bear vicissitudes which would otherwise destroy it.

Of all the phenomena of the animal body, there is none at first sight more remarkable, than that which animals possess of resisting the extremes of temperature.

The heat of the body, as has already been observed, continues at the same degree, though the temperature of the atmosphere be sometimes considerably hotter, at other times considerably colder, than the animal body: so that man is able to live, and to preserve the temperature of health, on the burning sands of Africa, and on the frozen plains of Siberia.

The alterations of temperature which the human body has been known to bear, without any fatal or even bad effects, are not less than 400 degrees or 500 degrees of Fahrenheit. The natural heat of the human body is 96 degrees or 97 degrees. In the West Indies, the heat of the atmosphere is often 98 degrees or 99 degrees, and sometimes rises even to 126 degrees, or 30 degrees above the temperature of the human body, notwithstanding which, a thermometer put in the mouth points to 96 degrees or 97 degrees. The inhabitants of the hot regions of Surinam support, without inconvenience, the heat of their climate. We are assured that in Senegal, about the latitude of 17 degrees, the thermometer in the shade generally stands at 108 degrees, without any fatal effects to men or animals. The Russians often live in places heated by stoves to 108 degrees or 109 degrees, and some philosophers in this country, by way of experiment, remained a considerable time in a room heated above the boiling point of water.

On the other hand, an equal excess of cold seems to have no greater effect in altering the degree of heat proper to animal bodies. Delisle has observed a cold in Siberia 70 degrees below the zero of Fahrenheit's scale, notwithstanding which animals lived. Gmelin has seen the inhabitants of Jeniseisk under the 58th degree of northern latitude, sustaining a degree of cold, which in January became so severe, that the spirit in the thermometer was 126 degrees below the freezing point. Professor Pallas in Siberia, and our countrymen at Hudson's Bay, have experienced a degree of cold almost equal to this. All these facts tend to prove, that the heat of animals continues without alteration in very different temperatures. Hence it is evident that they must be able to produce a greater degree of heat, when surrounded by a cold medium; and on the contrary, that they must effect a diminution of the heat, when the surrounding medium is very hot.

All these circumstances may be accounted for, by the principles we have laid down; the decomposition of oxygen in the lungs.

There have not been wanting, however, some very eminent physiologists, who have contended that animal heat is produced chiefly by the nerves. They have brought forward in proof of this the well known fact, that when the spinal marrow is injured, the temperature of the body generally becomes diminished; and that in a paralytic limb the heat is less than ordinary, though the strength and velocity of the pulse remain the same. These facts, and others of a similar nature, have induced them to believe, that the nervous system is the chief cause and essential organ of heat; and they have adduced similar arguments, to prove that nutrition is performed by the nerves, for a limb which is paralytic from an injury of the nerves, wastes, though the circulation continues. The truth is, that the nerves exert their influence upon these, and all other functions of the body, and modify their action. The liver secretes bile, but if the nerves leading to it be destroyed, the secretion of bile will cease; but who will say, that the bile is secreted by the nerves? The nitric acid will dissolve metals, and this solution will go on more quickly if heat be applied; but surely the nitric acid is the solvent, the heat being only an aiding cause.

But though the human body has been so wisely constructed, as to bear, without inconvenience, a considerable variation of temperature; yet this latitude has its limits, which depend upon the capability of extricating heat from the atmosphere. There must be a limit below which the diminution of heat takes place faster than its production. If this be continued, or increased, the heat of the animal must diminish, the functions lose their energy, and an insuperable inclination to sleep is felt, in which if the sufferer indulge, he will be sure to wake no more.

This is confirmed by what happened to Sir Joseph Banks and his party on the heights of Terra del Fuego. Dr. Solander, who had more than once crossed the mountains which divide Sweden from Norway, well knew that extreme cold produces an irresistible torpor and sleepiness, he therefore conjured the company to keep always in motion, whatever exertion it might require, and however great might be their inclination to rest. Whoever sits down, says he, will sleep; and whoever sleeps will wake no more. Thus, at once admonished and alarmed, they set forward; but, while they were still upon the naked rocks, the cold was so intense, as to produce the effects which had been so much dreaded. Dr. Solander himself was the first who found the inclination against which he had warned others, irresistible; and insisted on being suffered to lie down. Sir Joseph entreated and remonstrated in vain; he lay down upon the ground, though it was covered with snow; and it was with great difficulty that his friend kept him from sleeping. One of his black servants also began to linger, having suffered from the cold in the same manner as the Doctor. Partly by persuasion, and partly by force, they were got forwards; soon however they both declared that they would go no further. Sir Joseph had recourse again to entreaty and expostulation, but these produced no effect: when the black was told, that if he did not go on, he would shortly be frozen to death; he answered, that he desired nothing so much as to lie down and die. The Doctor did not so explicitly renounce his life, but said, he would go on, if they would first allow him to take some sleep, though he had before told them, that to sleep was to perish. They both in a few minutes fell into a profound sleep, and after five minutes Sir Joseph Banks happily succeeded in waking Dr. Solander, who had almost lost the use of his limbs; the muscles were so shrunk, that his shoes fell from his feet; but every attempt to recal the unfortunate black to life proved unsuccessful.

As the circulation of the blood is the means by which the heat produced is conveyed to all parts of the body; and as it is a function of the highest importance, I shall, in the next lecture, proceed to the consideration of it.

LECTURE III. CIRCULATION OF THE BLOOD

Two kinds of motion may be distinguished in the animal economy; the one voluntary, or under the command of the will, which takes place at certain intervals, but may be stopped at pleasure. The other kind of motion is called involuntary, as not depending on the will, but going on constantly, without interruption, both when we sleep and when we wake.

Of the first kind is the motion of the limbs, of which I have already spoken in general terms; the object of which is, to change the situation of the animal, and carry it where the will directs.

Among the involuntary motions, the most remarkable is the circulation of the blood, which I shall proceed to consider in this lecture.

There is one motion, however, which claims a middle place between the voluntary and involuntary; I mean respiration. This action is so far under the command of the will, that it may be suspended, increased, or diminished in strength and frequency: but we can only suspend it for a very short time; and it goes on regularly during sleep, and in general, even when we are awake, without the intervention of the will; its continuation being always necessary, as we have already seen, to support life.

The motion of the fluids in the living body is regulated by very different laws, from those which govern the motion of ordinary fluids, that depend upon their gravity and fluidity: these last have a general centre of gravitation to which they incessantly tend. Their motion is from above downwards, when not prevented by any obstacles; and when they meet with obstruction, they either stop till the obstacle is removed, or escape where they find the least resistance. When they have reached the lowest situations, they remain at rest, unless acted upon by some internal impulse, which again puts them in motion.

But the motion of the fluids in an animal body, is less uniform, constant, and regular; it takes place upwards as well as downwards, and overcomes numerous obstacles; it carries the blood from the interior parts of the body to the surface, and from the surface back again to the internal parts; it forces it from the left side of the body to the right, and with such rapidity that not a particle of the fluid remains an instant in the same place.

The principal organ concerned in the circulation of the blood, is the heart; which is a hollow muscle, of a conical figure, with two cavities, called ventricles; this organ is situated in the thorax or chest; its apex or point is inclined downwards and to the left side, where it is received in a cavity of the left lobe of the lungs.

At the basis of the heart on each side are situated two cavities, called auricles, to receive the blood; and these contracting, force the blood into the ventricles, which are two cavities in the heart, separated from each other by a strong muscular partition. The cavity which is situated on the right side of the heart, is called the right ventricle, and that on the left the left ventricle. From the right ventricle of the heart issues a large artery, called the pulmonary artery, which goes to the lungs, and is there divided and subdivided into a vast number of branches, the extremities of which are too small to be visible. These ultimate ramifications unite again into larger branches; these again into branches still larger, and so continually, till at last they form four tubes, called the pulmonary veins, which are inserted into the left auricle of the heart,

From the left ventricle of the heart there issues another large artery, called the aorta, which, in its passage, sends off branches to the heart, arms, legs, head, and every other part of the body. These branches, in the course of their progress, are divided and subdivided into innumerable minute ramifications, the last of which are invisible. These small ramifications unite again into branches continually larger and larger, till they form two great tubes, called the venae cavae; which large veins are inserted into the right auricle of the heart; where a vein, termed the coronary vein of the heart, which returns the blood from the heart itself, also terminates.

From what has been said, it will be evident, that strictly speaking, there are only two arteries and seven veins in the body; one pulmonary artery, which carries the blood from the right ventricle of the heart to the lungs, and four pulmonary veins, which bring it back again; then the aorta or large artery, which carries the blood from the left ventricle of the heart to all parts of the body; the two venae cavae, and the coronary vein of the heart, which bring it back again.

At the beginning of both arteries, where they leave the heart, are placed valves, which allow the blood to flow freely from the heart into the arteries, but which prevent its return to the heart. There are likewise valves between the auricles and ventricles, which permit the blood to flow from the former into the latter, but prevent its return into the auricles. The veins are likewise furnished with valves, which allow the blood to flow from their minute branches along the larger toward the heart, but prevent its returning to these minute branches.

The blood being brought back from all parts of the body into the right auricle of the heart, distends this cavity, and thus causes it to contract; this auricle, by contracting, forces the blood into the right ventricle; this muscular cavity being distended and irritated by the blood, contracts, and propels the blood through the pulmonary artery into the lungs: from hence it is brought back by the pulmonary veins, to the left auricle of the heart, by whose contraction it is forced into the left ventricle. The contraction of this ventricle propels the blood, with great force, into the aorta, through the innumerable ramifications of which, it is carried to every part of the body, and brought back by veins, which accompany these arterial ramifications, and form the venae cavae, which conduct the blood into the right auricle of the heart, from whence it is again sent into the right ventricle, which sends it through the pulmonary artery, to the lungs; the pulmonary veins bring it back again to the heart, from whence it is propelled through the aorta, to all parts of the body: thus running a perpetual round, called the circulation of the blood.

Thus then we see, that the circulation consists of two circles or stages, one through the lungs, which may be called the pulmonary, or lesser circle, and the other through all parts of the body, which may be termed the aortal, or greater circle.

That the blood circulates in this manner, is evident, from the valves placed at the origin of the arteries, and in the large branches of the veins, which prevent the return of the blood to the heart, in any other manner than that I have described. This is likewise evident, in the common operation of blood letting: when the arm is tied, the vein swells below the ligature, instead of above, and we do not make the opening above the ligature, or on the side next the heart. If the vein were opened above the ligature, it would not bleed. For it only swells next the hand, which shows that the blood does not flow into the vein downwards from the heart, but upwards from the hand.

If the ligature be too tight, the blood will not flow through the opening in the vein. The reason of this, is, that the artery is compressed, in this case, as well as the vein; and as the veins derive their blood from the arteries, it follows that if the blood's motion be obstructed in the latter, none can flow from them into the former: when we wish to open an artery, the orifice must be made above the ligature.

Another proof of the circulation being performed in this manner, is derived from microscopic observations, on the transparent parts of animals, in which the blood can be seen to move towards the extremities, along the arteries, and return by the veins.

The blood, however, does not flow out of the heart into the arteries in a continued stream, but by jets, or pulses; when the ventricles are filled with blood from the auricles, this blood stimulates them, and thereby causes them to contract; by such contraction, they force the blood, which they contain, into the arteries; this contraction is called the systole of the heart. As soon as they have finished their contraction, they relax, till they are again filled with blood from the auricles, and this state of relaxation of the heart, is called the diastole.

This causes the pulsation or beating of the heart. The arteries must, of course, have a similar pulsation, the blood being driven into them only by starts; and accordingly we find it in the artery of the wrist; this beating we call the pulse; the like may also be observed in the arteries of the temples, and other parts of the body. The veins, however, have no pulsation, for the blood flowing on, in an uninterrupted course, from smaller tubes to wider, its pulse becomes entirely destroyed.

The different cavities of the heart do not contract at the same time; but the two auricles contract together, the ventricles being at that time in a state of relaxation; these ventricles then contract together, while the auricles become relaxed.

Both the arteries and veins may be compared to a tree, whose trunk is divided into large branches; these are subdivided into smaller, the smaller again into others still smaller; and we may observe, likewise, that the sum of the capacities of the branches, which arise from any trunk, is always greater than the capacity of the trunk.

The minutest branches of the arteries, being reflected, become veins, or else they enter veins that are already formed, by anastomosis, as it is called; the small veins continually receiving others, become, like a river, gradually larger, till they form the venae cavae, which conduct the blood to the heart.

Anatomical injections prove, that the last branches of the arteries terminate in the beginning of veins; but it is the opinion of many celebrated physiologists, that the arteries carry the blood to the different parts of the body to nourish them, and that the veins commence by open mouths, which absorb or suck up what is superfluous, and return it back to the heart.

From what has been said, it must be evident that there is a considerable resemblance between the circulation of the blood in the animal body, and the circulation of the aqueous fluid on the surface of the globe. In the latter case the water is raised from the ocean, by the heat of the sun, and poured down upon the dry land, in minute drops, for the nourishment and economy of its different parts. What is superfluous is collected into little rills; these meeting with others, form brooks; the union of which produce rivers, that conduct the water to its original source, from which it is again circulated.

In the same manner, the blood is sent by the heart to different parts of the body, for the nourishment and economy of its different parts; what is superfluous is brought back by veins, which, continually uniting, form those large trunks, which convey the vital fluid to the heart.

The blood does not circulate, however, in the manner which I have mentioned, in all parts of the body; for that which is carried by arteries to the viscera, serving for digestion, such as the stomach, bowels, mesentery, omentum, and spleen, is collected by small veins which unite into a large trunk called the vena portarum; this vein enters the liver, and is subdivided in it like an artery, distributing through the liver a great quantity of blood, from which the bile is secreted: and, having served this purpose, the blood is collected by small veins; these unite and form the hepatic vein, which pours the blood into the vena cava, to be conducted to the heart.

The reason of this deviation, is probably, to diminish the velocity of the blood in the liver, for the secretion of the bile; which could not have been effected by means of an artery.

The force which impels the blood, is, first, the contraction of the heart, which propels the blood into the arteries with great velocity; but this is not the only force concerned in keeping up the circulation; this is evident, from the diminished heat, and weakened pulse, in a paralytic limb, which ought not to take place, if the blood were propelled merely by the action of the heart.

The arteries are possessed of an elastic and muscular power, by means of which they contract when they are distended or stimulated. It is however by the muscular power alone, that they assist in propelling the blood; for the elasticity of their coats can serve no other purpose than preserving the mean diameter of the vessel. If we suppose the arteries to be dilated by the blood, poured into them by the heart, they will, by their contraction, as elastic tubes, undoubtedly propel the blood: but supposing them to be perfectly elastic, the force of the heart will be just as much diminished in dilating them as the force of the blood is increased by their contraction. We are not however acquainted with any substance perfectly elastic, or which restores itself with a force equal to that with which it was distended: hence the elastic power of the arteries will subtract from, instead of adding to, the power of the heart. It is evident, therefore, that it must be by the muscular power of the arteries, which causes them to contract like the heart, that they propel the blood.

That such is the case, appears from the muscular structure of the arteries observed by anatomists; as also from the effects of mechanical irritation of their coats, which causes them to contract; this is likewise evident from the inflammation produced by the application of stimulating substances to particular parts; for instance, cantharides and mustard. It appears likewise, from the secretion in some parts being preternaturally increased, while the motion of the general mass of the blood continues unaltered.

The contraction of the arteries always propels the blood towards the extreme parts of the body: this must necessarily happen, because the valves at the origin of the arteries prevent its return to the heart, it must therefore move in the direction in which it finds least resistance.

If it were not for this muscular power of the arteries, the force of the heart would not alone be able to propel the blood to the extreme parts of the body, and overcome the different kinds of resistance it has to encounter. Among the causes that lessen the velocity of the blood, may be mentioned the increasing area of the artery; for it was before observed, that the sum of the cavities of the branches from any trunk exceeded the cavity of the trunk: and from the principles of hydrostatics, the velocities of fluids, propelled by the same force, in tubes of different diameters, are inversely as the squares of the diameters, so that in a tube of double the diameter, the velocity will only be one fourth; in one of the triple, only one ninth: and since the arteries may be looked upon as conical, it is evident that the velocity of the blood must be diminished from this cause.

The curvilinear course of the arteries likewise gives considerable resistance; for at every bending the blood loses part of its momentum against the sides; and this loss is evidently proportioned to the magnitude of the angle, at which the branch goes off. Convolutions are frequently made, in order to diminish the force of the blood in particular organs; this is especially the case with the carotid artery before it enters the brain.

The angles which the ramifications of the arteries make, are greater or more obtuse nearer the heart, and more acute as the distance increases; by which means the velocity of the blood is rendered more equal in different parts.

The anastomosing or union of different branches of arteries, likewise retards the velocity of the blood, the particles of which, from different vessels, impinging, disturb each other's motion, and produce a compound force, in which there is always a loss of velocity: and it is evident, from the composition of forces, that this loss must be proportioned to the obliquity of the angle at which the vessels unite.

The adhesion of the blood to the sides of the vessels, likewise causes a loss of velocity in the minuter branches, which may be owing to a chemical affinity: the viscidity or imperfect fluidity of the blood is another retarding cause. All these causes united, would render it impossible for the heart to propel the blood with the velocity with which it moves in the very minute branches of the arteries, if these arteries were not endowed with a living muscular power like the heart, by which they contract and propel their contents.

In the veins, the motion of the blood is occasioned partly by the vis a tergo, and partly by the contraction of the neighbouring muscles, which press upon the veins; and these veins being furnished with valves, the return of the blood towards the arteries is prevented; it must therefore move towards the heart.

That the contraction of the muscles of the body tends very much to promote the circulation of the blood, is evident, from the increase of the circulation from exercise, and likewise from the languid motion of the blood in sedentary persons, and those given to indolence. Hence we may account for the different diseases to which such persons are subject, and know how to apply the proper remedies. Hence likewise, we see the reason why rest is so absolutely necessary in acute and inflammatory diseases, where the momentum of the blood is already too great.

It has been doubted by anatomists, whether the veins were possessed with muscular power; but this seems now to be confirmed. Haller found the vena cava near the heart to contract on the application of stimulants, though he could see no muscular fibres; these, however, have been discovered by succeeding anatomists.

The magnitude of the veins is always greater than that of the corresponding arteries; hence the velocity of the blood must be less in the veins; and hence likewise we may account for their want of pulsation; for the action of the heart upon the arteries is at first very great; but as we recede from the heart, this effect becomes less perceptible; the arterial tube increases both in size and muscularity, in proportion to its distance from the source of circulation. The powers of the heart are spent in overcoming the different resistances which I have noticed, before the blood enters the veins; hence the blood will flow uniformly in these last.

The blood is subject in the veins to retarding causes, similar to those which operate in the arteries, but perhaps not in an equal degree; for the flexures are less frequent in the veins than in the arteries. As the capacity of the arterial tube increases with its distance from the heart, the velocity, from this cause, as has already been observed, is continually diminished; but a contrary effect takes place in the veins; for the different branches uniting, form trunks, whose capacities are smaller than the sums of the capacities of the branches, hence the velocity of the blood in the veins will increase as it approaches the heart.

Another retarding cause may be mentioned, namely, gravity, which acts more on the venous than the arterial system. The effects of gravity on the veins may be exemplified, by a ring being pulled off the finger with ease when the hand is elevated; also by the swellings of the feet that occur in relaxed habits, which swellings increase towards night, and subside in the morning, after the body has been in a horizontal posture for some hours.

In weak persons, the frequency of the pulse is increased by an erect posture, which may probably depend on gravity; as we know, from the observations of Macdonald and others, that an erect posture will make a difference of 15 or 20 beats in a minute. The experiments alluded to, were made by gently raising a person fastened to a board, where there being no muscular exertion, respiration would not be increased; so that the whole effect was probably owing to gravity accelerating the column of arterial blood.

The inverted posture produces a still more remarkable effect in accelerating the pulse, than the erect, for it sometimes causes it to beat 10 or 12 times more in the former case than in the latter.

While we are on this subject, it may not be improper to take notice of the effects of swinging on the circulation, which have been found by Dr. Carmichael Smyth, and others, to diminish the strength and velocity to such a degree, as to bring on fainting. These effects have never been satisfactorily accounted for; but they would seem to admit of an easy explanation on mechanical principles: they are undoubtedly owing, at least in a great measure, to the centrifugal force acquired by the blood.

By a centrifugal force, I mean, the tendency which revolving bodies have to fly off from the centre, which arises from their tendency to move in a straight line, agreeably to the laws of motion. Hence a tumbler of water may be whirled in a circle vertically without spilling it; the centrifugal force pushing the water against the bottom of the tumbler. In the same manner when the human body is made to revolve vertically in the arch of a circle, this centrifugal force will propel the blood from the head and heart towards he extremities; hence the circulation of the blood will be weakened, and the energy of the brain diminished. The contrary, however, will take place on a horizontal swing, as I have frequently observed, both on myself and others; for the centrifugal force in this case will propel the blood from the extremities towards the head.

It has been already observed, that the pulsations of the artery which we feel at the wrist, are occasioned by its alternate dilatations and contractions, which vary according to the strength and regularity of the circulation, which is liable to be affected by the smallest changes in the state of health. Hence physicians make use of the pulse as a criterion whereby to judge of the health of the body. And we may observe that there are few more certain characteristics of the state of the body than the pulse; yet the conclusions that have been drawn from it have often been erroneous; and this has arisen from trusting to observation without the aid of reason.

That we may better understand the phenomena of the pulse, I shall lay down the following postulata. 1st. It is now generally believed, that every part of the arterial system is endowed with irritability, or a power of contracting on the application of a stimulus, and that the blood acting on this contractibility, if the term may be allowed, causes contraction; and that the alternate relaxation and contraction gives the phenomenon pulsation. 2d. The greater the action of the stimulus of the blood, the greater will be the contraction, that is, the nearer will the sides of the artery approach towards the axis. 3d. That the velocity with which a muscular fibre, in a state of debility, contracts, is at least equal to that with which a fibre in a state of strength contracts, is a fact generally allowed by physiologists.

We shall afterwards see, that a deficient action of stimulus on the vessels may arise, either directly from diminishing the quantity of blood contained in them, or indirectly, from the application of too great a stimulant power, which has diminished the capability of contracting inherent in the vessels.

From these postulata, it will be evident, that the greater the action of the arteries, that is, the more powerful their contraction, the longer will be the intervals between the pulsations.

For the velocity being at least equal in debility and in strength, the times between the pulsations will be proportioned to the approach of the sides of the artery towards its axis: but the approach of the sides towards the axis is greater when the arteries are in a state of vigour than when debilitated; consequently the intervals between the pulsations will be greater when the arteries are in a state of vigour than when debilitated.

Hence it is evident, that a frequency of pulse must generally indicate a diminished action or debility; while a moderate slowness indicates a vigorous or just action.

Hence likewise the opinion of increased action, which has been supposed to take place in fevers, because a frequent pulse was observed, must be false, because the frequency arises from a directly opposite state, and indicates a diminished action of the vascular system.

In a sound and adult man the frequency of the pulse is about seventy beats in a minute; and in an infant, within the first five or six months, the pulse is seldom less than one hundred and twenty, and diminishes in frequency as the child grows older. But though seventy beats in the minute may be taken as a general standard; yet in persons of irritable constitutions the frequency is greater than this, and many, who are in the prime of life, have the pulse only between fifty and sixty.

It is generally observed, that the pulse is slower in the morning, that it increases in frequency till noon, after dinner it again becomes slow, and in the evening its frequency returns, which increases till midnight.

These phenomena may be rationally explained on the principles just laid down. When we rise in the morning, the contractibility being abundant, the stimulus of the blood produces a greater effect, the pulse becomes slow, and the contractions strong; it becomes more frequent, however, till dinner time, from a diminished contractibility; after dinner, from the addition of the stimulus of food and chyle, it again decreases in frequency, and becomes slow till the evening, when its frequency returns, because the contractibility becomes exhausted: and this frequency continues till the vital power have been recruited by sleep.

By the same principles it is easy to explain the quickness of the pulse in infancy, its gradual decrease till maturity, its slowness and strength during the meridian of life, and the return of its frequency during the decline.

Having now described the phenomena of the circulation, it will be proper to examine the changes produced by this function on the blood; and, in the first place, it may be observed, that the blood which returns by the vena cava to the heart, is of a dark colour inclining to purple; while that which passes from the left ventricle into the arteries, is of a bright vermilion hue. The blood which is found in the pulmonary artery has the same dark purple colour with that in the vena cava, while that in the pulmonary vein resembles the aortal blood in its brightness. Hence it would appear, that the blood, during its passage through the lungs, has its colour changed from a dark purple to a bright vermilion, in which state it is brought by the pulmonary vein to the left auricle of the heart; this auricle, contracting, expels the blood into the corresponding ventricle, by whose action, and that of the arteries, it is distributed to all parts of the body. When it returns, however, by the veins, it is found to have lost its fine bright colour. It would appear, therefore, that the blood obtains its red colour during its passage through the lungs, and becomes deprived of it during its circulation through the rest of the body.

That the blood contains iron, may be proved by various experiments: if a quantity of blood be exposed to a red heat in a crucible, the greatest part will be volatilised and burnt; but a quantity of brown ashes will be left behind, which will be attracted by the magnet. If diluted sulphuric acid be poured on these ashes, a considerable portion of them will dissolve; if into this solution we drop tincture of galls, a black precipitate will take place, or if we use prussiate of potash, a precipitate of prussian blue will be formed. These facts prove, beyond doubt, that a quantity of iron exists in the blood.

I shall not now particularly inquire how it comes there; it may partly be taken into the blood along with the vegetable and animal food, which is received into the stomach; for the greatest part of the animal and vegetable substances, which we receive as food, contain a greater or less quantity of iron. Or it may be partly formed by the animal powers, as would appear from the following circumstance. The analysis of an egg, before incubation, affords not the least vestige of iron, but as soon as the chick exists, though it has been perfectly shut up from all external communication, if the egg be burnt, the ashes will be attracted by the magnet.

But, however we may suppose the blood to obtain its iron, it certainly does contain it; if the coagulable lymph and serum of the blood be carefully freed from the red particles, by repeated washing, the strictest analysis will not discover in either of them a particle of iron, while the red globules thus separated will be found to contain a considerable quantity of this metal.

That the red colour of the blood depends upon iron, appears likewise from the experiments of Menghini, which show, that the blood of persons who have been taking chalybeate medicines for some time, is much more florid that it is naturally; the same is agreeable to my own observation. A late analysis, by Fourcroy, has likewise proved, that the red colour of the blood resides in the iron; but, though the red colour of the blood may reside in the iron which it contains, we shall find that this colour is likewise connected with oxidation.

If the dark coloured blood, drawn from the veins, be put under a vessel containing oxygen gas, its surface will immediately become florid, while the bulk of the gas will be diminished. Mr. Hewson enclosed a portion of a vein between two ligatures, and injected into it a quantity of oxygen gas; the blood, which was before dark coloured, instantly assumed the hue of arterial blood. Thuvenal put a quantity of arterial blood under the receiver of an air pump; on exhausting the air it became of the dark colour of venous blood; on readmitting the air, it became again florid. He put it under a receiver filled with oxygen gas, and found the florid colour much increased.

Dr. Priestly exposed the blood of a sheep successively to oxygen gas, atmospheric air, and carbonic acid gas; and found, that in oxygen gas its colour became very florid, less so in atmospheric air, and in carbonic acid gas it became quite black. He filled a bladder with venous blood, and exposed it to oxygen gas; the surface in contact with the bladder immediately became florid, while the interior parts remained dark coloured.

All these facts prove, that the red colour which the blood acquires in the lungs, is owing to the oxygen, which probably combines with it, and the last mentioned fact shows, that oxygen will act on the blood, even though a membrane similar to the bladder, be interposed between them.

The same effect, probably, takes place in the lungs; the blood is circulated through that organ by a number of fine capillary arteries; and it is probable that the oxygen acts upon the blood through the membranes of these arteries, in the same manner that it does through the bladder.

In short, it seems likely, that the blood, during its circulation through the lungs, becomes combined with oxygen; that this oxidated blood, on its return to the heart, is circulated by the arteries to all parts of the body; and that, during this circulation, its oxygen combines with the hydrogen and carbon of the blood, and perhaps with those parts of the body with which it comes into contact; it is therefore brought back to the heart, by the veins, of a dark colour, and deprived of the greatest part of its oxygen.

This is the most probable theory, in the present state of our knowledge; it was proposed by Lavoisier, who imagines the focus of heat, or fireplace to warm the body, to be in the lungs: others, however, have thought it more consonant to facts, to suppose, that, instead of the oxygen uniting with carbon and hydrogen in the lungs, and there giving out its heat, the oxygen is absorbed by the blood, and unites with these substances during the circulation, so that heat is produced in every part of the body; and this doctrine seems certainly supported by several facts and experiments.

The circulation of the blood, though so simple and beautiful a function, was unknown to the ancient physicians, and was first demonstrated by our countryman, Harvey; when he first published his account of this discovery, he met with the treatment which is generally experienced by those who enlighten and improve the comfort of their fellow creatures, by valuable discoveries. The novelty and merit of this discovery drew upon him the envy of most of his contemporaries in Europe, who accordingly opposed him with all their power; and some universities even went so far, as to refuse the honours of medicine to those students, who had the audacity to defend this doctrine;

but afterwards, when they could not argue against truth and conviction, they attempted to rob him of the discovery, and asserted that many of the ancient physicians, and particularly Hippocrates, were acquainted with it. Posterity, however, who can alone review subjects of controversy without prejudice, have done ample justice to his memory.

LECTURE IV. DIGESTION, NUTRITION, &c

The human body, by the various actions to which it is subject, and the various functions which it performs, becomes, in a short time, exhausted; the fluids become dissipated, the solids wasted, while both are continually tending towards putrefaction. Notwithstanding which, the body still continues to perform its proper functions, often for a considerable length of time; some contrivance, therefore, was necessary to guard against these accelerators of its destruction. There are two ways in which the living body may be preserved; the one by assimilating nutritious substances, to repair the loss of different parts; the other to collect, in secretory organs, the humours secreted from these substances.

We are admonished of the necessity of receiving substances into the body, to repair the continual waste, by the appetites of hunger and thirst. For the stomach being gradually emptied of its contents, and the body, in some degree, exhausted by exercise, we experience a disagreeable sensation in the region of the stomach, accompanied by a desire to eat, at first slight, but gradually increasing, and at last growing intolerable, unless it be satisfied.

When the fluid parts have been much dissipated, or when we have taken, by the mouth, any dry food, or acrid substance, we experience a sensation of heat in the fauces, and at the same time a great desire of swallowing liquids. The former sensation is called hunger, and the latter thirst.

From the back part of the mouth passes a tube, called the oesophagus or gullet, its upper end is wide and open, spread behind the tongue to receive the masticated aliment: the lower part of this pipe, after it has passed through the thorax, and pierced the diaphragm, enters the stomach, which is a membranous bag, situated under the left side of the diaphragm: its figure nearly resembles the pouch of a bagpipe, the left end being most capacious; the upper side is concave, and the lower convex: it has two orifices, both on its upper part; the left, which is a continuation of the oesophagus, and through which the food passes into the stomach, is named cardia; and the right, through which the food is conveyed out of the stomach, is called pylorus: within this last orifice is a circular valve, which, in some degree, prevents the return of the aliment into the stomach.

From the pylorus, or right orifice of the stomach, arise the intestines, or bowels, which consist of a long and large tube, making several circumvolutions, in the cavity of the abdomen; this tube is about five or six times as long as the body to which it belongs. Though it is one continued pipe, it has been divided, by anatomists, into six parts, three small, three large. The three small intestines are the duodenum, the jejunum, and the ileum; the duodenum commences at the pylorus, and is continued into the jejunum, which is so called from its being generally found empty: the ileum is only a prolongation of the jejunum, and terminates in the first of the great intestines, called the caecum. The other great guts are the colon and the rectum.

The whole of what has been described is only a production of the same tube, beginning at the oesophagus. It is called by anatomists the intestinal canal, or prima via, because it is the first passage of the food. It has circular muscular fibres, which give it a power of contracting when irritated by distension; and this urges forward the food which is contained in it. This occasions a worm like motion of the whole intestines, which is called their peristaltic motion.

The mesentery is a membrane beginning loosely on the loins, and thence extending to all the intestines; which it preserves from twisting by their peristaltic motion. It serves also to sustain all the vessels going to and from the intestines, namely the arteries, veins, lacteals, and nerves; it also contains several glands, called, from their situation, mesenteric glands.

The lacteal vessels consist of a vast number of fine pellucid tubes, which arise by open mouths from the intestines, and proceeding thence through the mesentery, they frequently unite, and form fewer and larger vessels, which pass through the mesenteric glands, into a common receptacle or bag, called the receptacle of the chyle. The use of these vessels is to absorb the fluid part of the digested aliment, called chyle, and convey it into the receptacle of the chyle, that it may be thence carried through the thoracic duct into the blood.

The receptacle of the chyle is a membranous bag, about two thirds of an inch long, and one third of an inch wide, at its superior part it is contracted into a slender membranous pipe, called the thoracic duct, because its course is principally through the thorax; it passes between the aorta and the vena azygos, then obliquely over the oesophagus, and great curvature of the aorta, and continuing its course towards the internal jugular vein, it enters the left subclavian vein on its superior part.

There are several other viscera besides those I have described, which are subservient to digestion; among these may be mentioned the liver, gall bladder, and pancreas. The liver is the largest gland in the body, and is situated immediately under the diaphragm, principally on the right side. Its blood vessels that compose it as a gland, are the branches of the vena portarum, which, as I mentioned in the last lecture, enters the liver and distributes its blood like an artery. From this blood the liver secretes the bile, which is conveyed by the hepatic duct, towards the intestines: before this duct reaches the intestines, it is joined by another, coming from the gall bladder: these two ducts uniting, form a common duct, which enters the duodenum obliquely, about four inches below the pylorus of the stomach.

The gall bladder, which is a receptacle of bile, is situated between the stomach and the liver; and the bile which comes from the liver, along the hepatic duct, partly passes into the duodenum, and partly along the cystic duct into the gall bladder.

When the stomach is full, it presses on the gall bladder, which will squeeze out the bile into the duodenum at the time when it is most wanted.

The bile is a thick bitter fluid, of a yellowish green colour, composed chiefly of soda and animal oil, forming a soap; and it is most probably in consequence of this saponaceous property that it assists digestion, by causing the different parts of the food to unite together by intermediate affinity. When the bile is prevented from flowing into the intestines, by any obstruction in the ducts, digestion is badly performed, costiveness takes place, and the excrements are of a white colour, from being deprived of the bile. This fluid, stagnating in the gall bladder, is absorbed by the lymphatics, and carried into the blood, communicating to the whole surface of the body a yellow tinge, and other symptoms of jaundice.

Конец ознакомительного фрагмента.