LECTURES ON PHYSIOLOGICAL DISCOVERY.

Delivered at the Royal Institution of Great Britain.

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ABSTRACT OF LECTURE V.—MUSCULAR TISSUE: ITS PROPERTIES AND MODES OF ACTION.

THE lecturer first gave a short account of the phenomena attending muscular contraction presently known to physiologists. These are essentially chemical changes—the production of heat, electrical variations of potential, and motion. He divided the history of the opinions of physiologists regarding muscular motion into three stages—namely, the speculative, the histological, and the experimental. The older anatomists attributed motion, not to the fleshy, but to the tendinous portions of muscle. About 1660, Robert Hooke (1635-1703) suggested that muscular fibre consisted of a series of vesicles placed end to end; and that, by the inflation of these vesicles, movement was effected. About the same period, Mayow (1645-1679) gave a chemical explanation of muscular contraction—namely, that the “nitro-aërial spiritus” united with salino-sulphureous particles chiefly in the muscles, there causing a kind of fermentation, and producing animal heat. The fibrous structure of muscle was described by Nicolas Steno (1638-1687), and by Croone in 1664. In 1680, Borelli's great work, *De Motu Animalium*, appeared, in which he elaborated by geometrical methods what may be called the vesicular hypothesis. Following him, John Bernoulli I (1667-1748) supposed that the vesicles were inflated by the red blood-corpuscles, which he described as little bladders full of elastic stuff under pressure. A contemporary, Keil (1673-1719), gave a more elaborate explanation of a mechanical kind, depending on the principle of attraction then recommended to scientific men by the brilliant generalisations of Newton (1642-1727). Indeed, Newton himself supposed that muscular movement might be excited by vibrations of the ether in the nerves communicated to the ether in the muscular vesicles. This view was strongly urged by Cowper, in his *Myotomia Reformata*, published in 1724. The lecturer here pointed out the danger of using fanciful analogies in the explanation of physiological phenomena, as shown by these mechanical hypotheses. Leuwenhoek (1632-1723), in letters to Robert Hooke, was the first to describe muscle as seen by the microscope. He saw the fibres, recognised the striation, and describes a membrane surrounding the fibrillæ. From his drawings it is clear that, from the imperfection of his simple microscopes, he did not see that the fibres were striated through their whole length, and it is probable that the membrane he describes was not the true sarcolemma, but connective tissue. De Heide and Muys, contemporaries of Leuwenhoek, made similar observations, about 1714. Muys supposed the fibrillæ to be tubes communicating with the capillary vessels, and that movements occurred by fragments of broken blood-corpuscles being forced into these. No progress was made in knowledge of the structure of muscle till 1778, when Prochaska (1749-1820) described the fibres and striation with great clearness. In 1781 Fontana made similar investigations, and described muscle as consisting of fasciculi and fibres. He described the primitive fibres as solid cylinders, marked externally with transverse lines or bands at equal distances. He also said the filaments lay side by side, and were not twisted together, and he first pointed out that neither the capillary vessels nor the nerves ended directly in the muscular fibres, thus exploding the idea that any kind of fluid passed from the one to the other. Whilst knowledge was thus being accumulated regarding the structure of muscular fibre, physiologists were obtaining clearer views as to its special properties. The term “irritability,” originated with Francis Glisson (1596-1677), who was professor of physic at Cambridge for nearly forty years. He thus defines irritability as distinct from sensibility: “*Irritatio est perceptio, sed sensatio est perceptio perceptionis*.” Following him, Baglivi (1703), De Gorter (1731), Winter (1746), and F. Hoffmann (1750), used irritability in the same sense; but one and all of these failed in recognising the property as one inherent in muscular substance. This was reserved to the great Swiss physiologist, Albrecht von Haller (1708-1777). The lecturer gave a short account of the life of Haller. According to him, irritability was a *vis insita*, a suscepti-

bility of movement in muscular fibre, inherent in the very constitution of the fibre, and not supplied to it by the nerves. This view was strongly combated by Whytt (1714-1766), who explained muscular contraction, not by the rational *anima* of Stahl, but by the supposed existence of a sentient principle residing in the nerves of the part. The lecturer showed how the controversy between these schools advanced physiology, by obliging the Hallerians to recognise that contractile movements occurred in other tissues than in muscle alone, whilst the neurologists recognised the great importance of the ganglionic system of nerves. He then showed how Haller's doctrine had been accepted by physiologists generally. The experiments of Valli in 1793, of Fowler in the same year, of Nysten in 1811, and of John Reid in 1835, all showed that a stimulus applied to muscular substance alone, caused contraction without the intervention of nerves. The *vis insita* of Haller was a metaphysical conception of the same kind as that of the vital principle of the older authors. Haller and his followers supposed it to be a special principle in the muscle, a *divinus*, in virtue of which it responded. Such a phrase explained nothing, and, as stated by Fletcher, it was in ridicule of this that Dean Swift represents the action of a smoke-jack as depending on a meat-roasting power, and that of a fiddle on a tune-playing power. Molière also made his candidate for a physician's diploma reply to the question, *Quare opium facit dormire? Quia est in illo virtus dormitiva, cujus est natura sensus assoupire*. Still, Haller's hypothesis was a great advance, especially when the metaphysical notion was abandoned, and the term irritability expressed merely a fact, without assuming the existence of a special principle.

John Hunter (1728-1794) explained muscular contraction by assuming the existence of a vital force. The lecturer showed that Hunter attached great importance to the functions of elastic structures in the mechanism of the body, but Hunter did not seem to be aware of the elasticity of muscle itself. Bichat (1771-1802), in his short lifetime, contributed largely to physiology by directing special attention to the functions of tissues; and in his work *Anatomie Générale*, published in 1801, divided muscles into two groups, those of animal life, and those of organic life. He attributes these functions to muscle, extensibility, contractility, and sensibility. There is no mention of elasticity.

About this time, from 1780 to 1800, the discovery of oxygen naturally led physiologists to attach great importance to this element. Thus we find A. Fothergill, in 1782, suggesting that, in cases of suspended animation, the lungs should be inflated with dephlogisticated air, that is, with oxygen. Following him in 1790, Girtanner actually identified irritability with oxygen. The notion of the fundamental phenomenon of life at this period was that of combustion.

In 1809, William A. Wollaston (1766-1828) discovered the muscular sound, and made the important generalisation “that each effort, apparently single, consists in reality of a great number of contractions repeated at extremely short intervals.” Thus Wollaston, by a kind of intuition, anticipated the modern view of the condition of tetanus.

The lecturer then alluded to various investigations into the structure of muscles, made by Everard Home and Bæuer in 1818, by Hodgkin and Lister in 1832, by Skey in 1837, and Mandl in 1839. Even up to this period, the prevalent opinion, first given by Hales in his *Hæmostatics*, and afterwards repeated by Prevost and Dumas in 1825, was that, when muscular fibres contracted, they were thrown into zigzag bands. This was first questioned by Richard Owen and Arthur Farre, and was finally shown to be incorrect by Allen Thomson. Then, in 1840, appeared the classical research on muscle by William Bowman, which undoubtedly marked an epoch in the physiology of muscle, not merely on account of the new facts contributed, but by being a basis and starting-point for the researches of recent histologists. Mr. Bowman also showed that a wave of contraction passed along a muscle from the stimulated point. The lecturer then alluded to the steps by which physiologists came to the opinion that the sarcolemmal elements of Bowman manifested properties similar to the sarcode of simple animals, a name first given to it by Dujardin in 1835. He alluded to the influence of the cell-theory, and more especially to the use of the word protoplasm by Hugo von Mohl in 1844.

In 1842, Liebig speculated as to the changes in muscle from a chemical point of view. Adhering to the hypothesis of a vital force, he assumed that it governed the chemical operations occurring in the body. Energy was liberated by the decomposition of muscle-substance, whilst heat was obtained by the combustion of non-nitrogenous matters. This view was objected to in 1845 by Mayer of

Heilbron, who argued that the chemical changes in the muscles were not different from those occurring in dead matter. On theoretical grounds also, he concluded that muscular action was not attended with great destruction of nitrogenous matter. Subsequent experiments have proved this to be the case, showing that muscular activity is not followed by an increase of nitrogenous matters in the excretions, but by an increase of non-nitrogenous matters, particularly carbonic acid.

Since 1840, our knowledge of muscular action has been gained chiefly by experiment. Schwann was the first to measure the force of muscular contraction. Weber, in 1846, showed that muscles possess elasticity, and that the elasticity is diminished as the muscle contracts. He also made the important discovery that tetanus is due to a rapid series of short contractions, fused together by the elasticity of the muscle. In 1846, Wertheim investigated the elasticity of muscle. In 1850, Von Helmholtz devised the myograph, an instrument which in its various forms has been of immense service in physiological research.

The lecturer then showed a number of experiments, illustrating the single contraction curve, the tetanic curve, and the method of studying muscular work. He also demonstrated the period of latent stimulation. Next, he referred to the researches on the mechanical work of muscle by Weber, Von Helmholtz, Fick, Heidenhain, and others. Von Helmholtz, in 1848, was the first to make accurate measurements of the heat produced by contracting muscle.

The lecturer referred very briefly to the chemical researches of Kühne (1859) and others as to the chemistry of muscle. Finally, he showed how Hermann had devised a theory to account for the phenomena of muscular contraction.

ABSTRACT OF LECTURES

ON THE

METAMORPHOSIS OF SUCTORIAL FISHES AND BATRACHIA.

Delivered at the Royal College of Surgeons of England.

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LECTURE III.—ON THE EARLY DEVELOPMENT OF THE LAMPREY.

THE ripe ovum of the lamprey is a slightly oval body, about one millimetre in diameter, formed of an opaque, nearly white yolk, invested by a membrane of an inner perforated and an outer structureless layer. There seems to be a pore perforating the inner layer at the formative pole, which may be called a micropyle. Enclosing the egg-membrane, there is a mucous covering, which causes the egg, when laid, to attach itself to stones or other objects. Impregnation is accomplished by the male attaching itself by its suctorial mouth to the female. The couple then shake together, and at the same time emit from their abdominal pores ova and spermatozoa. The segmentation of the ova is total and unequal, resembling that in the ova of the frog. The upper pole is slightly whiter than the lower. A segmentation-cavity is found very early, and is placed between the small cases of the upper pole and the large ones of the lower. The roof is formed of a single row of small cells. At the sides of the segmentation-cavity there are several rows of small cells, which gradually emerge into the larger cells of the lower pole. Segmentation is followed by an asymmetrical invagination, which leads to the formation of a hypoblast like that of the frog. A small circular depression forms near the border below the segmentation-cavity. The top of this is formed by the infolding of the small cells, while the floor is composed of the large cells. This pit is the commencement of the mesenteron. It soon becomes deeper, and forms a well-defined tube running in the direction of the segmentation-cavity; this latter gradually becoming smaller, and finally obliterated. The external opening, which eventually closes, is arched over by a prominent lip. Simultaneous with these changes, the small outer or epiblastic cells gradually spread over the yolk-cells. The growth of the yolk-cells is as in normal types of epibolic invagination. By the time the segmentation-cavity is obliterated, the whole yolk is enclosed by the epiblast, which is composed of a single row of columnar cells. During these changes, the mesoblast is formed as two plates from the primitive hypoblast. These plates are triangular in form, and are situated one on each side of the middle line. When the mesoblast is fully formed, the

lateral parts of the hypoblast grow inwards underneath the axial part, so that it becomes isolated as an axial cord, and is next enclosed between the medullary cord and a continuous sheet of hypoblast below. Here its cells divide, and it becomes the notochord. The notochord is thus formed out of the axial portion of the primitive hypoblast. The medullary plate forms as a streak extending forwards from the blastopore over fully one-half of the circumference of the embryo, about the time when the enclosure of the hypoblast by the epiblast is complete. The medullary plate first contains a shallow median groove; along its line, the epiblast becomes thickened, and forms a kind of keel projecting inwards towards the hypoblast. This becomes more prominent, and the groove in it disappears, and it becomes separated from the epiblast as a solid medullary cord. The embryo is now of an elongated form, and the medullary cord forms a ridge on its closed surface. At the lip of the blastopore, the medullary cord is continuous with the hypoblast, thus forming the rudiment of the mesenteric canal.

After the formation of the neural cord, the cephalic portion first becomes distinct, forming an anterior protuberance free from yolk; and at the same time the mesoblastic plates begin to divide into somites. Shortly afterwards, an axial lumen appears in the centre of the neural cord. With the growth of the embryo, the yolk becomes entirely confined to the posterior part of the embryo; the embryo itself becomes spirally coiled.

After hatching, the body is somewhat curved, the posterior extremity being thick with the yolk, while the anterior is thin. The larva exhibits only slow movements, and is not capable of swimming. On the ventral side of the head is placed the oral opening, leading into a large stomodæum, which is still without connection with the mesenteron, but prolonged a considerable distance under its anterior part. Behind the stomodæum is the branchial region of the mesenteron, which is laterally attenuated on each side into seven or perhaps eight branchial pouches; these extend outwards nearly to the skin. Between the pouches are placed mesoblastic segments, which enclose a central cavity. One segment is placed behind the last, and two in front of the first persistent pouch. This pouch is situated in the same vertical line as the auditory sac, and seems to be the hyobranchial cleft. At the front end of the branchial region of the mesenteron is a thickened ridge of tissue, which, on the opening of the passage between the stomodæum and the mesenteron, forms a partial septum between the two, and is called the vulum. On the ventral aspect of the branchial region is a sac extending from the anterior end to the third cleft. At first, it constitutes a groove opening into the throat above; but soon the groove becomes narrowed into a groove placed between the second and third permanent branchial pouches. The sac in the adult forms a glandular mass below the branchial region, and is equivalent to the thyroid gland in higher vertebrates.

ON SOME POINTS IN THE REPARATIVE SURGERY OF THE GENITAL TRACTS.

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It is proposed, in the first part of this paper, to consider a condition of the cervico-vaginal spaces which is most constantly associated with displacement, dysmenorrhœa, dyspareunia, and sterility. Arrest of development (certain normal transitory embryological states becoming fixed conditions in infantile life), or a failure of the second formative development of puberty, is the usual cause of this condition, although excessive developmental impulse quite frequently determines an increase of one or more of the factors of copulation, generation, or parturition.

Wherever there is a defect in symmetrical anatomical and physiological correlation of the generative organs, some abnormality is present to indicate either arrest or excess of embryogenic impetus. The symmetrical relationships and interconnections of the vagina, bladder, rectum, uterus, oviducts, and ovaries cannot be disturbed without protest upon the part of one of these organs, or possibly the whole of them. For the re-establishment of the symmetrical correlation of the congenital disorders of place and function, I have made certain surgical procedures successful, based upon the belief that there were possible plastic operations which might overcome teratological (fixed transitory embryonic) states. An understanding of the development and functions of the vagina will explain how its faulty implantation produces either an apparent, not true,