

what similar fact is observed in the difference in the course and fatality of measles and other epidemic diseases among civilised and uncivilised races: witness the extreme fatality of measles when it was introduced from Australia into Fiji for the first time, and carried off nearly a third of the population.

Tubercle in cattle ("perlsucht") leads almost always to the production of nodules which do not generally caseate and disintegrate, but *calcify*, and which by becoming confluent may form large tumours. The most frequent seats of the tubercle nodules are the pleura, pericardium, diaphragm, and peritoneum. In the younger nodules the bacilli may be very numerous; in the older ones they are very few in number and entirely confined to the giant cells.

In the horse tubercle occupies a position midway between the "perlsucht" of cattle and human tuberculosis. The tubercular nodules in the peritoneum and omentum show the greatest similarity to "perlsucht," whereas sections of the lungs in the same cases present completely the appearance of human lungs affected with miliary tuberculosis.

In pigs tubercle is very common, and frequently affects the cervical lymphatic glands, which become caseous. Calcification also occurs. In the lungs a peculiar form of "caseous pneumonia" is met with in which the alveoli are, in places, filled with numerous masses of tubercle bacilli. The origin of these cases is evidently the inhalation of large masses of bacilli.

In sheep and goats Koch only met with one case each. The only point to notice was the existence of a large cavity in each lung, filled with caseous pus, and exactly analogous to the cavities in human lungs.

In fowls tubercle sometimes becomes endemic, and may destroy nearly all the fowls in a brood. Nodules, of *firm* consistence and very frequently *calcified*, are found especially in the intestine and liver, but also in the marrow of the bones. Infection seems to take place from the intestine, as nodules are but seldom found in the lungs.

In monkeys tubercle differs in many respects from the same disease in man. As a rule it remains only for a short time limited to one organ, but soon spreads over the whole body. It does not, however, as in human miliary tuberculosis, lead to the formation of numberless small nodules of uniform size, but of a larger or smaller number of tubercular masses of very various size. These are especially frequent in the liver, spleen, and lymphatic glands, and, instead of being composed of a cheesy substance as in the human subject, contain thin pus, and thus resemble multiple abscesses. The presence of the tubercle bacillus shows their true nature. The infection appears to start most frequently in the lungs.

Dogs are very insusceptible, and require large doses of the tubercle virus to render a successful inoculation certain.

Guinea-pigs and rabbits are very sensitive to tubercle, which causes a remarkable enlargement of the spleen and liver, with a peculiar grey or yellow marbled mottling of these organs. They frequently become spontaneously tubercular, and cannot be kept longer than eight or ten months in the same building with tubercular animals without becoming themselves tubercular.

(To be concluded.)

ON THE FUNCTION OF THE CILIARY BODY.

By GEORGE EDWARD WALKER, F.R.C.S.,

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ALTHOUGH so much has been done, especially of late years, for the elucidation of the duties of the various parts of the eye, the function of that complex organ, the ciliary body, is even now by no means well understood. We know that it is composed of three parts—the ligamentum pectinatum, the circular muscle, and the radial muscle. We know that the ligamentum pectinatum is a spongy body capable of admitting a variable quantity of fluid as its meshes are expanded or contracted; that the circular muscle accommodates for nearness, and at the same time opens up the spaces of the ligamentum pectinatum. These points are, I think, not disputed; but of the function of the

greater part of the ciliary muscle, the radial fibres, very little has been said or is known. Far accommodation, it is generally maintained, is produced by the mere relaxation of the circular fibres. A few, of whom I am one, maintain that the circular ciliary muscle, like all other circular muscles, is antagonised by a radial muscle; and just as the sphincter ani is opposed by the levator ani, and the orbicularis oris is opposed by the buccinator and other muscles radiating from the mouth, so is the ciliary sphincter antagonised by the ciliary radial muscle, which therefore actively accommodates for distance. For the further illustration of this argument, and, as I submit, also for its proof, I must refer to my essay on Glaucoma.¹ But if, as appears to be acknowledged, the circular muscle have a double function, may not the radial also have a double function? For the purpose of argument I shall take it for granted that the radial fibres do accommodate for distance, and I shall proceed to show the reasons for my belief that it has a second and even more important duty. Before doing so, however, I think it necessary for the proper understanding of my argument to describe the minute anatomy of the parts concerned. Klein's description is so clear and concise that I make no excuse for copying it *verbatim* from his admirable "Elements of Histology" (pp. 295, 296):—

"The Ligamentum pectinatum iridis is a conical mass of spongy tissue joining firmly the cornea and sclerotic to the iris and ciliary processes. It forms an intimate connexion, on the one hand, with the junction of the cornea and sclerotic, and, on the other, with that of the iris and ciliary processes. This ligament is composed of trabeculae and lamellae of stiff elastic fibres, forming a continuity, on the one hand, with the lamina Descemeti of the cornea and the elastic fibres of the sclerotic, and, on the other, with the tissue of the ciliary border of the iris. These trabeculae anastomose so as to form a honeycombed plexus, and the spaces in this plexus are lined with a layer of flattened endothelial cells, directly continued from the endothelium of Descemet's membrane on the one hand, and with the layer of endothelial cells covering the anterior surface of the iris on the other hand." (That is, the ligamentum pectinatum is an elastic, sponge-like body, the cavities of which communicate by open mouths with the anterior chamber.) "At the point of junction of the cornea and sclerotic, but belonging to the latter, and in the immediate neighbourhood of the ligamentum pectinatum iridis, is a circular canal—the canal of Schlemm; this is lined by endothelium, and is considered by some (Schwalbe) as a lymphatic canal, and by others (Leber) as a venous vessel." (For reasons to be given later, I think the latter is the proper description.) "The ciliary muscle or tensor choroideae is fixed to this ligamentum pectinatum; it is composed of bundles of non-striped muscular tissue. This muscle consists of two parts: (a) one of circular bundles nearest to the iris—this is the portio Mülleri; (b) the greater part is composed of radiating bundles passing from the ligamentum pectinatum in a meridional direction for a considerable distance backwards into the tissue of the choroid membrane. It occupies the space between the ligamentum pectinatum, sclerotic, ciliary processes, and the adjoining portion of the choroid membrane. The bundles of the muscle are arranged more or less in lamellae; within each lamella they form plexuses. A rich plexus of non-medullated nerve-fibres, with groups of ganglion cells, belongs to the ciliary muscle."

Waldeyer says that some of the outer fibres are attached to the sclerotic, and of the action of these there can be no doubt, since the scleral attachment must be their fixed point, and the movable point the attachment to the ligament. I believe, and shall endeavour to show later, that the remainder of the meridional fibres act in the same manner, the choroidal attachment being the fixed or almost fixed point, and the ligamental attachment the movable one. So that the ciliary muscle, so far from being the tensor choroideae merely, is also the tensor of the ligament.

Although it seems to be impossible to estimate accurately

¹ Donders in his classic work speaks in opposition to this theory, and says that the subjective sensation for himself is conclusive. *Pace tantum viri*, this argument cuts both ways. I am both hypermetropic and astigmatic, and therefore have to accommodate a good deal even for distance. I have acquired such control over my ciliary muscles that I can see-saw between the two with almost as much ease as between the biceps and triceps of my arm; that is to say, I can contract my radial muscle so that the whole of my hypermetropia and astigmatism becomes manifest, just as would take place if the eye were fully under the influence of atropine, and the next moment, in spite of my hypermetropia and incipient presbyopia, I can read "brilliant" type.

the blood-pressure in the capillaries generally, it may be possible to infer, with some approximation to accuracy, the pressure in the capillaries of the eye. We know that the pressure in the anterior chamber, and therefore throughout the eye, is normally equal to about twelve inches of water. It necessarily follows that the pressure in the intra-ocular capillaries must be greater than this—the general intra-ocular pressure,—as otherwise the blood would be altogether expelled from the interior of the eye. We know also that even in complete glaucoma, when the intra-ocular pressure is vastly greater than the normal, the blood still circulates, though in diminished stream. We may reasonably take it therefore, that the intra-capillary pressure is very much, I might say many times, greater than the intra-ocular. It is generally believed that the waste fluids of the eye pass from the anterior chamber through the interspaces of the ligamentum pectinatum into the canal of Schlemm, and then into the venous system. This belief is founded on the fact that a suitable coloured fluid injected into an eye removed from the body, at a pressure of twelve inches of water, can be seen to find its way into the veins, though very slowly, and by no means as if there were direct channels between the anterior chamber and the veins. It is questionable whether during life this simple process of percolation obtains. In the dead eye there is no blood-pressure in the capillaries to counteract the pressure of the fluid injected into the anterior chamber, whereas in the living eye the blood-pressure in the capillaries is much greater than the lymph-pressure in the anterior chamber. Hence I think some other explanation must be sought.

Now, as in other parts of the body the propulsion of the lymph is effected chiefly by muscular pressure, aided by the lymphatic valves, which direct the current centripetally, it seems reasonable to suppose that some such action takes place in the eye; and if this be the case, then we see at once the object of the radial fibres. The circular, in the act of near accommodation, open up the meshes of the ligamentum pectinatum; and do not the radial fibres, in the act of accommodating for distance, reverse this action, close the meshes of the ligamentum pectinatum, and thus force the contained fluid into the canal of Schlemm, and so into the veins? For the openings from the lymph passages into the veins must be valvular, otherwise the blood would flood the eye, and the valves must open towards the veins. Hence some pressure, greater than the intravenous, must be brought to bear on the lymph spaces in the ligamentum pectinatum in order to force the contained fluid into the veins, and it seems impossible that this can be accomplished in any other way than by muscular action, and that by radial muscular action. If this, for the sake of argument, be conceded, I think I can account for and show the use of a condition which has doubtless puzzled many, as it has myself.

In estimating refraction, we take as a standard what we call an emmetropic eye—that is, one which receives parallel rays of light, and focusses them accurately on the retina without the intervention of accommodation. But does such an eye exist? We call such a typical eye a normal eye; but I doubt whether there be such an eye, save in a short period of transition between hypermetropia and myopia—that is, as a product of morbid action. I take it that a normal eye is slightly hypermetropic and slightly astigmatic; say, for instance, requiring from $\cdot 25+$ to $\cdot 5+$ for horizontal or nearly horizontal lines, and from $\cdot 75+$ to $1+$ for vertical or nearly vertical lines. Now, if this be the case, there must be, in seeing the largest or most distant objects, some accommodation; and inasmuch as the astigmatism of the cornea does not allow the accurate formation of an image with one uniform contraction of the circular fibres, since an amount of contraction sufficient to focus horizontal lines would be too little to focus vertical, and one to focus vertical lines too great to focus horizontal, it must follow that both muscles are constantly at work in every visual act. Judging by analogy, one would imagine that by rapid oscillations of the two muscles a series of pictures is formed on the retina, first of horizontal, then of vertical lines, in too quick succession for the brain to take cognizance of the interval. Or it may be that just as an inverted image on the retina is necessary for the appreciation by the brain of an object as erect, so such a succession of pictures may be necessary for the appreciation of correct outline.

This view of the functions of the ciliary muscle would shed a flood of light on the pathology of glaucoma, and, I would submit, it would add greatly to the probability of the theory of its production which I have advanced—

namely, that the disease is due to overaction of the ciliary muscle, which at last causes inflammatory engorgement and blockage of the ligamentum pectinatum. For in hypermetropia the circular fibres have so much to do in accommodation that their nutritive function must be very subsidiary indeed; and as we often find in hypermetropes such a degree of circular spasm as to require a strong concave glass for distance, it is difficult to believe that the nutritive duty can be satisfactorily performed under such a strain. It would seem that when the circular muscle is so cramped as to convert a hypermetropic into a myopic eye, the radial fibres never fully contract; therefore the valvular spaces are kept constantly open, and the fluid contained in them is, to say the least of it, insufficiently pumped out. Therefore it would appear that an eye is astigmatic designedly, in order that no accurate image shall be formed without the intervention of the muscular act of accommodation, which, if I am right, cannot be done without a change being made in the hydraulic apparatus of the eye.

PERTUSSIS.

By WALLACE B. CROSKERY, L.K.Q.C.P.I., &c.

WHOOPIING-COUGH is an affection which the general practitioner meets very frequently in practice, and yet presents so many complications, relapses, and so forth, that, notwithstanding the many cases he sees of it, his skill and wits are frequently exercised both as to treatment and general management. It drags along over a period of weeks, and often months, and the many specifics suggested for its treatment are resorted to with more or less success. I wish more particularly to direct attention to those cases which become complicated with bronchitis or broncho-pneumonia. This I take to be the most frequent complication we meet with in children beyond the age of infancy; I allude more especially to those who are between the ages of three and eight years. When this complication has set in, the little patients have paroxysms of coughing every half, three-quarters, or every hour; the respiration ranges from 35 to 60 per minute; and the pulse from 120 to 140, or even higher; the temperature sometimes being elevated, sometimes not, and, if elevated, not generally running high. The child lies with eyes closed between the paroxysms, tired out and drowsy, partly from want of sleep and partly from imperfect aeration of blood. Expectoration is no longer simply glairy, but has become muco-purulent, or sometimes apparently completely purulent; of this a very considerable quantity is brought up, and very frequently the stomach is emptied of its contents at the same time. The child becomes very weak, thin, and wasted. Percussion frequently shows patchy dulness, more especially posteriorly, and general want of resonance; auscultation reveals muco-crepitant râles in the medium-sized tubes, which are loaded with muco-purulent secretion; and oxidation of the blood is very much interfered with. The urine is scanty, with a high specific gravity, ranging from 1026 to 1036, and acid. This condition may go on from two to six weeks, and we have our skill taxed to the utmost to bring the patient safely through.

Among my notes on whooping-cough are those of a child aged five years. As the case is typical of the complication I have described, I will make some extracts. The father of the child carefully noted down the hours at which each paroxysm occurred, and I find the average number of paroxysms for the first week after the onset of bronchitis—which set in about the fourth week of whooping-cough—to be $30\frac{1}{2}$ in the twenty-four hours. In the night the paroxysms came on (as they generally do in severe cases) more frequently than in the day, the average from 10 P.M. to 10 A.M. being $17\frac{1}{2}$, and from 10 A.M. to 10 P.M. $13\frac{1}{2}$. During this week the average pulse was about 124 per minute and the respiration 40, the temperature ranging from $99\cdot 5^{\circ}$ to $100\cdot 5^{\circ}$. During the second week of the bronchitis, or the fifth of whooping-cough, the average number of paroxysms in the twenty-four hours was $23\frac{1}{2}$; the average pulse was 120; respiration 33; temperature 99° . During the third week of bronchitis the paroxysms averaged $16\frac{1}{2}$ in the twenty-four hours. During the fourth week there were about seven in the twenty-four hours. In these last two weeks the average pulse was 110, the average respiration 30, and the temperature normal. During the next