attached surface, was hollowed out corresponding to where the needles had passed or absorbed to a mere point; and thus it was that it broke away so readily.

October 9th. I syringed the ear. The tympanum was perfect. Hearing was also perfect.

THE MECHANISM OF THE ACCOMMODATION OF THE EYE.

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In spite of much elaborate investigation, the mechanism of accommodation in the eye still remains, to some extent, a matter of speculation. At the recent annual meeting of the British Medical Association, a novel and ingenious theory was brought forward by Mr. A. T. Norton of St. Mary's Hospital, and to test the truth of this theory the experiment described below has been undertaken. I shall venture, however, before discussing the uncertain points, to state briefly the facts which are already established in connection with the subject.

1. Parallel rays of light proceeding from a distant point and striking the eye can be brought to a focus upon the retina. Divergent rays of light proceeding from a point only four inches distant from the eye can also be focussed upon the retina. The eye, then, has the power of changing its refraction as it views objects at different distances.

2. This power of accommodation depends solely upon changes of form in the crystalline lens. This fact is proved by the catoptrical examination of an eye during accommodation. A flame is placed towards one side of the observed eye, at a certain angle with the axis of the cornea; the observer's eye is placed towards the other side, at a similar angle. Three reflections or images of the flame are seen; the first being reflected from the cornea, the second from the anterior lens-surface, the third from the posterior lens-surface, or, more strictly, from the anterior surface of the vitreous body. If these images be viewed through a microscope, and if the person whose eye is under observation be directed to look first at a distant object, and then at a nearer object placed in the same line of vision, the second image is seen to move towards the first image, and also to become smaller. The movement indicates an advance of the anterior lens-surface; and the diminution of size indicates, in accordance with optical laws, an increased convexity of this surface.

3. Accommodation for near objects is produced and maintained by voluntary effort.

4. Accommodation for distant objects is a purely passive condition; and to this condition the eye always returns when the voluntary effort above-mentioned ceases.

5. The mechanism by which accommodation for near objects is produced is actuated through the third nerve. So far, no room for doubt remains: all is definitely proved. The next statement is almost as certainly true—viz.:

6. The chief agent in the mechanism is the ciliary muscle.

Now, in what manner does contraction of the ciliary muscle effect a change in the form of the lens? Several different explanations of its action are given by the best authorities; but it is proposed here to examine only the ingenious theory brought forward by Mr. Norton. It is briefly this. The veins through which the blood returns from the ciliary processes pass through the substance of the ciliary muscle; hence, when the muscle contracts, these venous trunks are compressed, and the highly vascular ciliary processes are thrown into a state of turgescence and enlargement, producing an increase of pressure around the periphery of the lens, and a consequent change of form in that body. In direct opposition to this view is Mr. Bader's description of these parts. At page 215 of his work on *The Human Eye*, he says: "The arrangement of the blood-vessels of the ciliary region renders it probable that, during contraction of the ciliary muscle, the influx of blood into the ciliary processes is impeded, and that they contain less blood. The efflux of venous blood from the processes is supposed not to be impeded, since these veins do not pass through the muscle."

While such opposite descriptions are given of the minute anatomy of the region, it appeared to me that the turgescence theory could be conclusively tested only by ascertaining whether the circulation of blood in the vessels is necessary to the production of accommodation in the lens. To ascertain this, a galvanic current was passed through the enucleated eye of a rabbit, while, by means of a phacoidoscope, the effect produced upon the image of a flame reflected from the lens-surface was observed. In overcoming the difficulties of this experiment, I received much valuable help from Mr. Lloyd Owen, surgeon to this hospital, and from Mr.

Frederick Maberley; and, before attempting to carry it into execution, I was careful to make myself familiar, by numerous observations with the phacoidoscope, with the accommodation-movements of the flame image in the living human eye.

The phacoidoscope consisted simply of a black wooden stage, upon which a quadrant was figured; a microscope of simple construction, magnifying eight diameters, and having a micrometer eye-piece; a gas jet travelling in a groove, and capable of being placed at any desired point of the quadrant; and a point of attachment at the centre of the quadrant for the apparatus containing the rabbit's eye. This latter apparatus (Fig. 1) consisted of two small brass cups, each soldered to an

Fig. 1.

upright support, and of such size that, when containing the eye, their rims did not quite lie in contact. One of the uprights being made of watch-spring, the cup could be drawn back when the eye was introduced. The wires from a Gaiffe's battery, producing a gentle interrupted current, were connected, one with each upright, so that the circuit was completed by the passage of the current through the eyeball. A rabbit, weighing 29 ounces, was stupefied with chloroform, and then received a hypodermic injection of 20 grains of hydrate of chloral. During profound anaesthesia, the left eyeball was excised, and at once dipped in olive oil heated to 100 degs., before being placed in the cups. This point is important, for, if it be neglected, evaporation quickly changes the tension of the globe and dims the cornea. By means of a heated brick, the temperature of the air around the holding apparatus was maintained above 90 degs. Fahr.

When the microscope and the flame were placed, each at an angle of 35 degs. with the axis of the cornea, the reflexions from the cornea and anterior lens-surface were admirably seen. To prove that these were the images required, and that neither was produced by the posterior lens-surface, it was only necessary to observe that both travelled in the same direction when the flame was moved. During the first minute or two after the removal of the globe, the galvanic current produced no movement either in pupil or image. Doubtless, the division of the ciliary nerves, during the operation, had caused a spasmodic contraction both of iris and ciliary muscle, for the pupil was small, and the lens-image occupied that position which it afterwards assumed only during galvanic irritation. The pupil recovered its mobility a little while, perhaps a quarter of a minute, before the image did so. Very soon, however, both became responsive to the current. Figs. 2 and 3 show the

Fig. 2.

positions assumed by pupil and images during non-stimulation and during stimulation. The reflection from the cornea is fixed, and brighter than that from the lens-surface. The vertical lines in the diagram show

the divisions of the micrometer, each space corresponding exactly to $\frac{1}{32}$ of an inch. The whole is shown magnified eight diameters, as it actually appeared.

It will be seen that, during non-stimulation, the two images stood exactly two spaces distant from each other, and that, during stimulation,

Fig. 3.

the lens-image travelled towards the corneal image through exactly half a space. The observation of this movement was made very many times, during a period of an hour and three-quarters, and it appeared to be invariable in every way. The image occupied an appreciable time in its journey; it always assumed the same positions, so far as the eye could discern. The primary, the secondary, and the combined currents were successively employed, and each current was employed in varying intensity; but in every case the result appeared to be the same. The weakest current appeared sufficient to cause the image to perform its whole journey, while a much stronger one could not drive it further. When an hour and three-quarters had elapsed, and the surrounding temperature had fallen to 80 degs., all action ceased.

The influence of the current upon the iris was also carefully observed throughout, and is worthy of note, although not bearing upon the question at issue, namely, the turgescence theory of accommodation. The movements of the pupil showed, in several particulars, a want of correspondence with those of the flame-image. At the commencement of the experiment, as before stated, mobility was observed in the pupil before it occurred in the image. On breaking the current, the position of relaxation was resumed more quickly by the image than by the pupil. This was observed several times, but not invariably. On breaking the current, the pupil dilated to rather more than its permanent size, then again contracted slightly within it, thus performing several minute oscillations before assuming the size shown in the figure. This movement contrasted with the steady unoscillatory journey of the image. At the close of the experiment, when the image became permanently fixed in its position of relaxation, the pupil began very slowly to dilate, and ultimately assumed a fixed diameter of $\frac{5}{8}$ of the micrometer spaces, a greater size than it had hitherto ever obtained. It continued to be slightly influenced by the current for several minutes after the image had become completely fixed.

Accommodation, then, is proved to occur without help from vascular turgescence. It might still be urged, that, without turgescence, only a portion of the accommodation changes in the lens are obtained. Apart from the improbability of a second, and very different, agent being employed in an action, which is apparently admirably performed by muscular contractility alone, the following consideration is, I think, almost conclusive, that we have, in this experiment, obtained the whole amount. The lens-image has been shown to travel in the plane of the microscope about $\frac{1}{8}$ of an inch. Now, under the angle of 35 degs., at which the microscope stood, this distance will be found, on calculation, to correspond with an advance of the lens-surface of $\frac{1}{32}$ of an inch. In the human eye, the lens-surface advances, according to Professor Donders, only .4 millimetre, or about $\frac{1}{64}$ of an inch. It appears, then, that, in the eye of the rabbit, which is smaller than the human eye, the advance of the lens-surface, during accommodation produced by galvanism, is considerably greater than that occurring naturally in the human eye; hence it would be unreasonable to suppose that a still greater movement occurs in the former when it is in its natural condition. The foregoing result, showing an excess of movement in the smaller eye, may seem, at first sight, to throw doubt on the accuracy of the calculation, but will, on the contrary, tend to corroborate it, when we consider that the range of accommodation is probably much greater in the rabbit than in man. The rabbit, equally with ourselves, has need of distinct vision for distant objects, whilst his near point—as when feeding, for example—must be considerably nearer than ours.

Finally, the minute structure of the rabbit's eye so closely resembles that of the human eye, that it is impossible to suppose a different me-

chanism in the two cases: it may, consequently, be asserted as proved, that *the act of accommodation is in no way dependent upon vascular turgescence.*

CLINICAL MEMORANDA.

SUCCESSFUL VACCINATION, WITHOUT ILL-EFFECT, OF FOUR PERSONS FROM A CHILD SUFFERING FROM SMALL-POX.

THE contribution of Mr. Gayton on the limit of prophylaxis by vaccination, in the clinical memoranda of the BRITISH MEDICAL JOURNAL, recalls to my remembrance having vaccinated a child in the incubating stage of variola, and the vaccination being very successful. I vaccinated from this child, who was suffering from small-pox, although I did not recognise it, two children and re-vaccinated two adults. The particulars of the case are as follows, and, perhaps, are worthy of record; for it is also interesting, inasmuch as the small-pox was not communicable to those whom I had vaccinated with lymph from the infected child.

I vaccinated Thomas H. S. Scott at three months, on Monday, May 29th, 1871. He was brought to my surgery for inspection the Monday following. Every puncture had taken; and there were five well-developed vesicles well distended with clear lymph, and a sufficient, but not excessive, areola. Knowing the child's parents to be healthy, and believing the child to be so, the vesicles perfect and full of lymph, I selected this infant in preference to one or two others from whom to vaccinate two children and re-vaccinate two adults. The mother remarked to me that he had a slight rash of a few pimples on his chest and back, but this I mistook to be merely a rash due to the vaccination, which every now and then I had known to follow it. The next day, I was sent for to visit him, and was surprised to find him very ill and covered with a thick vesicular eruption, accompanied by considerable fever, which, upon hearing a lodger in the same house had died from small-pox the previous week, as also two or three persons in the same street, I felt sure would prove to be, as it did, an attack of confluent small-pox from which the child was suffering. The vaccine pustules looked healthy; the areola increased, and was of a deeper red than yesterday, but, up to the present time, in no way different from the usual appearance on the ninth day. The next morning, the child was much worse. There was no mistaking now the disease; each vesicle had the characteristic central depression and several of them coalesced; the areola of the vaccinated arm had suddenly failed; the scabs were dry, and the arm unusually pale; the child was soon unable to take the breast, and died on Monday, June 12th, the fifteenth day of vaccination and the eighth day of the eruption.

On discovering that the child was suffering from small-pox, I was anxious to know how those adults and children were whom I had vaccinated (arm to arm) with lymph from this infant. I called to see them the next day on the ostensible plea of knowing if the vaccination had taken, but really to see if they were suffering from any premonitory symptoms of variola, and was relieved to find them all well, and their arms taking. I saw them again on the eighth day and afterwards; all had perfect vesicles and were in excellent health. The only difference or effect of having been vaccinated from a child suffering from small-pox was the early appearance of the vaccine vesicles, and in the adults unusually successful re-vaccination, and are probably more than usually protected against an attack of small-pox.

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SURGICAL MEMORANDA.

THE ELASTIC LIGATURE.

ONE use of the elastic ligature not mentioned in the JOURNAL of November 29th is for the closure of wounds. The late Mr. Alexander Edwards, lecturing in 1860, recommended its employment with safety pins or hare-lip needles for fastening wounds likely to swell or gape. For this purpose he employed thread similar to that used in elastic-sided boots. As a wound or its edges swell the sutures yield, so that there can be no injurious dragging on the skin-apertures, and when the turgescence disappears, the surfaces become closely approximated. An advantage of this plan, over unyielding sutures, is that it is unnecessary to remove any of the fastenings until the edges are united.

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