production of glycosuria. One writer says it is capable of producing true diabetes.

I have used the drug to a considerable extent. During its administration I have watched the urine of the patients carefully, and have never seen sugar result from its ingestion. I have satisfied myself that the preparation of thyroid I use does itself contain lactose, which is less soluble, but a much stronger reducing agent than sucrose. It precipitates cuprous oxide when gently heated with alkaline cupric solution, but does not ferment with common yeast unless it has been inverted into glucose and galactose, which both ferment. Lactose passes unchanged into the urine after smaller amounts are taken than do the other saccharids.

Probably in some of the cases reported the sugar may have been only alimentary or have resulted from hypodermic injection of the drug.

Psycho-physical Perception. By F. W. EDRIDGE-GREEN, M.D., F.R.C.S.

IN the perception of a sensation there are the following factors to be taken into consideration :

1. The physical stimulus.
2. The sense-organ receiving this stimulus.
3. The nerves conveying the effects of the stimulus.
4. The centre of memory receiving the whole impression.
5. The perceptive centres conveying to the mind information concerning individual portions of the impression.

Therefore, imperfect perception may be due to a defect in any one or more of the above five factors.

1. *The physical stimulus.*—The physical stimulus is the force which acting upon the body gives rise to a sensation. It is often confused with the sensation itself, whereas the two are quite distinct. For instance, the force which acting upon the eye gives rise to the sensation of light, when falling upon the back of the hand gives rise to the sensation of heat, and may, when falling upon the head, covered by hair, give rise to no sensation whatever. Again, different physical stimuli may

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cause the same sensation, as a blow on the eye causing the sensation of light. It is very probable that there are many forces of which we are not cognisant, because they do not act upon any sense-organ, and yet these forces may be of the greatest importance. All physical stimuli agree in their ill-defined character, and the fact that they can be arranged in a series which has no definite commencement, no definite termination, and no definite unit. It is easy to arrange time in a series, but it is impossible to conceive a commencement to time, or that time can ever end, or that we can conceive a portion of time which cannot be subdivided; the portion of time that light takes to pass through the space of an inch can be divided into millionths. It is the same with the stimuli that cause the sensation of heat: there is a perfect series from the lowest to the highest possible temperature, and it is evident that there are innumerable gradations from one degree to another. In the case of the physical stimuli which give rise to the sensation of light, we know that similar stimuli exist below the red and above the violet, and that a regular series exists from the red to the violet. There may be waves far below the red or above the violet which may be performing very useful work in the scheme of nature, but of the existence of which we can only conjecture.

2. *The sense-organ receiving the physical stimulus.*—The effect of the sense-organ upon the physical series which I have just mentioned is that the series now has a definite commencement and a definite termination. For instance, though we know that the rays below the red and above the violet are physically similar to those of the spectrum, they are not perceived. Very high and very low notes are not perceived. It is the same with all other physical stimuli. As an example of the sense-organ I will take the sense of sight, as this is characteristic of the others, and is the one at which I have specially worked. I believe that light acting upon the retina liberates the visual purple from the rods and a photograph is formed. The impression is conveyed to the brain through the cones and optic nerve-fibres. Kühne, who made so many observations on the visual purple, stated that it could not be essential to vision, and could not be the visual substance, because it is absent from the cones, and only cones are to be found in the fovea centralis, the region of most distinct vision. He also stated that frogs

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whose retinas had been bleached saw as well as other frogs. The last objection does not seem to me of much moment, as the retina might be secreting sufficient visual purple for the purposes of vision. The first objection furnished me with a ready means of testing the truth of my theory. I have made numerous experiments which prove that light may fall on the fovea centralis without producing any sensation. The following experiments can be repeated by anyone.

(1) If we look at two small isolated stars of equal magnitude, either may be made to disappear by looking fixedly at it, whilst the other remains conspicuously visible. I found that the phenomenon was most marked on a dark night and when the star looked at was in a portion of the sky comparatively free from other stars, and when only one eye was used. On a very dark night a considerable number of small stars occupying the centre of the field of vision may be made to disappear, whilst stars occupying other areas of the field of vision are plainly visible.

(2) Other lights or objects when small and with dark surroundings, as, for instance, a piece of white cardboard on black velvet, may be made to disappear in a similar manner.

(3) No change can be observed if a very bright light, a group of stars, or a uniformly illuminated surface be made the object of the experiment.

(4) If we look at an illuminated object through a pin hole in a piece of black cardboard surrounded by black velvet, we find that unless it be very bright it will not be visible at all. On moving the eye so that the image does not fall on the centre of the retina the object appears brighter.

This view of the relative functions of the rods and cones of the retina is, as far as I am aware, entirely my own, and every experiment I have made on after-images, perception of luminosity, etc., supports not only the theory that there is a visual substance, but that this visual substance is purple. I find that the after-image of any spectral colour and of white light is purple, if we take care not to look at the colour too long. The following is an easy method of proving this. Look at a dull white cloud for a second or two and then close the eyes, covering them with the hands so that no light can enter the eyes through the eyelids. A dull purple will first be seen, and for a few seconds this gets brighter and brighter, giving the sensa-

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tion of a bright purple light. This gradually fades away without changing colour. It is best seen if the eyes be kept closed before being exposed to light, and then only opened for a second. The image is positive the whole time, the bars of the window are seen dark. The after-image is bluish at first, and then rapidly changes to purple. It is difficult to see an after-image of this kind if the eyes be previously exposed to light for some time. These after-images are quite distinct from the well-known negative after-images. The purple probably only gives the sensation of purple when in excess. Several very important experiments bearing on this point have been made by Mr. Shelford Bidwell.

It will be seen from this view that the cones themselves are not directly sensitive to light, but only to the products of decomposition of the visual purple. The actual length of the spectrum varies in different persons, just as individuals differ in their ability to perceive very high and low notes. I have shown that we may have shortening of either end of the spectrum without any other defect of colour perception. In these cases there is loss of light perception as well as colour perception, which is not the case in colour blindness due to defective psycho-physical perception.

3. *The nerves conveying the effects to the physical stimulus.*—The visual substance, being decomposed by light, sets up by chemical, mechanical, or some other physical action, impulses which are conveyed to the brain through the cones and optic nerve-fibres, the cones being the terminations of the perceptive fibres in the retina.

4. *The centre of memory receiving the whole impression.*—This I believe to be situated in the optic thalami; space will not permit me to give my reasons here.

5. *The perceptive centres conveying to the mind information concerning individual portions of the impression.*—The whole impression being brought to the centre of memory, different portions of the impression, colour, form, size, luminosity, etc., are conveyed to the mind through definite perceptive centres.

A psycho-physical series.—By a psycho-physical series I mean a physical series as it appears to the mind. A psycho-physical series is a sensation which is referred to external objects. It is obvious that the product of the physical

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stimulus may be considerably altered before it reaches the mind.

The chief points in which a psycho-physical series differs from a physical series are, that it has a definite commencement, a definite termination, and consists of certain definite units. The limitation of the series is probably due to the external sensory apparatus, and any unit of a physical series not coming within the defined range is not perceived. A high note which is heard distinctly by one person may be quite inaudible to another, and therefore he can form no opinion respecting its qualities. It is the same with the sense of smell. Professor Ramsay informs me that he has met with many persons who are unable to distinguish that hydrocyanic acid has any odour whatever, whilst they are able to recognise other odoriferous bodies. It is obvious that if this condition were general, prussic acid would be said to be odourless. Therefore, the definite standard length of a psycho-physical series having been found for the majority of persons, any increase in this length for any individual will be a gain, and any decrease a loss for the person examined. When the psycho-physical series is shortened, the physical stimuli occupying the shortened portion will not be perceived, and the same result will be produced as if the physical stimuli did not exist.

Unfortunately we cannot form series of other physical stimuli in the same way that we can with the rays of light, and therefore the study of the psycho-physical perception of these stimuli is attended with as much difficulty as the study of colour without the aid of the spectrum. Taking, for instance, odours, we are unable to range these in a series, though a good deal of light has been thrown upon the subject by Professor Ramsay, who suggests that a series might be formed in accordance with the molecular weight of the odoriferous body.

An absolute psycho-physical unit.—The absolute psycho-physical units are the basis of every psycho-physical series. When a person has succeeded in obtaining a match which to him appears perfect, it is evident that he has brought both stimuli within one of his absolute psycho-physical units, because all physical stimuli included in one of these units are regarded as identical. When a violin is tuned to the piano the following

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takes place. The A string of the violin is tuned until it is vibrating in harmony with a certain A of the piano. When a person has succeeded in getting the two strings to vibrate in apparently perfect unison, it is evident that he has brought the two into one of his absolute psycho-physical units.

A musician with a more accurate ear, to use the common expression, would probably not be satisfied with the result. Again, a person with no ear for music, to use the ordinary expression, would be perfectly satisfied with a match which was markedly incorrect to most persons. A person who could not distinguish any difference in sound between the bass and treble notes—and I have met with such cases,—would be perfectly satisfied with any match whatever. The perception of weight could be ascertained by giving a number of persons a series of weights, and telling them to pick out those which are identical. To sum up, a perfect match indicates that the physical stimuli are included in an absolute psycho-physical unit.

An approximate psycho-physical unit.—An approximate psycho-physical unit contains physical units which appear to be nearly alike. A difference can be distinguished between different portions of an approximate psycho-physical unit; but it is a slight difference. An approximate psycho-physical unit may be defined as a portion of a psycho-physical series containing absolute psycho-physical units the similarity between which is greater than the dissimilarity. A few examples, taken from the sense of taste, will make this clear. All physical stimuli which could be correctly defined by the word "sweet" would come within one approximate psycho-physical unit. There are many varieties of sweetness apart from the intensity of the sensation; thus sugar, honey, glycerine, and saccharin have each a particular characteristic sweetness, which would enable them to be distinguished from each other. If portions of the same liquid were sweetened with the above four substances, it would be evident enough on tasting one of these portions that it was sweet, but it would not be so evident which of the four substances had been used. On tasting successively the four liquids, the sweetening agent used for each would be evident. When we have obtained two mixtures which apparently taste exactly alike when compared very carefully, the physical stimuli are included in an absolute psycho-physical unit. An approximate psycho-physical unit

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can be recognised without comparison; thus it is not necessary to taste an acid substance to find out whether another substance is sweet or not. The approximate psycho-physical units in a series are comparatively few.

It is when we apply this theory to colour that we get the strongest confirmation. Every fact of colour-blindness and colour perception falls naturally into its place, and appears as a consequence of the theory. The spectrum forms an admirable example of a psycho-physical series; the approximate psycho-physical units are the colours which have received definite colour names, such as red and green; the absolute psycho-physical units are the varieties of the different colours, such as sage green, olive green, yellow green, etc. The colour blind may be classified according to the number of colours they see in the spectrum, five, four, three, two, or one, and they form a regular series from the normal sighted to the totally colour blind. When the spectrum is shortened the junctions of the colours are found to be nearer the unshortened side than in the normal sighted.

Space has only permitted me to give my views in the barest outline, and further information on the subject will be found in my two volumes in the International Scientific Series, but in this paper I have put the subject in a different form and added many facts which are not to be found in my books.

Discussion.

At the Annual Meeting of the Medico-Psychological Association, London, 1900.

Dr. Hayes Newington.—These problems are very curious, and one that has always been most curious to me is how a first-rate violinist can play out of tune. Dr. Green mentioned the great pain that occurs to a first-rate violinist when anybody plays out of tune, but how can a first-rate violinist play with a lot of other instruments, and yet play out of tune? I knew a case years ago of a very first-rate amateur who led an excellent orchestra. To me it has always been a puzzle that a thorough musician, hearing what the pitch of the music going on around him was, could receive an impression and coin it, so to speak, into a pitch of his own, and not discover the discrepancy.

Dr. Jones.—A most interesting case is where, with total deprivation of a particular sense, it is possible for a person to have a delusion of that sense; that is to say, in a case of congenital deaf-mutism, is it possible that the patient can have hallucinations of the sense of hearing? Dr. Dundas Grant informs me that it is quite possible. It is a very subtle point, and little is known about how the outside world does affect the terminal sense-organs; whether the changes are physical, chemical, bio-chemical, or electrical. Sir William Crooks has suggested upon the theory of the X rays that there may be some very subtle mental waves acting in a very peculiar and subtle way upon nerve-cells. This Society has encouraged psycho-physical, or experimental psychological papers, and it has been a great pleasure to hear one by Dr. Edridge-Green, who is a well-known authority upon these subjects.

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Dr. EDRIDGE-GREEN, in reply to the question raised by the President as to whether the disappearance of lights was not caused by exhaustion of the retina, said that the retina would become more readily fatigued by a bright light, whereas the experiment was made best with a feeble light and the difficulty increased in proportion to the brightness of the light. In his dark room he used four doors, and so had an absolutely dark room, and he arranged his lantern so that the centre spot only could be seen, and one eye was used. In a few seconds all light disappeared, leaving the whole field of vision quite dark. When the star was in a dark part of the sky, directly one looked at it, it disappeared, so that there was not enough light to cause exhaustion. He had mentioned two of Kühne's arguments, and a third was that there were many animals that did not possess visual purple, and were yet able to see perfectly well. He had not thought this was important enough to mention, because they might have a similar substance that was colourless to our eyes. When reading a paper at the Royal Society some years ago, he had explained how trichromic cases of colour blindness saw colours. Up to that time no person had mentioned any such case. Physicists said that normal vision was trichromic, but it is not. With regard to the point raised by Dr. Newington, he suggested whether there was not a tendency to get back to the natural scale. It had been pointed out to him that a certain violinist was playing out of tune, and on calculating the points on the string it was found he was passing on to the natural scale, while the rest of the musicians were playing on the arbitrary scale, and that he was really playing in tune. He thought that if the musician were better than his fellows, he was extremely likely to be put down as defective. As an illustration, he mentioned a case which had been brought to him as colour blind, and on examination he found that the man could see seven colours in the spectrum. In another case, that of an artist's pupil who was said to be more or less colour blind, on examining the patient he found that he possessed extraordinary colour perception, so much so that he could recognise what an Associate of the Royal Academy could not, namely, the faintest wash on a white surface. With regard to Dr. Jones's remarks, the sense of colour could be destroyed so as to leave the perception of light and shade perfect; everything was seen in degrees of light and shade just like a photograph.

Dr. HAYES NEWINGTON said he did not think the explanation was quite satisfactory, because practically there was no natural scale. The scale in which the violinist was playing was uniformly abnormal in whatever pitch the rest of the orchestra were playing.

Clinical Notes and Cases.

On Two Cases of Leptomeningitis. By J. O. WAKELIN BARRATT, M.D.Lond., F.R.C.S.Eng., Pathologist to the West Riding Asylum, Wakefield.

IN the following two cases of leptomeningitis the opportunity occurred of studying not only the histological, but also the bacteriological conditions present; and in this respect the cases are of more than usual interest, particularly the second one. Both were complicated by the co-existence of changes in the pia arachnoid prior to the advent of a terminal leptomeningitis. The clinical history throws but little light upon the semi-

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