

**Eyesight in schools : a paper read before the Association of Medical Officers of Schools, on April 15th, 1885 / by R. Brudenell Carter.**

**Contributors**

Carter, Robert Brudenell, 1828-1918.  
Ophthalmological Society of the United Kingdom. Library  
University College, London. Library Services

**Publication/Creation**

London : Harrison and Sons, 1885.

**Persistent URL**

<https://wellcomecollection.org/works/vbft6yfc>

**Provider**

University College London

**License and attribution**

This material has been provided by This material has been provided by UCL Library Services. The original may be consulted at UCL (University College London) where the originals may be consulted.

This work has been identified as being free of known restrictions under copyright law, including all related and neighbouring rights and is being made available under the Creative Commons, Public Domain Mark.

You can copy, modify, distribute and perform the work, even for commercial purposes, without asking permission.



Wellcome Collection  
183 Euston Road  
London NW1 2BE UK  
T +44 (0)20 7611 8722  
E [library@wellcomecollection.org](mailto:library@wellcomecollection.org)  
<https://wellcomecollection.org>

# EYESIGHT IN SCHOOLS.

A PAPER READ BEFORE THE ASSOCIATION OF MEDICAL  
OFFICERS OF SCHOOLS, ON APRIL 15TH, 1885.

BY

(6)

R. BRUDENELL CARTER, F.R.C.S.,

Ophthalmic Surgeon to St. George's Hospital.

---

*[Reprinted from the MEDICAL TIMES AND GAZETTE of  
April 25th and May 2nd, 1885.]*

---

LONDON:  
PRINTED BY HARRISON AND SONS,  
*Printers in Ordinary to Her Majesty,*  
ST. MARTIN'S LANE.

1885.

# STUDENT IN SCHOOL

THE UNIVERSITY OF CHICAGO  
CHICAGO, ILL.

JOHN M. JEFFERSON

CHICAGO, ILL.

THE UNIVERSITY OF CHICAGO  
CHICAGO, ILL.

JOHN M. JEFFERSON

CHICAGO, ILL.

1851976



# EYESIGHT IN SCHOOLS.

By R. BRUDENELL CARTER, F.R.C.S.,

Ophthalmic Surgeon to St. George's Hospital.

---

MR. PRESIDENT,—The question of "Eyesight in Schools," on which, by the favour of the Council, I am permitted to address you, is one of grave importance, not only to the scholars of the now rising generation, but also, it may be, to successive generations of their descendants. It would, I presume, be impossible to deny that the manner in which the eyes are used during youth and adolescence may exert a definite influence upon their development and their functional activity; or to deny that this influence, when exerted upon those who will afterwards become parents, may entail consequent modifications of structure upon offspring. If these propositions are conceded, we have to enquire further what is the extent of the influence; or, in other words, what is the amount of mischief which may be averted, or of good which may be secured, by judicious usage; what is the amount of injury, either temporary or permanent, which, during the period of bodily growth, may be inflicted by work performed under unfavourable conditions; and within what limits these conditions may be controlled.

I have determined to speak definitely of eyesight in schools, rather than of eyesight during education, because it is manifest that the regulations of school life must, in the main, be determined by the capabilities and requirements of the majority of scholars;



and cannot, excepting within narrow limits, be varied to meet the capabilities and requirements of a few. If, therefore, as I have reason to believe will be the case, it should be shown that certain classes of eyes are especially prone to suffer injury, it will be our business to discover what numerical proportion the eyes which constitute these classes bear to others, and by what methods and to what extent they may be protected. If we find that they are numerous, and that they may be protected easily, such conditions might call for some modification of school life in their behalf; while, if they are but few, and can only be protected with difficulty, the balance of advantage might be on the side of conducting the education of the affected individuals at their own homes, or in schools at which special attention could be paid to them. It will be necessary, in the pursuit of our enquiries, to proceed with the utmost caution, to verify all observations with the most scrupulous care, to take account of all compensating influences, to weigh all conclusions, and to put forth no statements which will not bear the test of rigid investigation. Our association has, I am convinced, a great future before it; a future in which it will control, in many important particulars, the conduct of scholastic training in this country; and we cannot be too careful, at this early period of our labours, in avoiding the utterance of any opinions which might even seem to have been formed in haste, or to be vitiated by inaccuracy. Nothing is farther from my own wish than to play the part of an alarmist. I have no pet hypotheses to maintain, no peculiar doctrines to expound, no panaceas to suggest, no other object than, as far as I am able, to ascertain and to declare the truth. I make these observations—observations which, in ordinary circumstances, it would be superfluous to address to a scientific assembly—because what I have already said upon a kindred topic has been made the subject of a certain amount of unintentional misrepresentation. I addressed a letter to the *Times* paper, and afterwards read a communication before the Society of Arts, on “The Influence of Civilisation upon Eyesight.” The latter communication was widely noticed, in the newspaper press, by gentlemen whose desire to write a startling paragraph was sometimes



sufficiently strong to supersede other considerations which might with advantage have prevailed. One widely circulated newspaper attributed to me the statement that "Londoners were rapidly losing their eyesight"; and, in doing so, deviated into at least three errors. I never mentioned Londoners; I said nothing about loss of sight, but only about possible deterioration of the eyes; and I said nothing about rapidity or slowness in relation to the matter. Even writers in our own profession, who have not clearly perceived the great difference between education—the preparation made in our youth for the sequel of our lives—and civilisation, the sum of the conditions by which we are surrounded from the cradle to the grave—have supposed that my observations upon the more extensive question were intended to apply equally to the more limited one. This, I need hardly say, is not quite the case; and it is to the more limited question that, on this occasion, I purpose strictly to confine myself.

The various states of the human eye are, no doubt, perfectly familiar to the audience which I have now the honour to address; but I must nevertheless venture to crave indulgence while I devote a few words to definitions and explanations which, although superfluous here, may not be equally superfluous to some of those into whose hands this paper may hereafter fall. We use, in relation to these states, the word "refraction," which expresses the optical power of the eye when passive; and the word "accommodation," which expresses a modification of the passive state by a voluntary or instinctive effort. The first essential of good vision is the formation of a clear image upon the retina; and the passive eye, or that which has its ciliary muscle in a state of rest, exerts upon the light which it receives a certain amount of influence, rendering the lateral rays of each pencil convergent towards the axial ray, in a manner which tends to the production of such an image. In the majority of adults, the length of the antero-posterior axis of the eyeball corresponds with the principal focal length of the refracting media, so that, when the eye receives parallel rays, such as proceed from infinitely distant objects, the image falls precisely upon the retina. Persons whose eyes are thus formed were said by



Donders to be "emmetropic;" that is, to possess eyes which are in correct measure or proportion. As long as the object of vision is distant twenty feet or more, the divergence of the rays which proceed from it is not appreciable, and the image is still formed correctly; but, as soon as the object comes within twenty feet, and in a constantly increasing degree as it approaches nearer, the divergence of the rays becomes too great for the refraction of the eye to overcome, so that, when they reach the retina, they have not yet been united. If the back of the eye were transparent, the light would pass through it, and the image would be formed in a posterior plane; but, the back of the eye being opaque, the light is intercepted, and forms on the retina either an image which is more or less blurred and incomplete, or an absolute dispersion circle, according to the degree in which the refraction falls short of the requirements of the case. An emmetrope with passive eyes would, therefore, have no clear vision of a near object, were it not for the exercise of accommodation, which is accomplished in the following manner:—The crystalline lens is, in youth, a highly elastic body, which, in the passive state of the eye, or rather of the ciliary muscle, is compressed from front to back through the intermediation of the zonule of Zinn, and is held in a flattened condition. When the ciliary muscle contracts, it brings forward the attachment of the zonule, relaxes the compression, and leaves the lens free to assume a shape of greater convexity, in which it exerts a greater degree of refracting power, and has its focus nearer than before. The performance of the function is guided, of course, by the resulting sensory impression, the ciliary muscle contracting more or less, according to the distance of the object, and always sufficiently to allow the precise amount of expansion of the lens which will afford a clear image. Hence the emmetrope, with a passive eye, has clear vision of all objects which are more than twenty feet away; and, by the exercise of accommodation, obtains clear vision of all objects which are nearer; with the single reservation that the power of accommodation is limited, and that there is a degree of approximation—a near point—within which the divergence of the rays becomes greater than the eye is able to overcome. It must be remembered, moreover, that the direction of the gaze



to a near point calls for the convergence of the axes of the two eyes upon that point, as a condition of binocular vision; and hence that accommodation and convergence, in the emmetropic, go hand in hand. It is impossible for them to converge without accommodation, or to accommodate without convergence; and the union between the two functions may be safely attributed to the close relationship which exists between the motor centres by which they are respectively controlled. This relationship is not disturbed by malformations of the organ of vision, which may, nevertheless, completely destroy the natural demand for co-operation between the two actions, and may thus become sources of much embarrassment and distress.

It follows from the foregoing description that the diagnosis of emmetropia will rest upon two characters. In the first place, the eye being passive, any lens, either concave or convex, however weak, will diminish the acuteness of distant vision; and, in direct ophthalmoscopic examination by the passive eye of an emmetropic observer, any lens, either concave or convex, however weak, will impair the definition of the smallest vessels of the retina in the neighbourhood of the yellow spot. We have therefore two signs of emmetropia, one depending upon statements made by the subject, when his vision is tested by lenses, the other depending upon the trained perceptions of an ophthalmoscopic observer.

It is manifest that the two magnitudes to which reference has been made, the focal length of the refracting media and the length of the antero-posterior axis of the eyeball, do not stand in any necessary relation to each other, and hence that coincidence between them is not likely always to occur. The persons in whom these magnitudes are of different value were said by Donders to be "ametropic," that is, to possess eyes which are not in true measure or proportion.

In an inequality between two magnitudes, it is manifest that either of them may be the larger. We have, therefore, two contrasted forms of ametropia: hypermetropia, in which the principal focal length of the media is greater than the length of the ocular axis; and hypometropia, more commonly known by the trivial designation of myopia or short-sight, in which the



focal length is less than the length of the axis. The hypermetrope, when the eye is at rest, can unite only convergent rays upon his retina ; the myope can unite only divergent rays.

There are no convergent rays in Nature ; and hence the hypermetropic person, when his eye is at rest, has no distinct vision. In order to see clearly, at whatever distance, he is compelled to diminish its focal length by accommodation ; and, the nearer the object looked at, the greater will be the accommodation effort which is required. Hypermetropia, when the accommodation is relaxed, is recognised by the fact that distant, as well as near vision, is improved by a convex lens, and in the greatest degree by one the strength of which measures the degree of the defect ; while the emmetropic observer, with relaxed accommodation, requires the same convex lens behind the ophthalmoscope, in order to see the smallest vessels of the retina with perfect sharpness of outline.

The myopic person, who can unite only divergent rays upon his retina, receives those rays only from objects which are within some definite distance, known as his far-point, beyond which, without optical assistance, he has no clear vision. Myopia is distinguished by the improvement of distant vision by a concave lens ; and its degree is measured by the nearness of the far-point, or by the strength of the concave lens which affords the greatest assistance, or through which, in the erect image, the vessels of the retina can be seen most clearly.

In all the foregoing conditions, there is a liability to error of diagnosis, both as regards the actual state of the refraction, and also as regards the degree, if any, of the ametropia, arising from the extent to which the conditions really existing may be concealed by the accommodation. The eye of an emmetropic person, which may be conveniently described as a normal eye, when accommodated for a point eight inches distant, is in the same optical condition as an eye which is passive, but which is short-sighted to the extent of having its far-point eight inches distant. As a rule, the normal eye, when turned from a near to a distant object, will undergo immediate and complete relaxation of its accommodation, and will display its true



characters. Assuming this not to occur, and the tension of the accommodation to be retained in spite of the change of direction, the normal eye would answer to all the tests for myopia. Its distant vision would be defective, and would be raised to the normal standard by a concave lens of five dioptries. A similar lens would be required for the direct ophthalmoscopic examination of its retina. It follows that, in order to render either test trustworthy, it is necessary first to ascertain that the accommodation of the examined eye is completely relaxed. In hypermetropia, since there is no clear vision, even of distant objects, without effort of accommodation, this effort can only be relaxed when the eyes are not looking at anything ; and the common result is that, during waking hours, it is never relaxed at all. In moderate degrees, the defect is commonly totally concealed by accommodation, which is habitually sufficiently exerted to keep the eye in a state of simulated emmetropia, so that even the weakest convex lens diminishes the acuteness of distant vision.

When such an eye is examined by the ophthalmoscope, its accommodation usually becomes relaxed, sometimes completely, sometimes only partially ; the eye, in the first case, showing the whole extent of its defect to the observer, in the second case showing only a part. In very high degrees, it is not uncommon for partial relaxation of accommodation to occur, so that a weak convex lens may be a help to distant vision. In a general way, therefore, it may be said that a portion of the total hypermetropia may be discovered by lenses and by the ophthalmoscope, usually more by the latter than by the former, and this portion is said to be "manifest." Another portion remains concealed, is said to be "latent," and is only brought to light when the accommodation is paralysed by atropia, which, for this purpose, must sometimes be applied for two or three days at regular intervals. The effort of accommodation, in such cases, has been rendered habitual by the necessities of vision, and has become permanent or spasmodic, so that its complete relaxation can only be effected with difficulty. In some instances, the effort does not cease when it has rendered the eye seemingly emmetropic, but proceeds still farther, and renders it seemingly myopic. Hypermetropic children constantly bring print close to their



eyes, in order to see under a larger visual angle, and thus to obtain larger retinal images, which, to some extent, compensate them for want of perfect definition. The accommodation effort which attends this approximation of the object becomes established, and then a simulated myopia is produced. A young gentleman was sent to me from Harrow, a few years ago, who was said to be "short-sighted," and who suffered great distress from his eyes. He brought his books very close to them, and used for distance concave glasses which had been prescribed for him. The use of atropia for three or four days revealed a total hypermetropia of nearly seven dioptries.

In myopia, as in hypermetropia, we often see the apparent degree of the defect increased by accommodation. The myopic subject has perhaps been accustomed to read in a bad light, and, in order to compensate for this, approximates the page even more than he is compelled to do. At any rate, it is quite common to find that, after an efficient application of atropia, the degree of short-sight, whether measured by lenses or by the ophthalmoscope, is materially less than it seemed to be before the application was made.

It will be manifest, from the foregoing considerations, that no rough and ready method of testing refraction can be regarded as trustworthy. The method first employed by Cohn, for example, when examined by the light of more recent experience, is seen to be essentially defective. There can be no doubt that this method led him to regard very many hypermetropic persons as emmetropic, and probably to include others among his cases of myopia.

The general terms, myopia and hypermetropia, are frequently used to include also the cases of astigmatism, which present themselves under five varieties: the simple and compound myopic, the simple and compound hypermetropic, and the mixed.

Astigmatism denotes the existence of a difference in the refraction of the eye in different meridians; the meridians of maximum and of minimum refraction being generally approximately vertical and horizontal, and always at right angles to each other. As a rule, to which there are exceptions, the maximum refraction is that of the vertical meridian, so that its focus is anterior to that of the horizontal. If the focus of one



meridian be on the retina, while that of the other is in front of or behind it, the astigmatism is said to be simple, the eye being emmetropic in one meridian and myopic or hypermetropic in the other. If both foci be anterior to, or posterior to, the retina, the astigmatism is compound, the eye being myopic or hypermetropic in both meridians, but more so in one than in the other. If one focus is anterior to the retina, while the other is behind it, the eye being myopic in one meridian and hypermetropic in the other, the astigmatism is said to be mixed.

Before proceeding to consider the meaning and effects of the several conditions which have been described, it is necessary to remember that their nomenclature is to some extent misleading. If not absolutely, at least comparatively, the focal length of the eye is an invariable quantity, and the axial length a very variable one. The word hypermetropia seems to imply an eyeball which is over measure, rather than a focal length which is too long for the eye : but the latter is the disproportion which actually exists. In hypermetropia the eyeball is flatter, in myopia it is more elongated than in the intermediate or emmetropic condition. With this preface, it may be said, in a general way, that emmetropia is the typical or normal state of the adult human eye, and that all departures from it must be regarded as examples of defective formation. The reasons for regarding emmetropia as a standard condition are, first, that it is that which exists in the vast numerical majority of healthy and well-formed adult persons ; and, secondly, that it is the result of such a harmony of proportion, between the optical power of the eye and its magnitude, as affords the maximum range of functional activity, in combination with the minimum of effort. It follows from these conditions that emmetropic persons possess the greatest acuteness of vision, and the greatest power of exerting the eyes for long periods without either suffering distress or sustaining injury. Hypermetropia, in a moderate degree, may be regarded as the natural state of the eyes during childhood ; but when present during childhood in a high degree, or when continuing into adult age, it must be regarded as an arrest of development. The eyes in which it is present in a marked degree are recognisable at a glance



as being mis-shapen ; and the very high degrees might often be described as cases of *microphthalmos*. Myopia appears to be a malformation, artificially created in the first instance, constantly aggravated by the conditions of life, and liable, like all other artificial malformations, to be handed down to offspring. It is possible that some children are born myopic ; and it appears certain that some are born with a strong predisposition to the defect. The anatomical basis of this predisposition is believed to be a weakness of the tunics at the posterior part of the eyeball, especially where the sclera is thinned by the space between the sheaths of the optic nerve, and in the region of the *protuberantia scleralis*, which has been described by von Ammon as existing at a certain period of foetal life. Astigmatism is myopia or hypermetropia, complicated by want of symmetry of the cornea.

If we pass on to consider the effects of the several forms of ametropia, we find that hypermetropia is frequently associated with discomfort in use, on account of the constant demand which it makes upon the muscles of accommodation. By compelling accommodation, it also, in many cases, compels convergence, and becomes the immediate cause of squint ; or, if it fails to do this, it produces muscular strain by the severance of the two functions. The directing and adjusting muscles of the eyes, instead of working smoothly and harmoniously, are kept in a state of perpetual struggle, the irksomeness of which will be greater or less, according to the degree of the defect, and according also to the state of the nervo-muscular system of the individual. When considerable in amount, the struggle has a manifest tendency to become an exciting cause of disease.

With regard to myopia, there is still a good deal of uncertainty upon many points. Twenty-one years ago, when the great work of Professor Donders appeared in an English dress, uncertainty was hardly recognised. Donders taught that myopia had a frequent tendency to become progressive in degree, because it required convergence to a near point as a condition of binocular seeing, and because the continued traction of the internal recti, by which the convergence was effected, produced tension of the posterior hemisphere of the eyeball, and consequent elongation of the antero-pos-



terior axis. There was a sort of vicious circle. The original myopia produced undue convergence, the convergence increased the myopia, the increased myopia necessitated a still greater approximation of the objects of vision, and consequently a greater convergence, and the greater convergence increased the myopia in a still increasing ratio. The stretching of the ocular tunics, which was implied in the increase of myopia, was constantly attended by morbid changes. The part which yielded first was the sclera, where it is thinned by the intervaginal space, usually on the outer side of the optic nerve, the space becoming thereby widened, and the connective tissue within it torn through. Donders gives a drawing which well displays this stretching; and a drawing from a similar specimen was exhibited by Dr. Brailley in his recent lectures at the College of Surgeons. By the stretching of the sclera the choroid is stretched in a similar manner, and, over the place affected becomes atrophied, showing the sclera through its wasted tissue, and thus forming the crescent, or "conus," which was at one time thought to be peculiar to myopia, although it is now known to exist in other conditions. In aggravated cases the sclera is not only stretched, but also projected backwards over the affected region, forming a posterior staphyloma; and not only the stretching, but also the choroidal atrophy, sometimes extends all round the disc, which is then bordered by an irregular white circle, around which another zone of choroid can often be seen in a state of commencing degeneration. Contemporaneously with these changes, the choroid is liable to be attacked by patches of inflammation which pass into patches of atrophy: and central vision is often destroyed by such inflammation invading the portion of choroid beneath the yellow spot. Even when this does not occur, the vitreous is apt to undergo fluid degeneration, and to be beset with floating particles; while intra-ocular hæmorrhage and retinal detachment are frequent terminations of the malady. Donders, after the examination of more than 2,500 cases of myopia, wrote "*ein kurzsichtiges Auge ein krankes Auge ist*," a sentence which his translator has softened into the words, "a short-sighted eye is not a sound eye."

As time passed on, and wider experience was gained,



it became evident that this dismal course of events, although happening often, does not happen universally. It would occupy me too long if I were to attempt a sketch of the clinical history of myopia ; but what seems to be true with regard to it is that a few cases occur, even among unlettered peasants, as a result of some personal tendency ; and that these cases are often progressive in character, are of the most serious kind, and come to the most disastrous ending. They seem to owe little, if anything, to the influence of external circumstances. In other cases, which form at least a considerable minority, the short-sighted eyes are not manifestly unhealthy ; and, if they are not very unfairly treated, the defect increases slowly during the earlier part of life, and becomes stationary after maturity is reached, usually at about the age of thirty. In others, again, the tendency is towards progress and morbid changes ; and this tendency can only be obviated by strict precautions and by careful management. It will sometimes be difficult or impossible, without observation extending over a year or more, to decide to which of the two last divisions any given case should be assigned.

A letter appeared in *Nature*, for the 26th of February, in which a Mr. G. A. Berry, who is, I believe, an ophthalmic surgeon in Edinburgh, asserts that "there is an undoubted tendency to increase in the degree of short sight with age alone up to the period of cessation of growth. This has been shown to be due to the elongation of the antero-posterior axis of the eye, and is in the vast majority of cases no more a disease than is the attainment of a greater than average height by a certain number of individuals." It is fair to Mr. Berry to add that he admits that a "small proportion" of cases of short sight are due to disease, and that in these pathological changes can "often" be detected with the ophthalmoscope. It is curious to contrast his experience with that of Professor Donders ; but, leaving this part of the subject, I will return for a moment to his "growth" hypothesis, which sounds plausible, but which is, I believe, entirely erroneous.

It is necessary to remember, in considering this hypothesis, that the absolute amount of growth which occurs in the eyeball is very limited, and that the full



magnitude is certainly attained early in life, say by about the fourteenth year. It is also necessary to remember that an increasing degree of myopia would imply an increase, not in all the dimensions of the eyeball, but in the amount of a previously existing disproportion between its different axes. If, in childhood, the antero-posterior axis were to exceed, by one mm., its proper length in proportion to the other axes, we might expect that, in process of growth, this excess of length would be maintained, but we should hardly expect it to be increased. If we saw a child whose index finger was as long as his medius, we should expect him to grow up with the fingers equal, but not that the index would become the longer of the two. Dr. Brailey has lately stated the normal length of the antero-posterior ocular axis in the adult to be 24.5 mm., that of the lateral axis to be 24.0 mm., that of the vertical axis to be 23.5. Among fifteen previous writers, I find that ten of the more recent state the length of the antero-posterior axis at between 24 and 24.7 mm. Petit alone, in 1726, places it at 27 mm., two others at 22.5, two others at 23.5. The average of the sixteen is 24.3 nearly; and this is the length in Listing's diagrammatic eye, which has a transverse axis of 23.6. Dr. Brailey also says that the length of the antero-posterior axis at birth is as much as 21 mm., thus allowing only 3.5 mm. for the whole amount of subsequent growth. Jaeger, the only other writer whose measurements of very young eyes I have met with, gives 17.53 mm. for the antero-posterior axis at birth; and Home found 21.14 mm. at six years of age. Jaeger's birth magnitude seems to me to be more in accord with probability than Brailey's; but we may certainly accept 21.14 mm. as a measure in early childhood, and it leaves only 3.36 mm. as a margin for growth after that period. The myopia found by Cohn in schools ranged from one to six dioptries in degree. A myopia of one dioptry, such as Cohn found in numbers of young children, implies an antero-posterior axis which is 0.306 too long for the refraction, or 21.45 mm., instead of 21.14. A myopia of six dioptries, such as he found in older students, implies an antero-posterior axis which is 2.045 mm. too long for the refraction, or 26.35 mm. instead of 24.3. We are therefore asked to believe that in short-sighted eyes an increase in the



consideration, such as the state of nutrition of the children, their inherited tendencies, the ventilation and general state of the schoolrooms, and so forth. Admitting that the progressive character of the myopia was directly due to the traction of the internal recti muscles in over convergence, it might still be expected that the ocular tunics of children who were themselves feeble, and who were placed under unwholesome conditions of living, would yield more readily than those of children who were originally stronger, and who were placed among more advantageous surroundings.

In England we have, unfortunately, but little evidence of the customary state of the eyes among children of school age. Mr. Priestley Smith found about five per cent. of myopia in 2,158 board school children, whose ages were from 7 to 13 years, the great majority being between 8 and 11. Among 357 students in training colleges, persons taken from the same class, or nearly so, as the children, and of ages ranging from 18 to 23, he found myopia in 72, or 20 per cent. Mr. Adams Frost examined a board school in London, and found therein, among 267 scholars, 73, or 27.3 per cent., with sub-normal vision. Among the 73, 26 were myopic, and 16 were hypermetropic; while in 31 the defect of vision was not due to error of refraction. Among the 194 children with normal vision, 40 were hypermetropic, making 56 cases of this condition in all, or 21 per cent. of the whole school. From the circumstances in which the examination was conducted, it is possible that the results were only approximations to the truth. With an exception to which I will presently refer, these are the only figures derived from an English source; and all I can do is to lay before you some of the results of examinations made in other countries. Of these there is no lack, but it is difficult to assign to each of them its proper value, or to say to what extent the differences between them may be ascribed to different degrees of carefulness in the conduct of the observations. I shall therefore, in the sequel, rely chiefly upon the statistics furnished by the Philadelphia Committee, of which Dr. Risley was Chairman. I do so partly on account of the published description of the methods pursued by the Committee, and partly because I have the pleasure of being well acquainted with Dr. Risley, and also



with Dr. Randall, one of his colleagues, and am able to speak from personal knowledge of the scrupulous accuracy with which their ordinary clinical work is conducted.

With regard to the method of procedure, I will quote from the report itself : " Each child, on entering, received a printed form with blanks for recording all the important features of the case. To one member of the Examining Committee was assigned the duty of noting, in proper order, the name, age, sex, residence, colour of eyes, hair and complexion, the condition of general health, and the condition of the eyes. Under the latter headings were recorded whether the eyes were comfortable or weak when used, the presence of blepharitis, conjunctivitis, corneal maculæ, or strabismus, and any other conditions or facts bearing upon the special or general medical history of the case."

"The pupil then carried the paper to a second examiner, who ascertained by the test-types of Snellen, and recorded, the sharpness of vision of each eye separately. A third tested, by means of Green's astigmatic cards at 20 feet, as to the presence of astigmatism ; and, if lines were positively selected as seen better in one position than in any other, the fact and the position selected were noted for each eye, any uncertainty being indicated by an interrogation point. A fourth then determined the near point and range of accommodation of each eye separately with No. 1 of Jæger's test-types, and examined as to insufficiency of the internal recti muscles at 12 inches. To determine this, a 9° prism was employed to give vertical diplopia, and then, if with Græfe's dot and line, or a modification of it by the substitution of a word of Jæger No. 1 for the dot, there were distinct crossing of the images, insufficiency was noted as present. The central color perception was then tested at 20 feet by squares on the same scale as the type of Snellen, and the result recorded in the same manner as the sharpness of vision. The color sense was further tested in matching colored worsteds after the method of Holmgren, and any error arising from ignorance of the names of the colors in the preceding test was completely excluded."

"With the paper upon which all these data had



been recorded, the pupil then entered the dark room for the ophthalmoscopic examination, which was made by the Chairman of the Committee (Dr. Risley), aided by the facts previously ascertained. The refraction was determined with the ophthalmoscope with all possible care, and any error and its apparent extent recorded. Then the fundus oculi was studied in detail, and any departure, physiological or pathological, from the normal was accurately described, and, where permitting of representation, sketched upon paper. So carefully was this done that, in the subsequent study of the work, a glance at the sketches was often quite sufficient to bring up vividly to mind the entire ophthalmoscopic picture and other details of the case, which the name, &c., did not in the least recall."

"As it was upon this ophthalmoscopic determination of the condition of refraction that most of the subsequent work hinged, it will be proper to state that all sources of error were excluded with the most painstaking care. The sharpness of vision and the range of accommodation previously recorded were carefully borne in mind, and used as checks to guard against mistake; and, if there appeared to be the slightest inconsistency between them, care was redoubled to find the sources of variation. If the vision were normal, myopia was at once excluded, and every means was employed to remove any spasm of accommodation which might simulate it; and the examination was prolonged until the apparent error had disappeared, often to give place to a distinct hypermetropia. In the examination, emmetropia and health were always presupposed, and the contrary was recorded only when unmistakeably present."

"Many of the cases of uncomfortable and unhealthy emmetropic eyes were cases of muscular derangement, which doubtless will account in part for the high percentage of disease in emmetropic eyes. The weakness of the internal recti muscles is an important factor in the causation of weak eyes, and moreover, in many instances, would account for any apparently anomalous relation between the distant vision, range of accommodation, and ophthalmoscopic examination, *e.g.*, with diminished distant vision and range of accommodation, the ophthalmoscope showing only a low degree of hypermetropia, the recorded high



insufficiency of the recti interni at once made plain the reason for the apparent discrepancy. The ophthalmoscopic record, by coming last, not only served to check the results of the subjective examination, but in the light of the preceding record the observer was less liable to be led into error by the active accommodation of the patient."

"The whole number of eyes examined by the Committee was 2,422, to which must be added 174 examined in the same manner and recorded on the same blanks by Dr. Jackson, of West Chester, making in all 2,596. The average time required and actually spent upon each case was twenty-eight minutes, and the record thus obtained was as complete and free from all sources of error as was possible from a single examination, unless a mydriatic were employed; so that, upon it," writes Dr. Risley, "I should not have hesitated to venture an opinion or to prescribe treatment, had that been the object of the diagnosis."

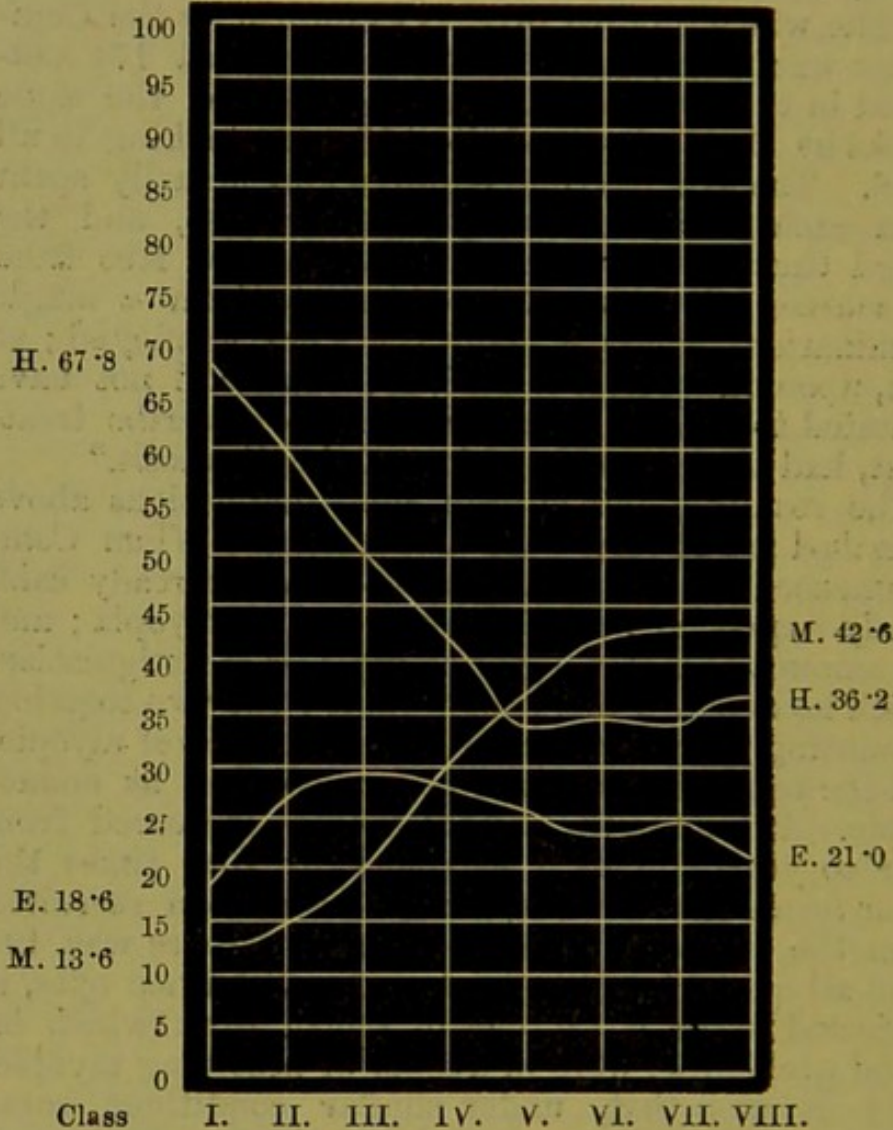
The results obtained from the examinations above described are of very high importance. When Cohn commenced his work, he was, as I have already said, chiefly impressed with the prevalence of myopia; and the amount of either hypermetropia or of astigmatism which he detected was insignificant; the two together amounting to less than a fourth of the cases of myopia, and the remaining children being described as emmetropic. It follows that, as the myopia increased from year to year, and as it exceeded by four times the other forms of ametropia, it must have been recruited from the emmetropia, and Cohn's inference was, beyond all question, that sound and well-formed eyes, if subjected to the conditions of school work which he found prevailing, were in danger of becoming myopic. Why it was that, under similar conditions, some suffered while others escaped, he did not make any attempt to explain. When his researches were repeated in other places, and by other observers, this noticeable difference in results became apparent, that hypermetropia was more commonly discovered; and the more carefully the examinations were conducted, the more frequent the hypermetropia became. Thus Erismann, at St. Petersburg, dividing his children into eight classes, of which the youngest stands first, found, in this first class, 13.6 per cent. of myopia, 18.6



per cent. of emmetropia, and 67·8 per cent. of hypermetropia. I have placed his results in a graphic form in Table I., in which the vertical lines show the classes,

Table I.

ST. PETERSBURGH. ERISMANN.



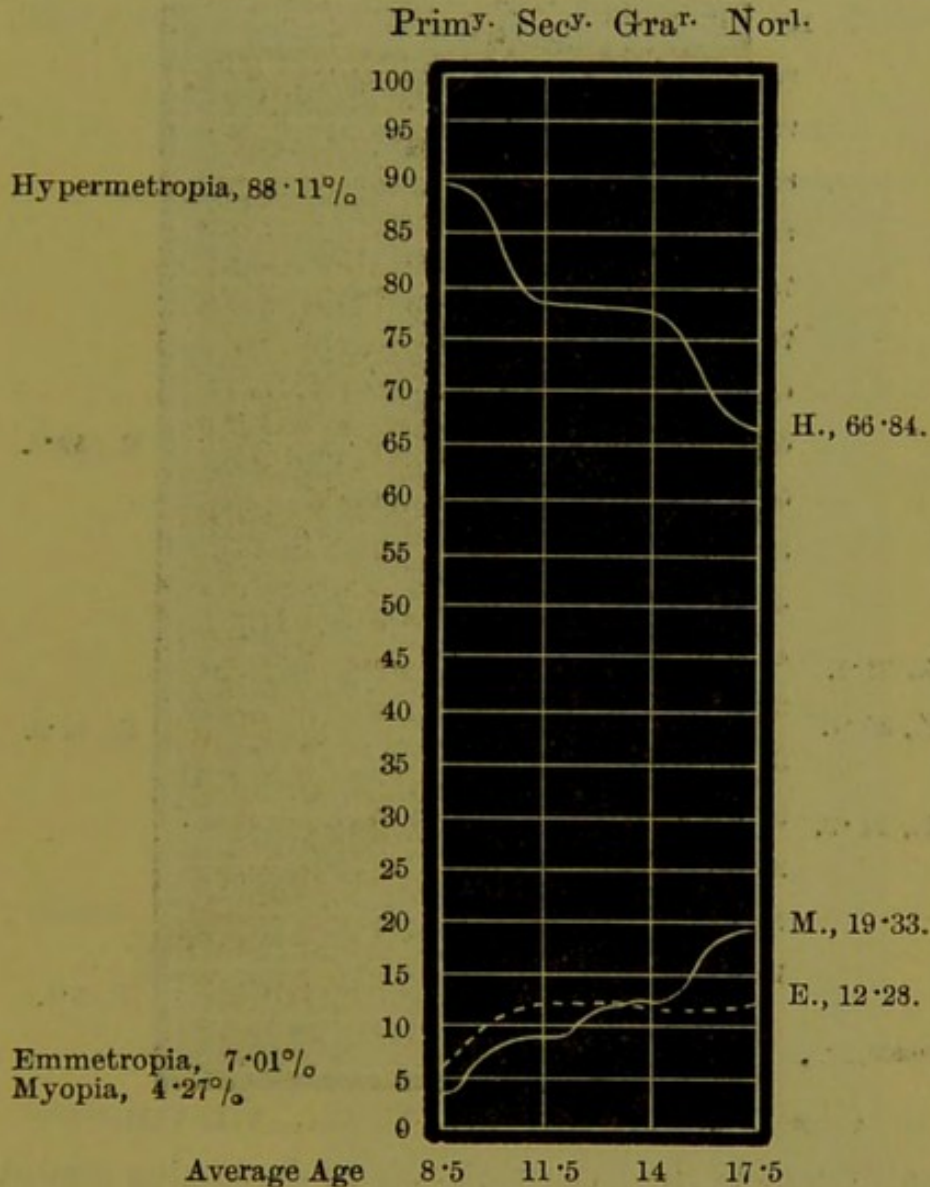
and the horizontal lines the percentages. According to him, the myopia, which increased from 13·6 per cent. in the first class to 42·6 per cent. in the eighth, was almost entirely recruited from the hypermetropia, which at the same time diminished from 67·6 to 36·2 per cent. The emmetropia rose a little in the intermediate classes, possibly from certain eyes which passed through this stage on their way to become myopic; but, on the whole, it remained almost



stationary. In Table II., copied from the Philadelphia report, the vertical lines refer to the primary, secondary,

Table II.

PHILADELPHIA. RISLEY.



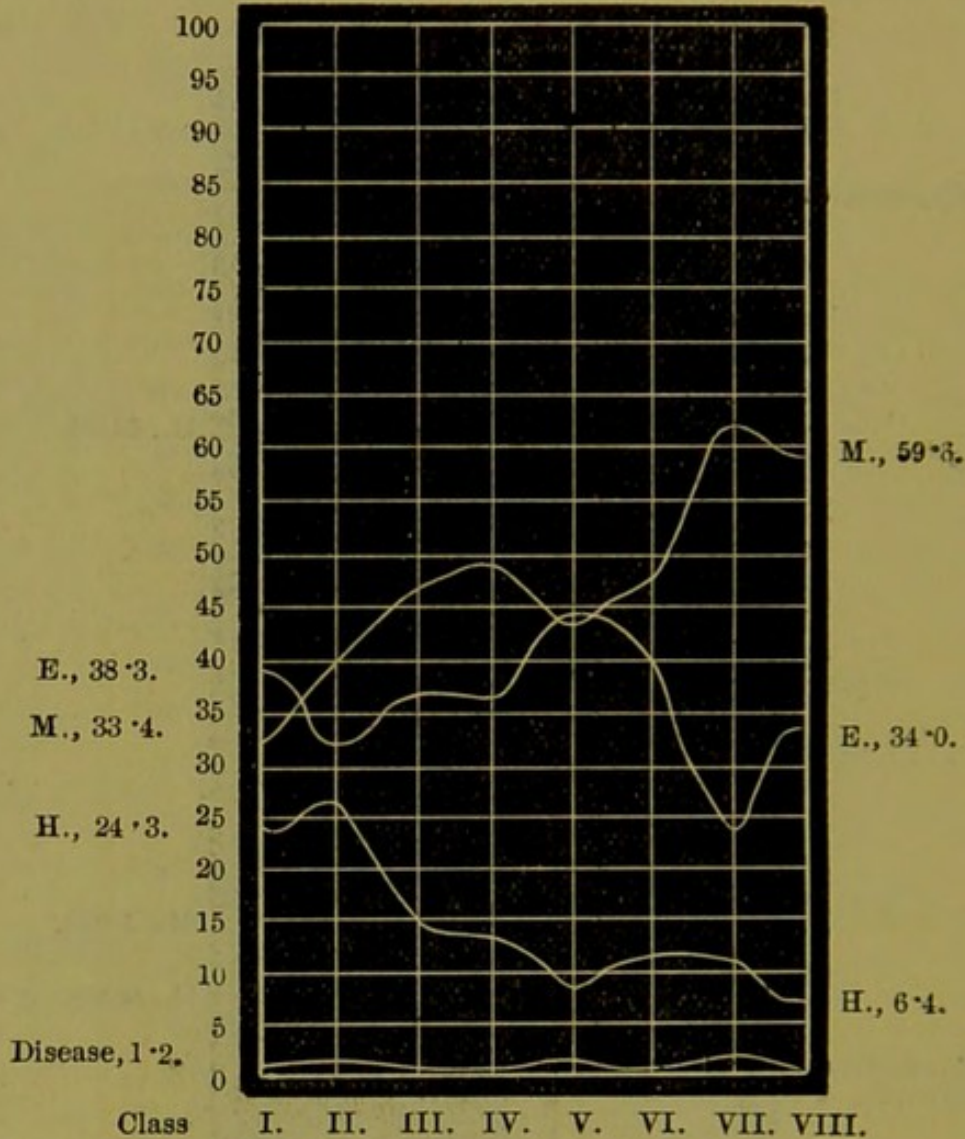
grammar, and normal schools ; the average age of the pupils in each being stated at the foot. This table shows nearly the same state of things as at St. Petersburg, the hypermetropia greatly in excess of the emmetropia, and diminishing as the myopia increases, while the emmetropia remains nearly at the same point ; thus showing that emmetropia is the stable condition, and that hypermetropia is a state which threatens to



pass into myopia. Von Reuss, at Vienna (see Table III.), found more emmetropia than hypermetropia, but

Table III.

VIENNA. V. REUSS.



he also depicts the hypermetropia as decreasing almost in the same ratio as the increase of myopia ; while the emmetropia, after rising in the way already indicated, terminates almost precisely at its original level. The only recent observers, as far as I know, who have found a decided preponderance of emmetropia over hypermetropia, have been Loring and Derby, in New York, and Conrad, in Königsberg, and I am not sufficiently acquainted with the methods which they pursued to be able to form an opinion as to whether

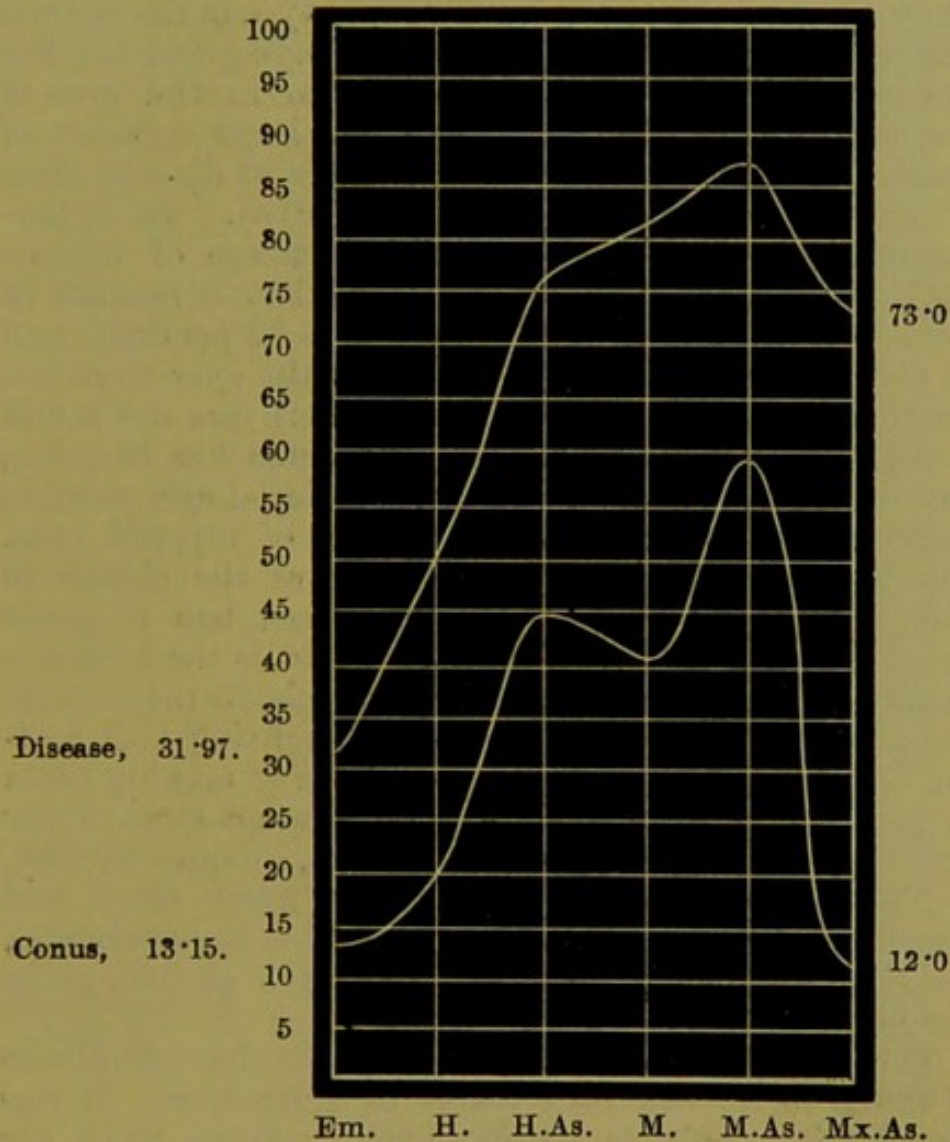


these methods were defective, or whether the children whom they examined were exceptional.

By nearly all observers, however, the general terms, myopia and hypermetropia, have been made to include the cases of astigmatism, and it is only when we come to separate these, that we become acquainted with their full significance. Table IV., copied from the

Table IV.

DISEASE IN RELATION TO REFRACTION.



Philadelphia report, shows the state of the eyes in the primary school in relation to disease, and the eyes are classified by refraction. The report states that in this category are included only distinct departures from health. They varied from retinal irritation, with congestion of the nerve, striation of the retina, and



undue redness of the entire eyeground, to marked neuro-retinitis, choroiditis, or posterior staphyloma. The percentage of these conditions in emmetropic eyes is seen to have been 31·97, a frequency which is partly explained by the fact that the eyes in the lower school were subjected to the incidence of a direct front light and to unfavourable hygienic surroundings, and partly because the other eye of the same pupil was often of a different refraction, and could fairly be regarded as the cause of a diseased condition which affected both. Only 20 per cent. of the emmetropic eyes in the normal school presented these pathological eye-grounds; but even here the difference of refraction in the eyes of the same individual was present in a large number of cases, thus causing a higher percentage of disease than if this difference had been eliminated. In hypermetropia, the primary school percentage of disease passes 50, in hypermetropic astigmatism it reaches 76 per cent. Myopia presented disease in 82 per cent., and in myopic astigmatism 87 per cent. of the eyes were unhealthy. In the secondary classes, there was not found a single myopic eye in which the fundus was healthy; and even in the normal school the diseased eye-grounds were present in nearly 82 per cent. of myopic eyes. The report explains that, while some of the classes in the primary and secondary schools had bad hygienic surroundings, and in the grammar schools the arrangements were not the best, in the normal schools the greatest possible care had been given to the lighting and seating of the class-rooms, with the result of making them as nearly perfect as possible in the present state of our knowledge of the requirements. Yet, in spite of this, and of the fact that the pupils were much older, and therefore less susceptible to unfavourable circumstances, the showing for myopic eyes was almost as bad as in the lower schools.

The lower curve of this table shows the prevalence of conus in the different states of refraction. It was found, often only in its incipient form, in 13·15 per cent. of the emmetropic eyes. In hypermetropia, it was found in 20 per cent., and, where hypermetropia was combined with astigmatism, it rose to 45 per cent. Myopia, with which many have claimed that conus is almost synonymous, presented it but in 41 per cent., distinctly less often than hypermetropic astigmatism;

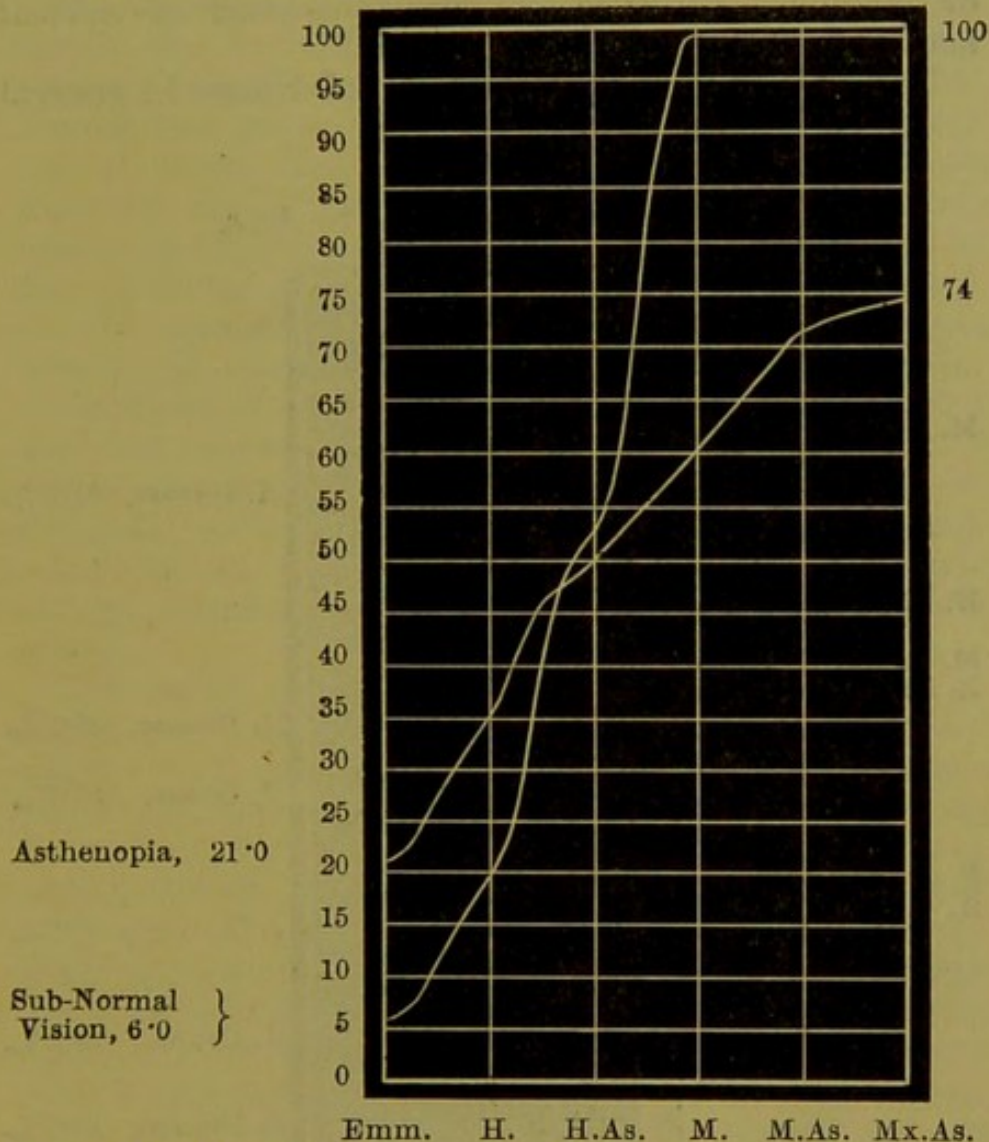


and only when myopia was itself complicated by astigmatism did the percentage of conus rise higher, then, however, to reach 60 per cent. The fall of both curves in mixed astigmatism hardly affords any basis for conclusions, the cases of this defect having been but few in number.

In Table V. another significant point is brought

Table V.

VISION AND PAIN IN RELATION TO REFRACTION.



forward. One of the important facts recorded in the examination was whether the eyes of each pupil were comfortable when at work, or asthenopic. In the latter category were included all the eyes which were painful after work, and also those which, though stated to be comfortable, gave distinct external

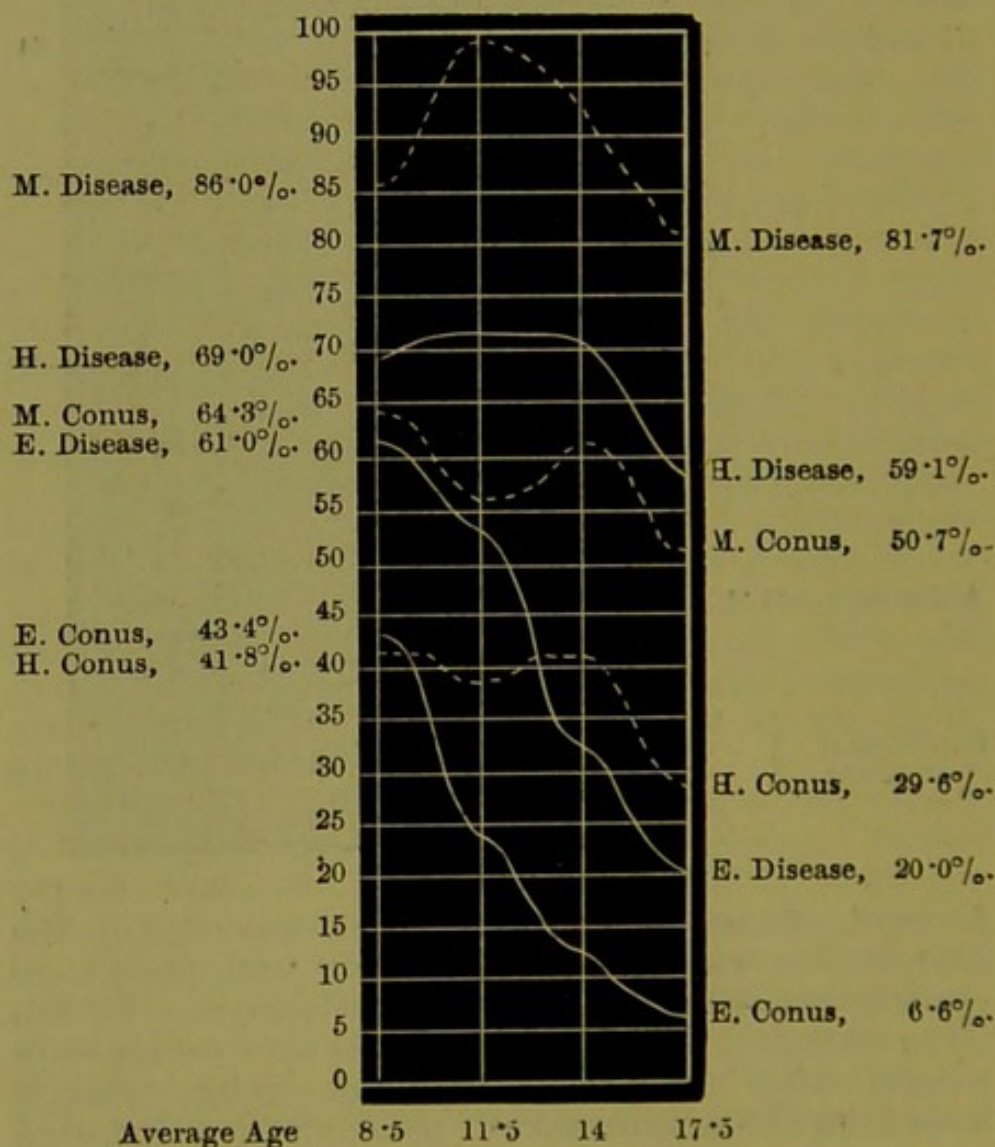


evidence to the contrary, as by frequent styes, blepharitis, conjunctivitis, and such affections. The relation of this matter of discomfort to errors of refraction needs no comment; the steady and rapid rise of the curve to 72 per cent. in myopic astigmatism affording sufficient evidence of the dependence. Defective vision, as indicated by the lower curve, increases with a sweep which would be startling, were it not that that familiarity has robbed the fact of much of its weight. It will be seen that no myopic or myopic astigmatic eye was possessed of normal acuteness of vision.

Table VI. shows the percentages of disease in general

Table VI.

DISEASE IN RELATION TO AGE.





and of conus specially, in relation to age and class, and the results brought out occasioned some surprise to the committee. In the primary school the emmetropic eyes (a small number, however, in all) presented conus in 43·4 per cent., and diseased conditions in 60·8 per cent. The hypermetropic eyes had conus in 41·8 per cent., and disease in 69·5 per cent., while in 64·3 per cent. of the myopic eyes conus was present, and disease in 85·7 per cent. In the secondary schools conus had fallen to 23 per cent., and disease to 53 per cent., among the emmetropic eyes; in the hypermetropic the variation was slight, while among the myopic, though conus had declined to 56·6 per cent., disease had gone up to 100 per cent., there was not one of them healthy. In the two upper schools diseased conditions steadily declined, except conus among the hypermetropes and myopes, which rose in the grammar school to fall still lower in the normal. In the normal school, where the educational process was at or near its completion, the showing was far more favourable. Of the hypermetropic eyes, 59·1 per cent. were diseased, with conus in 29·6 per cent.; while among the myopic eyes 81·7 per cent. were diseased, with conus in 53·7 per cent.; a showing which is an improvement, indeed, upon the preceding classes, but none the less sad for a model school.

The point on which the committee comment, in relation to these figures, is that, although disease and conus were most frequent among eyes of myopic refraction, and myopic refraction increased in passing from the lower to the higher schools, yet the tendency of the disease curves is downwards, as age and class advance. The explanation given is almost entirely dependent upon purely local conditions, partly upon the removal of children with defective sight, and partly upon unfavourable circumstances affecting the primary school, and tending to the production of disease and discomfort among its scholars. The conditions are of such limited application, that it would not fall within the scope of the present paper to dwell upon or even to describe them. It is admissible, however, to point out that they illustrate the great importance of attending to ocular hygiene at the very outset of the educational process, and support the belief that



mischievous which is then suffered to commence may never afterwards be completely remedied.

I have already stated that it would be necessary for me to refer to another set of figures derived from an English source ; and these are contained in a paper on "Education and Eyesight," by Mr. Charles Roberts, which appeared in the *Medical Times and Gazette* for the 7th of February, and has since been reprinted. Mr. Roberts speaks of statistics which have been industriously collected to show the injurious effect of school work on the eyesight, and proposes to refute the conclusions of ophthalmologists on the subject. The statistics, as far as I am acquainted with them, refer only incidentally to "eyesight," in the sense of acuteness of vision ; and the object of collecting them has been to show the effect of school work upon the refraction, chiefly with reference to the production and increase of myopia. Mr. Roberts' statements about eyesight, therefore, do not touch the particular question which has been raised. He wishes to show, by the results of examinations of several hundred boys at Marlborough College, that if there has been some degeneracy of the sight on the one hand (that is, I suppose, among certain individuals), there has been a corresponding improvement on the other (that is, among certain other individuals) ; and he accepts the good and the evil as balancing each other. His figures are founded upon examinations not made by himself, but by the Rev. T. A. Preston, one of the masters. Mr. Roberts is convinced that "it requires no special skill or knowledge to collect statistics of eyesight," all that is necessary being "a sheet of Snellen's test-types, a tape measure, and a conscientious record." The simplicity of the method thus suggested presents an instructive contrast to the more elaborate proceedings of the Philadelphia Committee ; and Mr. Roberts would manifestly not agree with John Hunter, in the opinion that "no experimental results can be depended on which have not been obtained by duly qualified observers."

Mr. Roberts presents his readers with two diagrams, the first of which, he tells us, is based upon the distances at which different boys could read Snellen's test-type No. 1. As I understand, it refers to the farthest distance only ; and this ranges from 36 inches

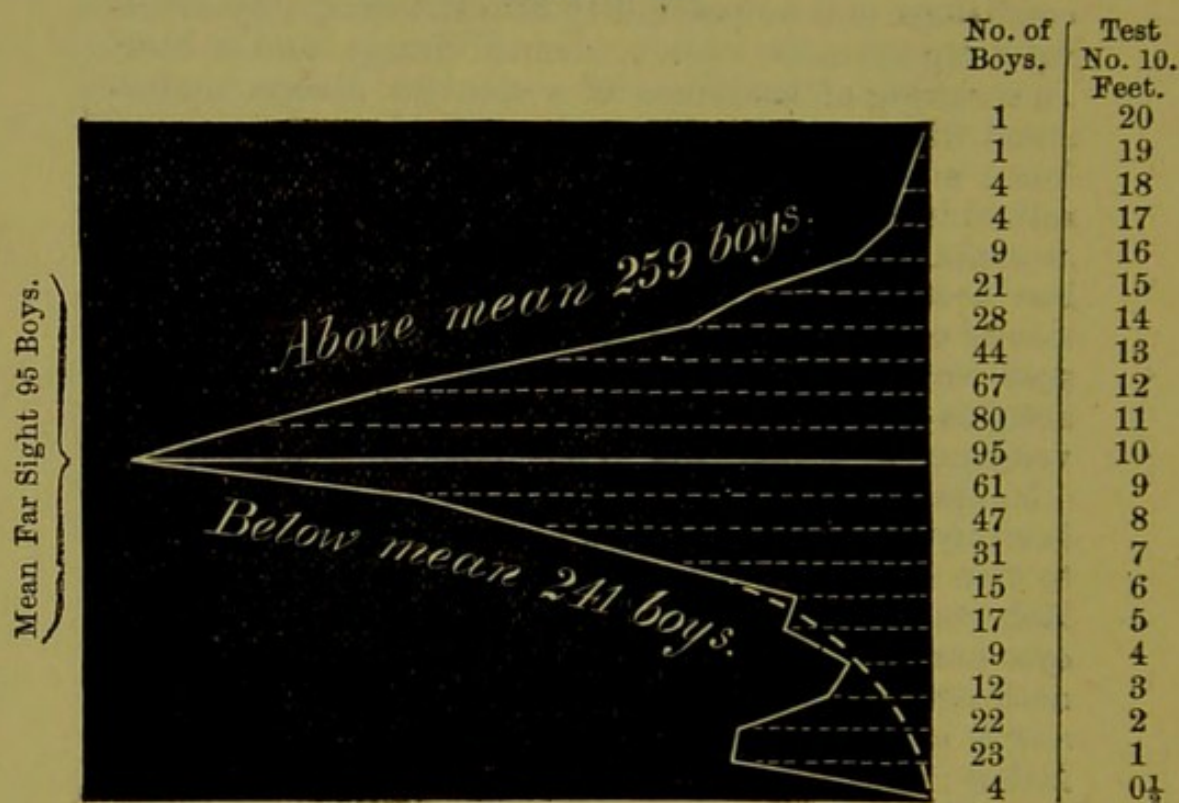


to 4 inches. Except in so far as they point to the probable existence of a good deal of myopia, the figures are absolutely worthless. They give no clue to the refraction or accommodation ; and hence they tell us nothing even about the matter to which they professedly relate, namely, the acuteness of vision. Acuteness of vision is a retinal function, depending upon the magnitude, distribution, and activity of the rods and cones ; and it is exercised upon a retinal image. From a given object, at a given distance, the emmetropic person receives a clear and well-defined image, while the ametropic person may receive only a dispersion circle or blur. In these circumstances the ametropes will, in one sense, have a less acute vision than the emmetrope ; but there is no real parallelism between the conditions, and no possibility of instituting any fruitful comparison between a defined image and a blur. In speaking of acuteness of vision we always understand that ametropia is first corrected by any necessary lens ; and then, when the ametropes obtain a clear retinal image, we may sometimes find that his vision is as acute as that of the emmetrope. Frequently it is less acute, in myopia, on account of the wider separation of the retinal elements by the expansion of the posterior hemisphere of the eye ; in hypermetropia, on account of original inferiority of structure or development. The two boys who read the small type at 4 inches might, among several other possibilities, have been myopic to ten dioptries, with normal vision, or myopic to five dioptries, with only semi-normal vision. Mr. Roberts tells us that the type used was such as normal eyes are supposed to read at one foot, but Snellen has nothing which answers this description. His smallest size is intended to be read at half a metre, or twenty inches ; and even this is not constructed on a definite geometrical scale, but is merely common printer's type, so that its legibility will vary greatly with the precise state of the fount, whether this be new or worn, with the precise pattern or cutting of the upper portions of the characters, and with the surface of the paper on which they are printed. Connected sentences in small type, moreover, although useful for clinical purposes, are of no value for testing vision. The power to read them depends more upon sight knowledge of the shape and general appearance of each



word as a whole, than upon vision of the actual letters of which it is composed ; and therefore always increases, as Mr. Roberts found, at an age when intelligence as well as vision is brought to bear upon it. In my own test-types I have successive lines of brilliant in English, French, and German, and the majority of English people read the first line far more readily than the second or third. Nay, more, the English line terminates with the unexpected word "sloop," and patients who read the preceding words with facility constantly stumble over this, and call it "sleep," or "step," or "shop." I pass on, therefore, to Mr. Roberts' second branch of enquiry, the results of which are displayed in a diagram which I have copied (Table VII.),

Table VII.



and which shows the distances at which 595 boys read the test-types No 10 of Snellen, which, as Mr. Roberts says, should be legible at ten feet. Two hundred and fifty-nine read them at more than ten feet, 95 at ten feet, 241 only at some smaller distance. There would be a source of error in the fact that a distance of ten feet is not sufficient to exclude disturbance from effort of the accommodation ; and it is plain, from the way in which Mr. Roberts speaks of supra-normal vision, that



he is not aware that the very moderate standard which, for strictly clinical purposes, is accepted as normal, is constantly exceeded, as much as two and a half times, by young and healthy emmetropes. But the circumstance which entirely vitiates the results is the absence of any enquiry into the state of the refraction. The only object of testing the acuteness of the unaided vision, in each one of a number of boys, is that doing so affords a ready means of roughly separating for further examination the cases of myopia and of considerable hypermetropia from the rest; and the grounds of the variations of acuteness must be investigated before these variations can be employed as materials on which conclusions can be based. It can only be a matter of conjecture, but I should think it probable that the boys who furnished the figures of the upper part of this diagram, including its middle line, were examples of emmetropia or of moderate hypermetropia; and that those who furnished the figures below the middle line were made up of a great preponderance of cases of myopia, with some of the higher degrees of hypermetropia, and some of spasm of accommodation or of insufficiency of the interni. Mr. Roberts says that in the diagram there are two curves, a large one representing the variations of far sight, including myopia, and a small one representing the cases of hypermetropia. I cannot feel sure, but I presume that by the large curve he means the lower sweep from the apex to the line running to six feet, and by the small curve the varied line below this point. If this be so, I should again conjecture that the small curve represents very little but high myopia, possibly with one or two cases of hypermetropia complicated by excessive spasm. There are 70 boys who cannot read No. 10 at any greater distance than four feet; and to class them as probable hypermetropes would not be in accord with my experience of the ordinary effects of hypermetropia on vision. But the strangest part of Mr. Roberts' contention, to my mind, is that the 241 boys who do not attain to the clinical standard of vision are to be in some way solaced by the discovery that there are 95 who do attain to it, and 259 who surpass it. I cannot repeat too strongly my belief that there must be, in most schools, a certain number of boys whose eyes are of faulty refraction and vulnerable,



and that the whole question before us is to ascertain how many of these vulnerable eyes there are, and by what means they can be protected. That there are also boys whose eyes are not vulnerable is a fact, gratifying and important in itself, but which has no relation to this question, nor will have until we discover a method of distributing the strength of the stronger eyes in such a manner as to compensate for the weakness of the rest. All that Mr. Roberts' figures have really done is to show that sub-normal vision exists at Marlborough in 241 boys out of 595, or 40·5 per cent. The sub-normal vision must either mean disease, myopia, a high degree of hypermetropia, astigmatism, or want of proper muscular co-ordination. No less than 70 boys fall short of the clinical standard by more than one half ; and in most of these myopia must be assumed to exist in a considerable degree. If, therefore, the figures are even approximately correct, they disclose a serious amount of myopia among boys in the rank of life of those from whom the pupils of Marlborough College are derived ; and they call loudly for enquiry with regard to the conditions under which these myopic boys are at present working, and also with regard to the extent to which their myopia is progressive.

In a postscript to his paper, Mr. Roberts pays me the compliment of a personal reference, and adds that every time I and my brother specialists order a pair of spectacles we interfere with the survival of the fittest by placing an imperfectly sighted patient on a level with the normal sighted, "and it is in this direction more than in any other—that is, by the transmission of hereditary or imperfect organs—that civilisation has done the greatest harm to our eyesight." The sentence is less luminous than might be desired, and I cannot feel certain whether Mr. Roberts intends it to contain a serious argument, or only as an endeavour to enliven a dull subject by pleasantry ; but I may perhaps be pardoned for taking the former view, and for pointing out that spectacles, by their power of checking the progress of myopia in the individual, and by thus keeping it limited in degree, are likely to diminish the amount of the defect which will be transmitted to offspring.

Upon the whole, I think the facts at our disposal must be held to justify the conclusion that, in other



countries, and probably also among ourselves, the considerable functional use of the eyes involved in education is liable to render pre-existing myopia actively progressive; and also to convert into progressive myopia the cases in which the act of seeing is rendered difficult, either by weakness of accommodation, by astigmatism, by hypermetropia, by inequality between the eyes, by insufficiency of the internal recti, or by any other departure from perfect co-ordination of the internal and external ocular muscles. The Philadelphia enquiry leads to the belief that the effect of these conditions may be greatly increased by the operation of unfavourable circumstances during the earlier stages of the educational process; and hence I think that, especially with children in the junior classes, and in preparatory schools, the medical machinery should be so arranged as to afford facilities for promptly bringing all instances of ocular discomfort under the notice of the medical officers. I frequently see cases in which the eyes have broken down during education, and in which I feel convinced that, if they had been looked after in good time, the breakdown might have been averted, and the work of the school continued. It might perhaps be well that each pupil should either bring with him, on admission, a statement of the condition of his eyes as regards refraction, accommodation, vision and muscular efficiency, or that he should be tested upon these points before being suffered to commence his studies. The teacher has greatly to rely for his results upon the eyes of the pupil, and there would be a manifest advantage in his being made fully acquainted with their capabilities. When weakness was detected, it might be so small in degree as to call for no more than a well chosen seat and a little watchfulness, or so considerable as to suggest a complete modification of the whole scheme of work.

I assume, of course, that in all schools which are under the charge of members of this Association, reasonable care has been taken about desks and fittings, and that such fittings and such bodily postures as those condemned by Cohn are not likely to be permitted. Assuming this, I think nearly all we can do, at present, is to watch for and to rescue children who are obviously suffering, and to strive for further and more definite information about the facts. If



those whom I have the honour to address will only co-operate in the work, sufficient English statistics may soon be obtained ; and we shall then be in a position to speak to parents and teachers from an assured basis of knowledge, and to tell them the true magnitude and importance of an impediment to education which we know exists in some degree. Even if we think that the view taken by Donders, of the diseased condition of a short-sighted eye, is in excess of the truth, we must still remember that it is certainly true to some extent ; and that, moreover, short sight is a serious or total disqualification for many callings in life, as well as a formidable barrier against mental growth in certain directions. It is a great, and unquestionably a growing evil ; and if we can see our way to aid in its diminution, it is our duty to spare no effort for the purpose.

