THE BRITISH JOURNAL OF OPHTHALMOLOGY

NOVEMBER, 1928

COMMUNICATIONS

WILLIAM CHARLES WELLS, M.D., F.R.S.
1757-1817

BY
R. R. JAMES
LONDON

WELLS is chiefly to be remembered for his essay on single vision with the two eyes. A short memoir of him occurs in Munk's Roll of the Royal College of Physicians and in the Dictionary of National Biography; the foundation of each is, of course, the memoir, written by himself, which is included in the collected edition of his works (1818.) Whatever the value of an autobiography may be in some instances, in this it is all we have.

Wells was the second son and fourth child of Scottish parents and was born at Charlestown, South Carolina in May, 1757. His father had settled in a mercantile house in Carolina in 1753, but the business failed, and he became a bookbinder and bookseller, to which craft he had been bred in Dumfries. Prospering in his new vocation he began the publication of a newspaper, "for which he was well qualified from his previous education, being a good Latin scholar, and well read in history; he had, besides, studied his own language grammatically, and wrote it with great correctness and purity."

After the peace of 1763 disloyal principles prevailed in America, and the younger Wells was obliged to wear a tartan coat and blue Scotch bonnet to make him consider himself a Scotsman, but this

object was perhaps more certainly attained by the lad being sent to Dumfries school at the age of eleven years. Here he stayed for two and a half years; and in 1770 he attended several of the lower classes in the University of Edinburgh. In the summer of 1771 he returned to Carolina and was apprenticed to Dr. Alexander Garden, at that time the chief physician in Charlestown. Wells's manners, "rude and rough from his infancy," had been toned down by his courses at Edinburgh, where he had as friends David Hume and William Miller, afterwards Lord Glenlee; but Dr. Garden and he seemed to have been rather incompatible with each other. Most of the pupils would seem to have been of a low standard, and Wells, addicted to speaking the truth, was indignant when Garden suspected him of falsehood. He became reserved and taciturn, and finding no entertainment in the society of his fellows, he betook himself seriously to study and, in the course of three years, though unassisted, acquired more knowledge than in any three subsequent years of his life. Before his indentures were out the American rebellion broke out in New England. His father, the printer of a paper constantly maintaining the cause of royalty, had become offensive to the people of Carolina, and found it prudent to return to England. Three months later, in spite of efforts to keep him in America, the son followed his father, returning to England in the autumn of 1775. On his arrival he went to Edinburgh, where he put in three more years of study and passed the preparatory trials of the M.D. in 1778. He did not graduate then, but came up to London in order to attend the lectures of William Hunter. At this time he became a surgical pupil at St. Bartholomew's Hospital for three months before accepting a surgeoncy in a Scottish regiment in the service of Holland. He joined the regiment in 1779. The colonel bore the good Scots name of Hamilton, but was scarcely able to speak English (nothing is said as to whether he could speak Scots!). Wells was difficult and each was incompatible to the other; after having been confined to barracks for two days, Wells resigned his commission and offered to fight a duel with his former colonel, who in consequence had him seized and put in prison. A report arriving shortly afterwards, that "surgeon Wells was no longer an officer in the service," he was liberated. In reference to this broil he admits that his temper was hot and that his conduct was rash, but says in extenuation that two surgeons and a chaplain had retired from the regiment on account of the treatment they had received from Col. Hamilton. Early in 1780 he spent three months at Leyden and occupied himself with a thesis (*de Frigore*), on which he graduated M.D. Edin. on his return in 1780.

By this time Carolina had been conquered by the King's troops and Wells was sent over by his father to look after his affairs. He

arrived early in 1781 and did his best to clear up his father's estate by taking on the family business of a bookbinder and printer. Not long after his arrival orders came from the commander-in-chief at New York to evacuate the garrison of Charlestown, and Wells set sail in December 1782 for St. Augustine, South Florida, taking with him the press and most of the types. He had some difficulty in setting the press up on his arrival at his new home; apparently it was one of those things that are extremely easy to take to pieces, but not so easy to set going again, but with the help of a negro carpenter it was ultimately accomplished. His spare time was spent as a captain of volunteers and as an actor. In 1783 he was back in Charlestown where he was arrested for an old debt of his father's, in spite of the fact that he came there under a flag of truce; he had to buy his freedom and on his return to St. Augustine was nearly drowned in a shipwreck. In 1784 he left America for the last time and came to London where he obtained the friendship of Matthew Baillie, to whom the collected edition of his works is dedicated. Wells's early years in London practice were very grim; he entertained a high notion of the dignity of his profession, and felt a contempt for the apothecaries with whom he had to associate and through whom a consultant at that time obtained most of his practice, with the consequence that he spent "fully ten years in London before his income from every source amounted to £250 per annum." In 1790 he was chosen physician to the Finsbury Dispensary which post carried with it an honorarium of £50 per annum. Like many another he had to borrow money, for his father was precluded by the state of his affairs from being of any assistance, but he records the fact that his debt never amounted to more than £600, and in 1795 his income and expenditure began to balance, and during the next five years he was able to pay off some of his debt. He held the Finsbury appointment for 8 years, and in November 1795 he was elected assistant physician to St. Thomas's Hospital, to which institution he became physician in 1800. In 1793 he was elected F.R.S., and in 1814 F.R.S.Edin. He was awarded the Romford medal by the Royal Society for his essay on dew. In 1792 his essay on vision was published. In the *Philosophical Transactions* for 1795 appeared his paper on the influence which excites the muscles of animals to contract in Mr. Galvani's experiments; in 1797 appeared his experiments on the colour of the blood, and in 1811, some experiments and observations on vision. Erasmus Darwin, in the *Zoonomia*, attacked Wells's statements about giddiness, and his answers were published in two letters in the "*Gentleman's Magazine*." He also published numerous papers in the *Transactions of a Society for the promotion of medical and allied knowledge*, a letter to Lord Kenyon, and several biographical sketches.

In 1800 he had an apoplectic fit of slight degree; this was an occurrence that ran in his family, and as a consequence he gave up much of his active practice and betook himself to literary pursuits, the chief of which, with the addition of the essay on dew, published in 1814, have already been mentioned. He died on the 18th of September, 1817, and was buried at St. Bride's, Fleet Street. Struggling ophthalmologists will read with interest what Wells has to say about his professional income. After sixteen years in London he was making only £307 per annum. In the next year his income sank to £235. From 1806-1812 it fluctuated between £325 and £455. In 1813 he made £457; in 1814, £441; in 1815, £764, this, his bumper year, included £210 for giving medical evidence at Exeter. In 1816 he made £572.

Wells's collected works contain, beside the memoir, two essays: one upon single vision with the two eyes; the other on dew; a letter to the Right Hon. Lloyd, Lord Kenyon, and an account of a female of the white race of mankind, part of whose skin resembles that of a negro; with some observations on the cause of the differences in colour and form between the white and negro races of men.

In an ophthalmological journal it is only needful to give some excerpts from his famous essay upon single vision with the two eyes. "Previous opinions on this subject may be reduced into two classes. The first comprehends those of Galen, Alhazen, Rohault, Dr. Briggs and Sir Isaac Newton. Their universal answer to the question is because the two impressions are united before they are communicated to the mind. To the second class are to be referred the opinions of those who hold it as certain that an object is seen single by both eyes, because it is seen by each of them in the same external place; and who profess to point out some law, or constant rule of vision, from which this sameness of place is to be derived as a necessary consequence. Aguilonius, I believe, first gave this view of the question which has since been adopted by Dechales, Dr. Porterfield, Dr. Smith of Cambridge, and Dr. Reid of Glasgow." Wells considers that the opinions of the first class are 'conjectures, founded upon certain supposed changes in the brain and nerves, the existence of which it is impossible, from the nature of the parts, either to demonstrate, or to refute by experiments; and that no one of them, though admitted to be true, is yet sufficient to explain the phenomenon on account of which it was framed.

The opinions of the second class demand more accurate investigation. Wells takes the opinions of Aguilonius, and states that what he says concerning this observer's views will apply to those of Dechales and Porterfield, "who have done little more than copy what he wrote." "If a line be drawn through the point of the mutual intersection of the optic axes, parallel to the interval

between the eyes, Aguilonius calls it, from its office, the *horopter*; and if through this line, a plane be made to pass at right angles to that of the optic axes, he names it the *plane of the horopter*. After discussing these terms, he asserts that, by a law of our constitution all bodies which we see with one glance or look, whatever are their real places, appear to each eye to be situated in this plane. And if this be granted to him, he easily and satisfactorily shows why some should be seen single with the two eyes, and others double. For since, according to a second opinion maintained by him, and not contradicted, I believe, by any other writers upon vision, the two lines of direction, in which an object is seen when we employ both eyes, can meet each other only in one point, it follows that all bodies which are really situated in the plane of the horopter must necessarily appear single, as the lines of direction in which any of them is perceived by the eyes coincide in that plane and nowhere else; and that all bodies which are not situated in the plane of the horopter, must as necessarily appear double, since, in this case, the lines of their visible directions intersect each other, either before or after they pass through it. Against the truth of this explanation only one argument need be offered. Were the visible places of all bodies to be contained in the plane of the horopter, these would appear of magnitudes proportional to the angles which they subtend at the eye. To Aguilonius, however, the merit is due of being the first who so far generalised the phenomena of single and double vision, as to observe, that those objects alone are seen single, which are really situated in the plane of the horopter."

The opinions of Dr. Smith, upon "corresponding places of the retinas" are next examined, and then those of Dr. Reid.

The second part of the essay is Wells's own theory respecting visible direction, and his solution hence derived of the question, why objects are seen single with the two eyes. The following explanation of terms is offered. "(1) When a small object is so placed with respect to either eye, as to be seen more distinctly than in any other situation, I say it is then in the optic axis, or the axis of that eye; and if another small body be interposed between the former and the eye, so as to conceal it, and if a line joining the two be produced till it falls upon the cornea, I call this line the *optic axis*, or the axis of the eye; leaving for future determination the precise point of the cornea it falls upon or what part of the retina receives the picture of an object which is placed in it. (2) When the two optic axes are directed to a small object not very distant, they may be conceived to form two sides of a triangle, the base of which is the interval between the points of the corneas where the axes enter the eyes; but if the object be very distant, then they may be supposed to be two sides of a parallelogram whose base

is the same interval. To avoid circumlocution I shall call this interval the *visual base*. (3) If there be a line drawn from the middle of the visual base through the point of intersection of the optic axes, or parallel to them, if they be parallel to each other, I name it the *common axis*. The term I believe was invented by Alhazen, but with him it signified a line drawn from the centre of the junction of the optic nerves, through the middle of the interval between the centres of the retinas. Such a line was consequently immovable. As the term, however, is not in modern use, no mistake can arise from confounding the two meanings, and the reason will soon be seen why I employ it in the sense I have mentioned. Those who are acquainted with the writings of the older opticians, will perceive that I give it nearly the same signification as they did to their *common radius*."

Wells next proceeds to prove the following propositions:—(1) Objects, situated in the optic axis do not appear to be in that line, but in the common axis. (2) Objects, situated in the common axis do not appear to be in that line but in the axis of the eye, by which they are seen (3) Objects, situated in any line drawn through the mutual intersection of the optic axes to the visual base, do not appear to be in that line, but in another drawn through the same intersection to a point in the visual base distant half this base from the similar extremity of the former line, towards the left, if the objects be seen by the right eye, but towards the right, if seen by the left eye.

The third part of the essay deals with some consequences from the foregoing theory of objects being seen single with the two eyes, together with the explanation of several other phenomena of vision. It consists of eighteen pages, which are here partly transcribed.

"It has hitherto, I believe, been thought by opticians, that, if the position of the eye be unchanged, the visible direction of an object will be the same, as long as its picture occupies any one point of the retina; and that, in every different position of the eye a picture, which continues to occupy the same point of the retina, will represent its object in a different direction. But if the theory be just, which I have advanced in the preceding part of this essay, neither of those opinions can be universally true. For it follows, from what was there mentioned, that if one of the optic axes be kept fixed, and the other be at different times variously bent toward it, objects, though situated in the fixed axis, will nevertheless change their visible directions, with every variation of the moveable axis; since they must always appear in the common axis, which alters its position with every change of the moveable axis. And again, that, if the two optic axes should vary their inclinations to each other in such a manner that the common axis, may, notwithstanding, remain fixed, an object placed in either optic axis, and following it in every motion, will possess but one visible direction, in all this variety of real positions. That these conclusions from my theory, or rather parts of it, are true in fact, I can assert upon the authority of observations, and I shall now attempt to trace them both to a common principle, by means of some experiments, which were instituted with a very different view. When we have looked steadily for some time at the flame of a candle, or any other luminous body, a coloured spot will appear upon every object, to which we shortly after direct our eyes, accompanying them in all their motions, and exactly covering the point, which we desire to see the most accurately. Whatever therefore can be proved concerning the apparent direction of such a spot,

in any given position of the eyes, must likewise be true in the same position of the eyes, with regard to the apparent direction of an object, situated at the concurrence of the optic axes; as its pictures must occupy in this case, the very parts of the retinas, upon the affections of which the illusion of the spot depends. This being premised, I shall now relate one or two observations, respecting the apparent directions of the spot, and consequently upon those of external objects, which, as far as I know, have not been mentioned by any other person.

1. The spot is always seen single, whether the surface upon which it is projected be touching the face, or at the greatest distance from us; and the reason is plain. For the parts of the retinas, by whose affections from the luminous body it is occasioned, are those likewise which receive the pictures of objects, placed at the intersection of the optic axes; and as such objects always appear single, so must also the spot.

2. The spot not only appears single in every ordinary position of the optic axes, but cannot even be made to appear double, by any means whatsoever. If it be projected, for example, upon a piece of white paper, whoever makes the trial will find, that, although on pressing one eye upward or downward, or to either side, the paper will be seen double, yet the spot will always appear single, and to possess its former place on the paper, as seen by the eye, which is not disturbed.

3. Having looked steadily for some time at the flame of a candle, with *one* eye only, I directed afterward, with both eyes open, my attention to the middle of a sheet of paper, a few feet distant; the consequence of which was, that a spot appeared upon it in the same manner, as if I had viewed the flame with both eyes, though somewhat fainter. My attention remaining fixed upon the sheet, I now pushed the eye, by which the spot was not seen, successively upward and downward, to the right and to the left, and in every oblique direction; the spot however never altered its position, but kept constantly upon the middle of the appearance of the paper, perceived by the undistorted eye, though the appearance of the paper to the distorted eye was always separate from the former and the sheet consequently seen double. My conjecture, therefore, was proved to be ill grounded and all suspicion of fallacy in the former experiment ceased.

Now it is evident, from these two last experiments, that the situation of the spot does not depend upon the bare position of the eyes, or else, in the former of them, it would have appeared double, and in the latter, it would have been moved from the middle of the paper when the only eye by which it was seen was pushed from its place. Neither can it depend upon the bare position of the muscles of the eye, as these were also moved in the same experiments; nor upon any affection whatever of the optic nerve. For since this last substance is altogether passive, even in those motions of the eyes which do occasion a change of the spot's situation, every alteration, induced upon the nerve by these motions, must be ultimately ascribed to a change of its position; and we have seen that similar changes of its position have been produced by external violence without any alteration of the spot's situation. The apparent situation of the spot being, therefore, dependant upon none of these circumstances, and being at the same time affected by the *voluntary* motions of the eye, it must, I think, be necessarily owing to the *action* of the muscles, by which these motions are performed. Assuming then as true, that the apparent direction of an object which sends its picture to any given point of the retina, depends upon the state of action existing at the same time in the muscles of the eye, and consequently that it cannot be altered, except by a change in the state of that action, I shall proceed to trace to this principle, several phenomena of vision, particularly the uniform singleness of the spot already described, and the two facts respecting the visible directions of objects in the optic axis, which were mentioned in the beginning of this part of my essay.

The thing is universally acknowledged, though a dispute has arisen whether custom or an original property be the cause, that every voluntary motion of one eye, in persons who do not squint, is attended with a corresponding motion in the other. Now as all voluntary motions are produced by muscular action, it follows, that every state of action, in the muscles of one eye, has its corresponding state in those of the other, and that the two are constantly conjoined. When, therefore, the spot appears single to both eyes in their free positions, the states of action in the muscles must be such, that the direction, in which it is seen by one eye, coincides with that in which it is seen by the other. But, if we push one eye from its place, no change is hereby made in the action of its muscles; for the state of

action in those of the free eye is confessedly the same as it was; and it will be attended with a corresponding state in those of the distorted eye; in proof of which it may be observed, that, whenever the pressure is removed, the distorted eye immediately returns to its former position, without the aid of any new muscular effort. The conclusion then is, that, since there has been no alteration in the action of its muscles, neither ought there to be any in the direction of the spot seen by it, which is the fact to be explained.

Hence also is to be derived the true reason, why objects appear double, when one eye is pushed from its place. For as their pictures must fall upon points of the retina in this eye, different from what they formerly possessed; and as no change is made, by the distortion, upon the visible direction, suggested by any part of retina, the objects will be seen by the pressed eye, exactly in the same directions as they would have been, *before* it was pressed, had the pictures *then* fallen upon the points of the retina, which they *now* occupy. They must therefore be *now* seen in different directions by the two eyes, and consequently double. An experiment with a contrary event will confirm this explanation, and likewise show more clearly, in what I differ from those who have endeavoured to account for the same fact. Both eyes being open, let one of them be pushed from its situation, and let two similar objects, such as two pieces of money of the same metal and stamp, be afterwards so placed, that one shall lie in each optic axis; these two objects will now appear to be one, and the object so compounded will be seen in the place to which the undisturbed eye refers the truly single object lying in its axis.

Another inference from this doctrine is, that, if the eyes are in any very unusual position with respect to each other from the action of their own muscles, as in persons who squint, two objects placed in the optic axes, one in each, will not appear as one object; for each will be seen in the direction, which is determined by the state of action in the muscles of the eye, upon whose retina the picture falls; and as this state, in one eye, does not correspond with that in the other, the directions cannot coincide. This conclusion is verified by the result of an experiment of Dr. Reid upon a person, affected with strabismus, and by that of another, made by myself, both of which have been already related. To explain, therefore, why an object in the optic axis appears at different times in different directions, though the axis be kept fixed, it is only necessary to show, that, whenever this happens, a change, notwithstanding, occurs in the action of the muscles which move the eye. With this view, I observe, that the motions of that organ may be divided into two sets; the first, consisting of those, by which one eye is carried along with the other, upward and downward, to the right and to the left, and in every oblique direction, the interval between the pupils remaining constantly the same; the second, of the motions of the pupils, or the anterior parts of the eyes, to and from each other. Supposing now, that both the optic axes are perpendicular to the visual base; should the left axis be afterword inclined to the right side, the natural tendency of the right axis is to incline equally to the same side, so as to preserve its former parallelism to the left. This tendency, however, in the right axis to follow the left, may be counteracted by an effort of the muscles, which regulate the interval of the pupils, until the two axes intersect each other within two or three inches of the face. But it is evident, that the same degree of muscular force will be required to retain the right eye in its original position, as is necessary to give to the left eye its motion toward the right; and hence, that, in every different inclination of the left axis to the right, an object placed in the latter, though its real position be unchanged, will nevertheless, appear in a different direction, in consequence of the different state of action in the muscles of the right eye, which accompanies every new degree of inclination of the axes to each other. As the object must always appear in the common axis, the alteration, in this example, of its visible direction, from an *increase* of the mutual inclinations of the optic axes, will be from left to right; but when the inclination decreases, from right to left. If the right axis be the one which is moved, and the left fixed, the alterations of visible direction in an object placed in the latter, from similar changes in their inclinations, will be contrary to those which have just been mentioned.

The reason also can now be made to appear, why an object, preserving constantly its place in the optic axis, may, in a considerable variety of its real positions, possess but one visible direction. For, in such cases, the change of its visible direction, which might be expected to accompany the motion of the eye in the axis of which it is situated, is prevented from occurring, by a tendency.

to a change of its visible direction the contrary way, produced by the muscular actions which regulate the mutual distance of the pupils. To know how this happens, suppose the two optic axes to be parallel to each other, and perpendicular to the visual base; and let a physical line be placed in either of them, so as entirely to coincide with it. This line will, therefore, not only be in reality perpendicular to the visual base, but will, in the present state of things, likewise appear so. Incline afterward both the axes equally to the left side, and it is manifest that the line coinciding say, with the right axis, must appear equally inclined. Let now the right axis be kept fixed, and the left be carried back again, and its original motion continued, until it be as much inclined towards the right side, as itself was just before, and as the right axis is still to the left side; the consequence will be, that the line in the right axis must again be seen perpendicular to the visual base; for such is the present position of the common axis. Here then we have had two opposing causes of change of apparent direction acting in succession. The muscular actions, producing the joint motions of the eyes, first bent the visible position of a line, in the right optic axis, from a perpendicular to the visual base toward the left; and the muscular actions, which regulate the mutual distances of the pupils, by *increasing* the inclinations of the axes to each other, moved it afterward, from the left to the right, back again to a perpendicular to the visual base. Let these two causes act together, and it is plain, that no observable effect will be produced by either, as long as they are thus proportioned. When they are not so, only the difference of their forces will be exhibited by the phenomena.

Having thus shown in what directions external bodies are seen, when their situation with respect to the eye is given, and upon what circumstances the various directions depend, in which a picture upon any one place of the retina can exhibit the object producing it; I should render the theory of visible direction complete, were I now to point out the relative positions of the two lines of direction, in which any two different parts of the retina represent their objects. To ascertain this, the first step must be, to find the place of the retina which receives the picture of an object, whose situation with respect to the external eye is known; and if two such points of the retina were determined, I think the chief difficulty in this matter would then be overcome. But as it appears to me, that the structure of the eye has not yet been sufficiently explained, I forbear saying anything more upon the subject."

The last part of the essay consists of about 50 pages devoted to experiments and observations on several subjects in optics. These are dealt with under the following headings: On visible position, and visible motion; on a supposed consequence of the duration of impressions upon the retina; and on the effects of accurate vision being confined to a single point of that membrane; on the connexion between the different refractive states of the eyes, and the different inclinations of the optic axes to each other; and on the limits of perfect or distinct vision. Enough of his views have been here transcribed, and it does not appear needful to quote from the essay on dew, or from the letter to Lord Kenyon; the latter being relative to some conduct of the College of Physicians of London, posterior to the decision of the Court of King's Bench in the case of Dr. Stanger; and containing observations on a principal ground of that decision.