The Nature of Man's Structural Imperfections.[1]

By Sir ARTHUR KEITH, F.R.S.

II.

DARWIN regarded the appendix as one of man's vestigial structures, and Metchnikoff accepted this verdict without demur, although there were then anatomists, particularly Prof. R. J. Berry,[15] who refused to regard the appendix as a useless structure. Every child is born with a fully and well-developed appendix which varies in length round a mean of 35 mm. Ribbert's investigations[16] showed that amongst the Swiss the appendix has reached its maximum length, 97 mm., by the twentieth year; thereafter the average length falls slowly, so that by the sixtieth year it has become reduced to 85 mm. Prof. Berry[17] found in the population of Edinburgh that the appendix did not attain its full length, 89 mm., until the fortieth year, falling to 83 mm. by the sixtieth year. Drs. Garcia and Salloza[18] measured the length of the appendix amongst Philippinos—a people living chiefly on a vegetarian dietary. By the twentieth year the appendix of this people had attained a length of 81 mm.; its maximum length, 96 mm., was not reached until the fiftieth year, while the average length fell to 82 mm. by the seventieth year. An organ which increases in length until the twentieth year, or even until the fiftieth, does not merit the name vestigial.

The size of the appendix at birth in the various forms of anthropoid apes we do not know, but in adult gorillas, chimpanzees, and orangs the appendix usually attains a length of 150 or 160 mm.—nearly double the length of the human appendix. In the most primitive form of anthropoid known to us, the gibbon, the appendix is most variable in length. In six animals which I dissected fresh from the jungle, all of them adult, the appendix varied in length from 75 mm. to 175 mm. In two of the animals, the cæcal contents were laden with numerous fruit stones as large as those of a cherry; the appendix in these two cases held a row of fruit stones, showing that it shared in the digestive work of the cæcum. There is no evidence to lead us to believe that anthropoid apes suffer from appendicitis in their natural habitat; they become subject to this disease when kept in confinement. Of 61 chimpanzees dying in captivity, 10 of them suffered from appendicitis.[19] The evidence, such as it is, leads us to believe that when the appendix breaks down under the conditions of modern civilisation, it does so not because it is "vestigial," but because of its inability to withstand the conditions to which it is being exposed.

To express the real nature of the structural and functional imperfections seen in the human appendix, it is convenient to use a term coined by the late Sir William Gowers. He noted that in some families certain structures, such as the hair on the crown of the head, was apt to be shed as the result of a premature atrophy of the scalp. To such examples of premature senility on the part of any organ or structure he applied the term *abiotrophy*.[20] In this sense the appendix is an abiotrophic structure, one which is apt to suffer from a disordered life-history; in a large proportions of Europeans it becomes atrophic or senile when other parts of the body are in full vigour. On the evidence collected by anatomists and pathologists, it is permissible to infer that if we could follow the life-histories of 1000 modern Europeans from birth to their seventieth year, the following would be the fate of their appendices. By the end of the tenth year the lumen of this structure would be partially or completely obliterated in 40 of them; by the twentieth year the same fate would have overtaken 70 more; by the thirtieth year 60 others would have been added to the list; by the fortieth year 80 further cases of obliteration would have occurred; by the sixtieth year there would be 110 additional cases. Of the thousand people who reached the age of seventy, only 500 of them would retain their appendix in an unblemished functional state; in the other 500 the appendix would have undergone a premature atrophy at succeeding stages in the journey through life. In this the appendix keeps company with all structures which are of a lymphoidal nature. The tonsils, the thymus, lymphatic glands, and Peyer's patches have similar life-histories, but no one would describe them as vestiges or rudiments. There is much in the name we apply to structures; when we name them "vestigial," "congenital," or "useless," we shut the door on all further inquiry. As Paley declared a century ago, our list of "useless" structures decreases as our stock of knowledge increases.

The eye, which is man's chief organ of sense, has, under the stress of civilisation, become the subject of a wrong growth or abiotrophy. If we take a thousand men or women over the age of twenty-five years, we shall find that about 150 of them suffer from a degree of myopia which prevents them from seeing distant objects clearly; and yet in all of them, just as was the case of the appendix, the eye was normal at birth. The incidence of the disorder is somewhat similar to that of the appendix; it appears during the period in which the eye is undergrowing growth—a process of the most complex kind[21]; in a few, myopic changes appear by the fifth year, the highest rate of incidence taking place as puberty is reached and passed. We cannot believe that among our hunting ancestors, for whom distant sight was so vital, that every seventh man was myopic.

Myopia we must regard as a structural disharmony occasioned by the conditions which civilisation has entailed on us. Short sight, as Dr. John Kirk has stated,[22] is certainly a disorder of growth, and the essential problem is to discover not why 15 per cent. of our population suffers from it, but why it does not occur in the remaining 85 per cent. Children may be fed on the same food and undergo the same school

[1] Continued from p. 823.
[15] *Anat. Anz.*, 1895, vol. 10, p. 761; *Journ. Anat. and Physiol.*, 1906, vol. 40, p. 247.
[16] Prof. Ribbert, *Virchow's Archives*, 1893, vol. 132, p. 66.
[17] Prof. R. J. Berry, *Anat. Anz.*, 1895, vol. 10.
[18] Garcia and Salloza, *Phillipine Journal of Science*, 1921, vol. 18, p. 707. See also Fawcett and Blackford, *Journ. Anat. and Physiol.*, 1900, vol. 34, p. xxi; S. Rutherford Macphail, *ibid.*, 1917, vol. 51, p. 306.
[19] Weinberg, *Bull. de la Soc. de Path.*, 1908, vol. 1, p. 556.
[20] The reader will see later that I use this term in a somewhat wider sense—one which includes irregular as well as reduced growth.
[21] I have dealt with the incidence and nature of myopia in the *British Journal of Physiological Optics*, 1925, vol. 1, p. 369.
[22] *Brit. Med. Journ.*, 1921, vol. 2, p. 8.

tasks, yet only in certain individuals does the eyeball undergo abnormal elongation. They only are affected by modern conditions, the others are not.

Perhaps no structure in the human body illustrates abiotrophic changes so well as the lens of the eye. By the age of forty-five the elasticity of the lens has become so reduced in most of us that we have to seek the aid of spectacles. Some time ago Dr. Ernest Clarke [23] examined the eyes of 1200 people of all ages, and charted in graphic form the condition of the lens. From that chart we can see that some individuals at the age of forty-five retain the elasticity of lens which is normal at thirty-five years of age, while others have reached a stage usually found in men and women of sixty. It is with the lens of the eye as with the appendix, abiotrophy sets in prematurely in some; in others the change is delayed.

The consideration of the functional failure of the lens of the eye brings us to a problem which fascinated Metchnikoff. What is the term of life which is natural to man? Metchnikoff inclined to place it at a hundred years—that if we escaped accident and disease the inherent vitality of our tissues was sufficient to make a centenarian of every one. At the age of forty-five the lens of the normal man is already old; it has reached the term of its full utility. We have no reason to suppose that civilisation has shortened or is shortening its period of usefulness. The indication it affords supports the belief that Nature has worked out the evolution of the human family on a mean life tenure of forty-five years; she has hitherto run the human army on a short-service system. Unfortunately we have no vital statistics of our nearest allies, the anthropoid apes. Micky, a chimpanzee which died lately in the Zoological Gardens of London, lived there for twenty-six years, and was three or four years of age when he arrived. Thirty years ago I made an intensive study on the age changes of the teeth and skulls of the great anthropoid apes and came to the conclusion that very few of them reached the fifth decade of life. All the elastic tissue and cartilage of the body keep the lens company in their rate of aging; they lose their resiliency by the middle of the fifth decade. The age of forty-five years sees the end of the term of child-bearing which is normal for women. When we consult the rates of mortality which now prevail we find that a sudden rise sets in during the fifth decade, and this rise assumes a steeper and steeper gradient with every subsequent decade. All of these facts seem to show that forty-five years was the span allotted to man when he was the blind slave of Nature. Civilisation now permits many men and women to live the span of two such lives, but whether it would be an advantage for civilisation that all should live to be centenarians, as Metchnikoff believed, is a moot point. We must take civilisation in the round; if it has searched out the weak points in our inherited organisation, it has also added incalculably to the span and comfort of life.

All the structural imperfections of man's body which have been discussed up to this point are of a kind which perish in the grave. We have no means of telling whether or not our remote ancestors suffered from appendicitis or were the victims of myopia. Fortunately, from this point of view, there are certain of the durable parts of man's body which manifest abiotrophic changes—the teeth and jaws. During the last twenty years I have had an opportunity of examining the facial parts of more than three hundred individuals who lived in England more than a thousand years ago, some of them so much as eight or ten thousand years ago. Seven years ago I made an elaborate comparison between fifty of these ancient skulls—twenty-five of which were adjudged to be those of men and twenty-five of women, with equal numbers of individuals who had lived in England within the last two centuries.[24] In only three of the fifty ancient skulls did the upper and lower teeth fail to meet in an edge-to-edge bite; in all of the fifty modern skulls the bite was of the overlapping or scissors type. Our teeth are in an abiotrophic state; the failure of the wisdom teeth or third molars to form, or to erupt if they are formed, is but one symptom of this abiotrophic change; it affects crown, cusp, and root development. In the fifty ancient skulls, instead of 100 upper wisdom teeth, there were only 82, 13 being absent from non-development and 5 from non-eruption. In the fifty modern skulls, instead of 100 upper wisdom teeth, there were only 59; 30 of these were absent from non-development, 11 from non-eruption.

Such evidence shows that although abiotrophic changes had overtaken the dental system of the western European as early as the Neolithic period, yet these changes have been accelerated during the more recent centuries. Dental abscesses were nearly as common in the ancient skulls as in the modern; carious teeth, on the other hand, were three times more frequent in modern skulls than in the ancient. The researches of the Mellanbys [25] have proved that the quality of enamel and of dentine, particularly of secondary dentine, has a relation to the vitamin content of a dietary. Equally important for the proper formation of teeth, as McCollum and his colleagues [26] have demonstrated, is the presence in food of a due proportion of certain mineral salts. Nevertheless, although a school of children are exposed equally to unfavourable conditions, it is only in a certain number that dental defects will occur; in this respect the dental system behaves as do all structures which are liable to abiotrophic changes.

In not one of the fifty ancient skulls was the palate contracted, whereas of the fifty modern skulls there were thirteen in which this condition was present to a recognisable degree—in more than half of them to a marked extent. No matter which stratum of our population we make observations on, we shall find that every fourth or fifth child or adult we examine possesses a palate which, compared with the older type, may be described as both altered in form and reduced in size. I have never seen this defect and irregularity of palatal growth except in skulls from cemeteries of the eighteenth and nineteenth centuries. It may be thought that this irregular growth with reduction in the size of palate, and the defects in the formation of the jaws and face which usually accompany them, are merely the results of the soft and highly prepared kinds

[23] NATURE, 1916, vol. 97, p. 554.

[24] Some of the details of this comparison were published in "Five Lectures," issued by the Dental Board of the United Kingdom, 1924.

[25] Dr. E. Mellanby, *Brit. Med. Journ.*, 1912, vol. 1, p. 831; Dr. May Mellanby, *ibid.*, 1924, vol. 2, p. 354.

[26] *Johns Hopkins Hospital Bulletin*, 1922, vol. 33, p 202.

of food we eat; with such a dietary the teeth, jaws, and chewing muscles are deprived of the work which fell to them in more primitive times. That this is not the true explanation is proved by this fact. When children are fed, clothed, and exercised exactly alike, all are not affected; only some of them develop irregularities of the palate and jaws. There is a special susceptibility to these imperfections in certain races and in certain families.

Amongst modern British people are to be seen various facial characters, particularly in the orbits, in the cheek bones, and in the bony supports of the nose, which are never to be noted in the facial framework of people who lived in Britain during the pre-Norman period. When a Continental cartoonist seeks to represent John Bull he always emphasises these new facial characteristics. Such changes in the form of the facial bones, like contraction of the palate, which they usually accompany, are not the result of a nasal obstruction such as might be caused by enlarged adenoids or tonsils; the cause lies deeper. The incidence of irregularities in the growth of the face follow the same laws as hold for all abiotrophic structures such as the appendix, the sclerotic coat of the eye, the thymus, and the tonsil. Further research will likely prove that the disorders of growth which overtake all these structures are linked to a disturbed action of lymphocytes and of all the constituent elements of the lymphoid tissues. Dr. W. Cramer has become convinced that lymphocytes are actively concerned in assimilation of food and in the nutrition of tissues, and that the nature of the dietary does directly affect their activities. It seems to me very probable that a fuller knowledge of the life-histories of lymphocytes, particularly of the office they perform in growing tissues, will go far to explain the disharmonies which civilisation is producing in the bodies of some of us. But the problem of explaining why some members of our community are highly susceptible to these new conditions, while others are less so, and why the majority remain unaffected, will still remain.

I have touched only the fringe of a great subject; I have left undiscussed the numerous imperfections and disharmonies which civilisation has made manifest in structures concerned in the maintenance of posture,[27] and in those which are concerned with the circulation of blood and with the duties of respiration. I have said enough, I believe, to show that Metchnikoff was right when he declared that civilisation had launched man on a great experiment. From this experiment there is no turning back. We cannot return to the conditions of human life which prevailed in Britain 6000 years ago; there are more people in one of the lesser back streets of London than could find an existence in the whole length and breadth of the Thames valley if we were to resume the manner of living of our distant ancestors. We cannot go back; we must go on. Seeing how differently we are now circumstanced in every relationship of life—in food, in drink, in shelter, in warmth, in occupation, and in amusement—the wonder is, not that structural imperfections and functional disharmonies should develop in a proportion of our numbers, but that so many of us should escape harm altogether and enjoy good health. It says much for the adaptational reaction which is inherent to the human body that it withstands the artificial conditions of modern civilisation so well as it does.

How are our bodies to be protected against these ills with which civilisation threatens them? Metchnikoff, a declared and open rebel against Nature, hoped that science might discover some short-cut for man's escape, some way of speeding up the evolutionary machinery of his body and so making it perfectly fitted for the life which ever-advancing civilisation is forcing on mankind. I also believe that science will find a means of escape, but not by Metchnikoff's way. The solution of our problem is a fuller knowledge of the use and working of those parts of our bodies which are most apt to give way under our modern manner of living—the use of such structures as the great bowel. When we have replaced our ignorance by real knowledge we shall then be in a position, not to adapt our bodily structures to our mode of living, but our mode of living to our bodily structures. This seems to me the best way out.

[27] I have discussed the "Imperfections of Man's Postural Structures" in the *Brit. Med. Journ.*, 1923, vol. 1, pp. 451, 493, 545, 587, 642, 669.

Hypothesis about Push or Contact Force.[1]

By Sir OLIVER LODGE, F.R.S.

ONE of the remarkable discoveries of our times has been the pressure of radiation. Though this pressure is ordinarily so extremely minute that it was difficult to discover—and perhaps would not have been discovered had it not been predicted mathematically beforehand by Clerk Maxwell—yet in certain circumstances the pressure of light can be very large and of cosmic importance. Whether it has an influence and ought to be taken into account in the intimate structure of atoms, I am not prepared to say, but I suggest it. The Boscovich contemplation of regions where force changes sign, and our whole knowledge of the stability of Bohr's atomic orbits, represent facts which have not yet been accounted for.

Moreover, I am going to suggest that the pressure of light may have to be taken into account before the most ordinary operations of daily life, even the propulsion of a wheelbarrow, are properly explained. The force of ether-waves may encroach on the region of mechanism, and be needed for a fuller interpretation of the familiar mechanical force exerted by one body in contact with another. When denying action at a distance we must not slur over a difficulty by pleading that the distance is small.

It may seem absurd to demand a theory of the manner in which one piece of matter pushes another. Even if one denies actual contact between atoms, it is reasonable to think of each atom as so surrounded by planetary electrons as to oppose similar electrifications to each other, and thus account statically for the repulsive

[1] From the first Norman Lockyer Lecture, "On the Link between Matter and Matter," delivered to the British Science Guild in the Goldsmiths' Hall, E.C., on November 16.