PARASYMPATHETIC DOMINANCE AS A CAUSE OF MALOCCLUSION*

F. W. Broderick, M.R.C.S. Eng., L.R.C.P. Lond., L.D.S. Eng.

A YEAR or so ago Mr. Robert Cutler read a paper before this Society entitled "Postnormal Occlusion as a Manifestation of the Lymphatic State." I was not a member at that time and was not present to take part in the discussion which followed, but there was so much in the paper with which I was in agreement that when he asked me to contribute something to this meeting, I felt that I should like to reopen the subject once again, giving it, perhaps, a wider background.

I present this paper with some diffidence, in that I appreciate my ignorance of the subject of orthodontics as it appeals mostly to the members here; nevertheless, possibly I may be able to interest you by presenting a new approach to the etiology of those conditions which it is the purpose of this Society to study: an approach built upon the study of biochemistry and biophysics, the teachings of which I have attempted to correlate with dental pathology.

Mr. Cutler built up his argument, in the paper mentioned, along the lines of inherited diathesis, as something giving a special type of metabolism to an individual, the consequences of which were to bring about a certain well-recognized deformity of the jaws which resulted in postnormal occlusion. He described the characteristics of the child—the subject of this diathesis—and then proceeded to show that a large proportion of children with postnormal occlusion were of this particular type.

Now, I have interested myself in this matter of constitution and diathesis for a number of years and have considered it in its relation to the etiology of the common dental lesions of caries and of pyorrhea. Since reading Mr. Cutler's paper I have taken note of those cases of postnormal occlusion which have come my way, and have noticed that, in a very large proportion of the comparatively small number of cases which I have seen, the teeth which the children possessed were extremely good; in fact, there would seem to be a definite immunity from caries in cases of postnormal occlusion. If this is indeed true, and if there is any truth in my hypothesis as to the cause of dental caries, which I shall presume is well known to you, then this fact might possibly be an important guide to the etiologic factors which bring about this condition.

Mr. Cutler dealt only with end-points, the beginning and the ending, the lymphatic state and the malocclusion; he made no attempt to explain the cause of the former, the underlying causative factors on which the metabolic inefficiency rests, nor to trace the production of the maldevelopment of the jaws in relation to this inefficiency. I agree, as did a number of the speakers on that occasion, that there is a definite connection between the two states, and should like to take this opportunity of placing before you my ideas as to the causation of the diathesis, in the first place, and to suggest how, possibly, this might be

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productive of the changes in the dental apparatus which eventually come about. In the course of this discussion it may be possible to throw some light upon the seeming exceptions which were so stressed by the opponents of Mr. Cutler's hypothesis.

I have brought to your notice this evening an ultramicroscopic blood picture, demonstrating the colloidal protein particles of the blood plasma. These constitute the matter primarily concerned in the processes of metabolism, the interchange taking place at the interfaces of the colloidal particles, and as the chemicophysics of matter in the colloidal state is probably unknown to the majority, perhaps I may be allowed to give just a brief summary as an explanation of that picture.

All matter in dispersion is either in solution—that is, in molecular dispersion or in coarse dispersion—or in the colloid state, the difference depending upon the size of the particles. Sugar dissolves in water and is an example of molecular dispersion; sand does not dissolve and slowly settles out, the particles precipitating and falling to the bottom of the vessel holding the water. Between these two types of dispersion lie limits within which matter is neither in solution nor in precipitated particles, but is present in minute dispersion in what is known as the colloidal state. Quite arbitrarily the size of a colloidal particle has been fixed as being between 0.1 of a micron and 1.0 of a millimicron, a micron being 1/1,000 of a millimeter. The colloidal particles, therefore, lie within the limits of 1/10,000 and 1/1,000,000 of a millimeter. Particles of this size are invisible under the highest power of a microscope, but they are too large to pass through the pores of a parchment membrane: they are, however, visible with the ultramicroscope, which differs in principle from a microscope in showing not the particles themselves, but their reflected images. The principle of the ultramicroscope is, in fact, demonstrated by the beam of light passing through a hole in a window blind and falling into a darkened room. You are all familiar with the particles of dust which this makes visible, but what you are seeing are not in reality particles of dust, which are invisible outside the limits of the ray, but their reflected images.

Matter in molecular solution is invisible even with the ultramicroscope, and the particles are small enough to pass through a parchment membrane, this constituting matter in the crystalloid state, as differentiated by Graham; on the other hand, matter in coarse dispersion has particles which when not visible to the unaided eye are visible under an ordinary microscope.

Thus we see not only that there are three kinds of matter in dispersion, but that with matter in the colloidal state itself we may have particles of different size within the limits in which this state is possible.

Now, matter in this form possesses certain chemicophysical characteristics which differentiate it from all other, to which are due all the possibilities of life; in fact, life is only possible through the colloidal state, all living matter being colloidal, and as soon as it ceases to be so, death supervenes. Schade says: "The physicochemical investigation of the human body extends far beyond the cellular pathologic concept of Virchow.

"As in the case of all branches of biology, medicine, thanks to the quickening influence of colloidal chemistry, is on the verge of a new era. Medical re-

search has broken a road for itself in still another direction; instead of the earlier humoral pathology, which explained all disease upon the basis of a disturbance of the 'humors,' there arose a cellular pathology, as a consequence of the development of the microscopic technic, according to which the cell was regarded as an entity controlled by its own laws, whose independent behavior was etiologically determinate. To this conception we could apply the old principle of Virchow: 'If the matter is to be understood and the details grasped, nothing remains but to go back to the elementary constituents; and the elementary constituents for the chemist are atoms, for the physicist, molecules, and for the biologist, cells.' Now behind the cell we find the micellæ as part of a colloidal system, so nothing remains but to go back to them. Everywhere in the body, in the cells, in intracellular tissue, in the blood, in the body fluids, are found colloids; practically every process bears the imprint of their individuality. Striking new results of far-reaching importance have led a not inconsiderable number of physicians to believe that in colloid research lies the key to profound penetration of the mysteries of etiology. The vivification of medicine by colloid chemistry justifies us in calling this a new era in medicine.''

The chief importance of matter in the colloidal state in the living body lies in the enormous development of surface area which it brings about. In much the same way as the tree develops surface area by the output of its leaves, so that a single large tree in full foliage in reality covers many acres of surface, so the body of a single person, on account of colloidal dispersion, would cover square miles of area at the intersurfaces of which energy production comes about. Consider the surface of a cube of metal, each surface of which is 1 cm. square, giving thus 6 sq. cm. If this were divided into smaller cubes with sides of 1 sq. mm. the whole surface area would be 60 sq. cm. If it were subdivided into a billion little cubes of a thousandth of a millimeter, or 1 micron to a side, the total surface area would be 6 sq. meters, and still it would be a coarse dispersion and not colloid. If subdivided into millionths of a millimeter, which would be within the limits of matter in the colloidal state, the surface area would be roughly an acre and a half.

In addition, however, to the enormous increase in surface area, and the number of interfaces which the colloidal state makes possible, certain other characteristics are inherent in particles in this state of dispersion, the most important of which is that of the power of adsorption of ions from the medium in which they are dispersed, through which the processes of metabolism, the turning of food into energy, are brought about. We have to consider not the colloid micellæ as separate and distinct things, so much as the relation of these micellæ to the medium by which it is surrounded, any change in this medium immediately affecting the character of the micellæ themselves, and through change in surface tension, enlarging or diminishing their size and characteristics, and therefore their metabolic possibilities.

We have seen that the colloidal state may exist with particles differing in size from that of 1/10,000 to 1/1,000,000 of a millimeter. In this difference lies the story of constitution and diathesis. As the particles approach the size of true solution, in molecular form, at one extreme, or those of a coarse disper-

sion at the other, which will depend entirely upon the constitution of the surrounding medium, so will alter the whole character of the individual, metabolic, chemical, physical, and psychologic.

The colloidal particles have been compared, by analogy, with solar systems; in the center, as representing the sun, lies a positive electrical charge, the proton, around which revolve the satellites, held in position by varying degrees of attraction; these are formed of the adsorbed ions. In the outermost orbit lie electrons, particles of negative electricity; next in position lie the inorganic salts, next sugar, then urea and uric acid, followed, still from without inward, by the amino acids and the fat. With perfectly functioning particles all these constituents are firmly held to the nucleus, but under certain conditions they tend to pass out of the colloidal complex, loose, as it were, into the surrounding medium, as the adsorptive power of the particle diminishes. When the colloidal complex tends to break up in this manner, as the result of changes in the dispersal medium, away come the constituents from without inward according to the amount of disturbance, the particles tending to get progressively smaller until they eventually go into true solution. On the other hand, the particle may enlarge, due to changes in surface tension, when they will hold their constituents still closer, adsorbing more from the surrounding medium, in which case these latter may even tend to disappear from the blood plasma, and, being changed from crystalloid into a colloid state, will be incapable of being differentiated by ordinary analysis. This is the explanation of such conditions as hypoglycemia or hypocalcemia, on the one hand, and of hyperglycemia and hypercalcemia, on the other. Further, as the particles enlarge, the total surface area diminishes and metabolic processes slow down.

As, when particles get smaller in this way and lose their adsorptive powers, they give up water, and when they enlarge and increase their adsorptive power they take in water, McDonagh speaks of them as dehydrated and hydrated particles.

In this way we get three kinds of colloidal particles: the normal, that is, as small as is consistent with the colloidal state, giving a normal adsorptive power and enormous surface area; the dehydrated particles, still small but not perfect particles in that they have lost adsorbed constituents; and the large, hydrated, particles with increased adsorptive power, and lessened surface area. These can be differentiated with the ultramicroscope, as they also offer other differentiating signs, with which we have not time to deal here.

I have said that the characteristics of the colloidal particles depend essentially upon the constitution of the dispersion medium in which they lie. The chief changes in this will be its reaction, the amount of hydrogen ions which it contains, designated its pH; the proportion of ions of the monovalent and the polyvalent salts, mainly those of sodium and potassium, on the one hand and of calcium and magnesium, on the other; on the balance of circulating hormones, and of the autonomic innervation of the tissues, whether this be primarily through fibers of the sympathetic or of the parasympathetic. Further, as this innervation is antagonistic, the one stimulating to activity and the other inhibiting any particular function or organ, according as to whether it is conservation or expenditure of energy which is necessary at the time, it will be

seen that the whole colloidal system, i.e., the particles themselves and the intermicellary liquid, will be constantly in a state of change, alternating backward and forward according to the necessities of the moment.

Now all these circumstances taken together, the pH of the tissues, the ionic balance, the hormonic balance, the nervous innervation, and the state of the colloid particle, all reacting the one with the other, make up what is known as the vegetative system, on which depends metabolic activity.

It will be within your knowledge that I have fathered the hypothesis that the dental lesions of caries and of pyorrhea depended ultimately upon vegetative balance. It is true that when I commenced thinking upon these lines I considered only the matter of tissue reaction, acidosis, on the one hand, and alkalosis, on the other. As my knowledge grew, however, I appreciated the fact that this could be only one part of the story, that these conditions, clinically at any rate, represented only symptoms, themselves dependent upon other circumstances. This observation carried me back to the autonomic nervous system associated with hormonic influences; here again one found that one had not reached bedrock. It was still necessary, following Virchow's method, to get back to elementary constituents, so I took up the study of colloidal chemistry, which united all these factors which I had previously considered into the vegetative system as conceived by Zondek and Krous. Farther back than the colloidal system it is impossible to go, for these are the ultimate particles of life.

Now vegetative imbalance, designated sympathetic and parasympathetic status, or dominance, and including not only excessive sympathetic or parasympathetic innervation (as visualized by Eppinger and Hess) but the whole matter of colloidal disquilibrium: reaction, ionic, and hormonic imbalance, becomes the basis of diathesis or altered constitution, giving the fundamental threshold not only to dental, but to all general and systemic, disease through changes in metabolic efficiency, primarily through capillary reactions and permeability which this will bring about. Here we get, not only why, but how, the recognized changes take place.

Ramsey, considering the onset of disease, says: "Biochemistry and biophysics have taught us that the living body is an admirably equipped laboratory in which nature is continually performing experiments. When they are successful we are not conscious that anything is happening, everything goes like clockwork, and we feel in good health. When, on the other hand, the experiments fail we become aware of unpleasant sensations, which we have learned to recognize as symptoms of disease. Health, therefore must be considered as a dynamic rather than a static state. We keep healthy as the result of a perpetual struggle to maintain physiological equilibrium in the reactions constantly taking place between the cells of the body and the nutrient capillaries. Physicochemical changes, therefore, which originate in the capillary system, are the first departures from health, and the cause of the earliest symptoms of disease.

"The part played by the capillaries is quite distinct from that played by the heart and the other blood vessels, all metabolic interchanges taking place through their walls; consequently they form the most active, purposive, and dynamic part of the vascular system. Their contractility is controlled not only by the vasomotor nerves, but also by chemical stimuli, the former acting as

a coarse, the latter as a fine, adjustment. The capillaries are not simple tubes through which blood flows. They do not respond to the amplitude of the pulse-waves in the arteries. They are really a constituent part of the tissues in which they lie, and their blood circulation is regulated and controlled by the requirements of the individual cells of the structures which they supply. All the important business of life is transacted through the walls of the capillaries.''

Now, capillary activity is controlled by the vegetative system, as we have just considered, the sympathetic status representing a state of tissue activity with contracted muscle fibers, and therefore with contracted capillaries, with diminished permeability of the capillary walls, calcium accumulation within the cell, increased acid formation, increased thyroid and adrenal activity, and a dehydration of the colloidal particles of the blood plasma; whereas the parasympathetic status represents just the opposite: muscle relaxation, dilated capillaries with increased permeability, calcium dissimilation, alkaline reaction, diminished activity of the thyroid and the adrenals, and an hydration of the colloidal particles. Thus, although it must be appreciated that these are constantly interchanging the one with the other in the processes of life, sympathetic being replaced by parasympathetic activity, it will be seen that with a constitutional, inherent tendency to overactivity of the one or the other, one set of functions, catabolic or anabolic, will, in some degree, tend to overbalance its antagonist, giving a definite trend to individual metabolism. In this way we get a glimpse of individuality, in health or disease, as set by vegetative balance or imbalance. But it is not quite so simple as this might seem to suggest; in practice it never is, for although it is easy to conceive extreme cases of sympathetic or parasympathetic predominance affecting every organ and tissue, this rarely eventuates. With sympatheticotonia it is much more common to have the whole of the body affected at the same time, as is seen in adrenal or emotional shock, when we get a typical picture of sympathetic predominance, but the parasympathetic does not, as a rule, work quite in this way, on account of certain anatomic differences in its build. Here certain functions or organs only, innervated by the parasympathetic part of the autonomic nervous mechanism, may show deviations from the normal, the remainder behaving normally. For instance, should this be the lungs, asthma may come about, if the nasal mucous membranes, hay fever, if the organs in the portal area, hyperchlorhydria or mucous colitis, and so on. Thus the symptoms of a constitution essentially parasympathetic need not always be the same; in some these may refer to one set of organs or functions, in others to another.

Mr. Cutler picked out one type of parasympathetic status, the dull, heavy child, predominantly anabolic, with enlarged lymphoid tissue, water-logged, and deficient of thyroid secretion, but all parasympathetic dominant individuals do not show these characteristics. Mrs. Lindsay and Mr. Steadman criticized Mr. Cutler's hypothesis because they found postnormal occlusion in persons who do not conform to his class, which I suggest he made too narrow, and, on the contrary, because they have found this same deformity in persons of another type, which they make too wide; this does not, however, mean that these are of the opposite type, the sympathetic, but rather that their parasympathetic dominance did not affect the particular organs which Mr. Cutler had stressed. It is

true that Mrs. Lindsay called these children acidotics, but it is so easy to go wrong in attempting to classify children from obvious signs only. For instance, I have recently investigated a young man of about twenty-one years, active, bright, pale, and anemic looking, subject to asthma and hay fever, with beautiful teeth, who gave all the characteristics of parasympatheticotonia, and hydrated colloidal particles. He might easily have been called an acidotic by a person with incomplete knowledge, which he certainly was not; indeed he was highly alkalotic.

Again, constitution, the consequence of inheritance, is not the whole story; this simply sets the threshold from which the strains and stresses of life begin to act; it is these latter which bring about the signs and symptoms of disease, and if the stresses are not present the special characteristics will not appear; if these should be of the opposite kind, and severe enough to overcome constitutional tendencies, then the opposite signs may show themselves. These stresses, for example, may be dietetic, carbohydrates tending to dehydrate the colloidal particles and therefore to shift the patient to the sympathetic side; if he be predominantly parasympathetic to begin with, no ill effects will come about, but if sympathetic in tendency, but a small surplus of carbohydrate will be productive of exaggerated signs, as in caries; if, however, the carbohydrate feeding is very excessive, and the parasympathetic dominance but small in amount, this may be sufficient to pass the child over to the sympathetic, although he be constitutionally parasympathetic.

All the difficulties encountered in appreciating this approach to the etiology of disease revolve around what we mean by the word disease. Is this to be limited to end-points only? Are we to consider, say, chronic interstitial nephritis as a disease, and all the circumstances which slowly lead up to the formation of fibrous tissue within the kidney as health? Surely not; yet medicine, as at present practiced, is not interested in and cannot diagnose disease until it has reached an end-point, with damaged organ or changed function. As dentists, we are equally blameworthy; we diagnose a tooth cavity as caries, but all the circumstances which have led up to the enamel decalcification we perforce disregard, yet the latter in reality constitute the carious process, the former being just an end-point.

I once stated in a paper that we had not the slightest idea as to what was meant by disease, and the sentence was censored out by an indignant sub-editor, who was quite certain that he, or she, knew all about it; but I, most humbly, beg to differ.

Disease, like health, is a dynamic and not a static process; a deviation from the normal in physiologic processes, which slowly and inevitably lead up to organic changes, which themselves are not diseases but the consequences of disease; and these deviations are the result of changes in vegetative balance, which alone constitute disease at its onset.

I have shown you an ultramicroscopic blood picture, the basis on which vegetative stability or instability is built. Of course, the matter is by no means as simple as one of hydration or dehydration of colloidal particles. I have no opportunity at this time to go further into the details and altered pictures in

disease, such as would be presented in different conditions. It is, however, along the lines suggested that all disease commences, whether this be dental caries or pyorrhea, allergy, arthritis, or even susceptibilities to this or that infection.

The physiologic dehydrators and hydrators of the colloidal particles, through which the body attempts to maintain a stable vegetative balance, are the hormones and the vitamins, which thus come into the picture medically and scientifically. It is not enough to diagnose an hormonic deficiency or excess, or a vitamin deficiency at one end of the scale and the fully developed lesion, medical or dental, at the other, and think that the whole matter is solved. There obviously must be intervening links through which the one or the other brings about the end-point.

As a leader-writer in the *Lancet* recently stated: "The difficulties met with in our understanding of diseases of nutrition are, to a large extent, the legacy of a not very fortunate conception of specific deficiency diseases which was put forward in the early days of the study of vitamins. This conception which finds expression in such terms as antirachitic, or anti-infective vitamins, postulated a direct causal relationship between vitamins and certain diseases. The disease was supposed to spring into being without any intervening pathologic changes as soon as the vitamins in the food were withdrawn and any reserves within the body exhausted. At present it is widely believed that rickets, for example, must necessarily appear when the antirachitic vitamin is not present in the food in sufficient quantity. But Sherman and Pappenheim published experiments nearly ten years ago showing that rickets does not occur in the absence of vitamin D if the proportion of calcium and phosphorus in the diet is kept near the optimum point. The real function of the vitamin is to correct the absorption and assimilation of calcium and phosphorus when these are not supplied in suitable proportions. The term antirachitic vitamin is therefore misleading so far as it gives the impression that the absence of this vitamin must necessarily be followed by the disease."

As a matter of fact Hahne and also McDonagh have shown that the vitamins act solely through their effect upon the surface tension of the colloidal particles; vitamin D, for instance, being a hydrator, that is increasing parasympathetic effect, increasing alkalinity, and drawing into the colloidal complex the calcium, whereas vitamin C acts as a dehydrator with the opposite effects. Hormones, similarly, act through the colloidal system, the thyroid and adrenals being the natural dehydrators. If we consider this carefully we shall see how these various substances bring about the changes within the body associated with their excess or diminution, through vegetative activity, stimulating or depressing metabolism, increasing catabolism or anabolism, and regulating the conservation or expenditure of energy.

The action of insulin McDonagh believes to be that of a dehydrator. It is usually believed that this substance acts primarily upon blood sugar, thereby regulating carbohydrate metabolism. From what has been said it will be seen that in the act of hydration the colloidal particles will draw sugar more firmly into the colloidal complex, in which form it will become unrecognizable to ordinary methods of analysis; consequently a hyperglycemia would be made to disappear, or even to be replaced by a hypoglycemia on the administration of in-

sulin, without this substance being in any way specific to blood sugar. When we come to consider that the methods which, experimentally, will prevent insulin shock, usually considered to result from hypoglycemia, are the giving of dehydrators, of which glucose is one, but oxygen subcutaneously, and many other substances, such as adrenalin, are others, we see that the matter of sugar as such does not primarily come into the story. As a matter of fact, I have used this idea in the treatment of excessive caries in nondiabetic young children: if dental caries is due, as I believe, to an acidosis, to a predominance of sympathetic function, to a dehydration of the colloidal particles, then hydration should be the preventive treatment. I have found in the small number of cases in which I have been able to experiment, that daily doses of insulin over a period of two to three weeks bring about the definite clinical entity of arrested decay, without any other change whatsoever in the daily life of the children. This is not the opportunity further to discuss this matter, as there are certain difficulties to be overcome, but I submit that it does definitely prove my hypothesis.

In this way, with a visualization such as is here presented of disease in its onset, we are enabled to see just how a particular constitution, resulting in a peculiar metabolic activity, links up various symptoms and end-points. Cutler finds, as do others, that what he has described as the lymphatic diathesis is frequently associated with a certain type of malocclusion. There are exceptions both ways, as there are bound to be if one attempts to draw conclusions too rigidly without taking into consideration all the factors on which the association rests. For example, I recently had a small boy sent to me for advice as to the prevention of very rapid caries. By constitution he was a parasympathetic dominant, but on investigation one obtained figures of acidosis, sympathetic predominance, and dehydrated colloidal particles. The history, however, solved the seeming paradox. The boy had had frequent attacks of angioneurotic edema, a definite parasympathetic syndrome, he would have gone into Cutler's group of lymphatic, water-logged, thyroid-deficient children. His teeth had been exceptionally good until a year or so ago, when they started to go wrong, the reason, incidentally, why he was referred to me, at about that time he had had a very severe attack of measles, so severe indeed that he almost died of bronchopneumonia, this was followed in a few weeks by whooping cough, to which naturally his parasympathetic constitution would not make him immune, although it would alter the character of his reaction to the infections. The consequence of these illnesses, naturally, would be to swing his metabolic activities over to the sympathetic side, giving him a tendency to caries although his primary characteristics were parasympathetic.

But when we find, as I believe we do find, that generally speaking, the teeth of these children with postnormal occlusion are of exceptionally fine quality and to a very great extent are free from caries, we get yet another association with parasympathetic status. And when we go one stage farther and find what I believe is a recognized after-effect of treatment—pyorrhea supervening in middle life, so frequently attributed to excessive movement of the teeth and damage thereby to the periodontal membrane, but obviously, according to my conception of etiology, due to the constitutional imbalance which was productive of the lymphatic state and of the caries immunity—the whole of our difficulties

of causation fades away. Here, then, we have the *why* these conditions are associated; we have still to consider *how* the parasympathetic state brings about the changes which result in postnormal occlusion.

Here I am afraid it is impossible to be dogmatic; all that I can do is to point out the effect of this condition upon calcium metabolism, upon the ossification and resorption of bone, leaving you with your greater knowledge of the strains and stresses to which the growing maxillary and mandibular bones will be subjected in cases of lymphatic overgrowth, and swollen and congested mucous membranes of the throat, to work out how this abnormality might come about.

We have seen that the chief effect of alterations in vegetative status are dependent upon changes in the activity of the capillary system; that with parasympathetic dominance these are more dilated and permeable, with increased circulation to the tissues supplied. Leriche and Policard point out that bone is not, in reality, the fixed immutable tissue which we are sometimes inclined to believe it to be, but that it is always in a state of flux, taking up, or giving out, lime salts according to the needs of the body at any particular moment; that the bones, in fact, are the great calcium reservoir of the body. They say: "Important relations connect bone resorption with an increase in the blood circulation; wherever this is increased there will tend to come about resorption of bone, and where it is diminished, an ossification. The calcium thus freed becomes available for ossification elsewhere within the neighborhood. The important factor in the stability of bone seems to be circulatory efficiency." When we consider the effects of experimental and surgical alteration of local vegetative balance, such as is brought about by the operation of sympathectomy, the cutting of the nerve fibers containing the sympathetic nerve supply to a particular area, we see that this is upheld. Quoting these same writers again: "In an entirely empirical way we can today consider it as established that periarticular sympathectomy at a distance modifies the region in a definite way. In fact, it is followed, experimentally, by a rapid ossification in the fractured zones (of bones) and, clinically, by a reossification of regions in too active resorption, where there is no utilization on the spot of the freed material. With all the reservations which the insufficiency of our knowledge imposes one can say that periarticular sympathectomy precipitates bone resorption, and thus permits ossification, but that these phenomena may pass beyond bounds. Events take place as if there were, for the preservation of bone, an optimum of circulation which this operation modifies in a direction which is always the same, but in a quantity that we do not know how to proportion."

Now the condition produced by sympathectomy is obviously one of parasympathetic dominance in the area affected, the removal of sympathetic stimuli allowing the antagonist, the parasympathetic, to have complete control; consequently we have in these cases changes in bone deposition and removal which could presumably affect such parts, in growing bones, as the glenoid fossa and rami of the mandible, should these be subjected to certain stresses such as might be produced by diminished airways, which themselves might be the consequence of the same disturbance.

I feel the inadequacy of this paper very strongly; my excuse must be that the subject is too large for a single contribution. I am at present engaged in an attempt to deal more adequately with the matter in the form of a book, where my stage is so much wider. If I have been enabled to interest any of the members of this Society in a new approach to the etiology of malocclusion, they will, at their leisure, be able to follow up the suggestions which I have brought forward.

DISCUSSION

Mr. R. Cutler said that some years ago he had had the temerity to read a paper to the Society dealing with the application of modern pediatrics to the study of orthodontics. That paper had met with a rather cold reception, a number of members of the Society feeling themselves quite unable to lend support to his views. He had not been at all discouraged, however, as he had realized that the fault lay with himself in not making his meaning fully clear at the time. In his opinion, subsequent experience had entirely confirmed the truth of the views he had expressed in his paper, and it was rather pleasant to him to hear those views supported on the present occasion by some one who was not an orthodontist but had arrived at his conclusions on general reasoning. Mr. Broderick had rather taken him to task for having made such a limited survey of an exceptionally deep subject, and he was afraid that that kind of reproof must be given to many junior colleagues who started investigations upon subjects of orthodontics or general dental interest. The reason for that was that practicing dentists had little or no scientific background to enable them to approach the study of complex problems, such as the one under discussion, at all efficiently, and, even if they had, the stress and strain of conducting general or specialized practice under modern conditions entirely sterilized the enthusiasm they might have felt during their earlier years. That was probably one of the troubles that beset the study of orthodontics at the present time. There were, on the one hand, expert clinicians and technicians, who went on perfecting their art more and more and obtaining beautiful results, often obtaining those results, probably, in a way that they could not explain; and, on the other hand, there were the completely academical workers, who probably knew nothing at all about orthodontics and who might know nothing about dentistry even, but who carried out a great deal of research work upon jaw growth and other subjects of tremendous importance to orthodontists. There were very few people who combined a practical knowledge of orthodontics or dentistry with a really scientific background and who could thus act as liaison officers between the two opposing groups. There were technicians like himself, on the one hand and, on the other hand, there were workers in medicine and pathology and embryology who were doing a great deal of excellent work on matters which might be very relevant to the practical side of orthodontics, but there was no one to focus their energies and abilities on lines that would be of help to orthodontists. Whether the members agreed with Mr. Broderick's views or not, they should be extremely grateful to him for presenting new viewpoints on old subjects. Mr. Broderick's paper at least made them take stock of the older explanations of disease and abnormality which had so easily satisfied them in the past. It was not so many years ago that enlarged tonsils, adenoids, mouth-breathing, etc., were regarded as being the direct cause of, or in direct relation to, the Class II condition. At the present time any such connection was spoken of with great diffidence by those who knew most about the subject, and rightly so, but similar ideas had been tamely accepted up to the present; and now, as a result of recent work, whether it was correct or not, orthodontists were at least beginning to question the truth of the old explanations. Dealing more specifically with the subject matter of the paper, he might say that there was one practical point which appealed to him, i.e., the marked resistance to caries of Class II cases. Those who did much hospital work, whatever the disadvantages of that might be, had at least the advantage of seeing the end-points or extremes that disease and metabolic maladjustments might cause. That advantage was denied the practitioner in specialized practice, who dealt with children brought up under the best possible conditions and who very rarely saw the end-points of disease, and who might therefore miss certain basic fundamentals. If those who carried out hospital work reviewed the Class II cases which they had seen at a hospital during the course of a week, he thought they

would agree that those cases had a very high resistance to caries. There was a practical reason for that, namely, that a Class II case in which, for instance, the lower mandibular first permanent molars had been lost as a result of caries was, from the standpoint of the technician, virtually untreatable, and therefore such as would be turned away. If, however, the members reviewed the Class II cases which they had seen in the last week or month or year, they would find there were really very few cases which they felt they could turn away as being technically impossible to treat. Second, Class II cases seemed to develop a degenerative gum condition which might lead on to pyorrhea, for instance, and, again, that condition seemed to develop whether the case was treated or not. Those were two practical points in connection with the subject under discussion, and apparently Mr. Broderick had an adequate explanation for them, which so far had not been given by any other authority. It so happened that the resistance to caries and the tendency to develop a gum condition were clinical signs which were obvious to an ordinary dentist like himself, but he was quite certain that to the skilled biochemist there were many other more subtle manifestations of metabolic and other forms of growth maladjustment which dentists missed and which they would continue to miss until a closer cooperation was brought about between the two entirely opposing forces in orthodontics at the present time. Personally he would be very grateful if Mr. Broderick continued his work on general matters, and, if Mr. Broderick had time to carry out further researches in orthodontic problems, he thought it would be eventually of great benefit to orthodontists.

Mr. Broderick said the whole subject was built upon the question of the inherent diathesis or constitution which an individual possessed from birth or before birth. It would be remembered that the medicine of a hundred years ago was essentially built upon constitution and diathesis, and pathology dealt with various types—the strumous type, the tubercular type, the lymphatic type, the nervous type, and so on. Then there came the work of Pasteur, and diathesis went out of fashion. It seemed as if medicine was on the eve of something which might be called specific etiology, a definite division of disease and a definite division of causation, all disease caused by microorganisms and every disease caused by a different specific microorganism. The hope of that had been disappointing, and it was now known that, over and above the question of a specific microorganism or any microorganism being the cause of disease, there was a great deal to be said for the soil, the individual himself who became infected with the microorganism. The question of soil was a question of diathesis, a question of individual constitution with which the patient was born. It was not quite such an easy matter—taking acidotic fathers and mothers and expecting to find acidotic children. There might be something of the Mendelian law in the matter, but he himself had three children, two of whom were definitely parasympathetic and one definitely sympathetic. If people were to be divided along the lines suggested, that would mean that he was sympathetic and his wife was parasympathetic. The definite constitution which regulated the metabolism of the individual and his reaction to disease throughout the whole of his life was something inherent in him. It was most noticeable, of course, in the extremes, the extreme parasympathetic dominant and the extreme sympathetic dominant. There were many other forms of classification, such as the acidotic or the alkalotic, or, coming to McDonagh's views, the hydrated or the dehydrated individuals, with reference to the state of the protein particles of their blood, which McDonagh believed to be the essential difference in the reaction of every individual to disease. He would suggest that even the earliest type of malocclusion or the earliest stage at which a dentist saw it was an end-point. In that connection he did not agree with what Mr. Cutler had said, that in hospitals the end-points were seen, whereas private practitioners did not see end-points. Personally he contended that all the stages were end-points. Leading up to the end-point was the constitution of the individual from the moment of his birth, and then there entered into the question such things as calcium metabolism, giving a mandible which would react differently to various strains and stresses. He could not enter into a discussion on that subject, because he knew nothing whatever about it. If the members present would bring forward the difficulties which they felt in understanding what he was attempting to talk about, it would help him very much in explaining the matter. Having been dealing with the subject for the last twenty years he found it a little difficult to appreciate the points which some of the members might not understand, as they had become to him quite simple matters.

Mr. Bradlaw asked if Mr. Broderick would state what physiologic evidence there was for the existence of a sympathetic and a parasympathetic system which were physiologically antagonistic. He did not know why they should be regarded as pulling in different directions. Unless the members could understand that fundamental point, he did not think they could grasp Mr. Broderick's learned argument. With reference to the liaison between the research worker and the clinician to which Mr. Cutler had referred, an attempt was being made at the present moment by the British Dental Association to bring about such a liaison, so that the pure research worker, the physiologist and the pure scientist might be put into touch with the needs of the clinician. He felt it might be possible for the Society to do something along the same lines to make known the needs of clinical orthodontists.

Mr. Broderick said that, with regard to the evidence of a nervous system built up of two antagonistic parts, without having time to think the matter out along proper lines, he would make the following suggestion. There were individuals whose pulses ran in the sixties and the low seventies and others whose pulses would always be in the high seventies and the eighties. If the individuals in the latter class were treated with drugs which stimulated the sympathetic, their pulse rates would go up. There were patients to whom an injection of adrenalin, for example, would give a mild shock, and there were patients who could be given very much larger doses of adrenalin without any fear of shock. Obviously those who were affected by adrenalin were the sympathetic dominants, in whom normally the adrenal secretion was marked, and those who were not affected by adrenalin were the parasympathetic dominants, whose adrenal and thyroid glands were relatively inactive. Taking the patients with normally quick pulses, their pulse rates would be reduced by injections of atropin, which paralyzed the vagus. It was from pharmacologic experience that Eppinger and Hess of Vienna built up the clinical differentiation between the two classes of patients whom they called sympatheticotonics and vagotonics, but later physiologic knowledge had gone much farther than that, and it was now realized that the vegetative status of the individual was not regulated entirely by the sympathetic or the vagus nerve supply. It was a question of the reaction of the tissues, as to whether they tended to be acid or alkaline; a question of the predominance of various ions, particularly those of calcium, on the one hand, which stimulated the sympathetic, and potassium, on the other hand, which stimulated the parasympathetic; a question of hormonic influences, and, according to McDonagh, a question of the size of the protein particles. In people whose metabolism was dominated by the vagus, parasympathetic, side of their vegetative system the tendency was for the protein particles to be large, whereas they were small in the sympathetic dominants. Any one who was interested in the subject and watched people in trains and trams, and so forth, could build up a very great deal from it by classifying people according to whether they were dominated by the one or by the other side of the vegetative system. One could then come to the question of temperament, of psychology, of reaction to infections, or reaction to emotions, and so forth. He thought there could be no doubt at all clinically that in a greater or a lesser degree the vast majority of the inhabitants of the world could be put into one or the other group.

Mr. W. A. Bulleid said he realized from what Mr. Broderick had said that the protein ions which Mr. Broderick had shown under the microscope varied with the dominance of the sympathetic or the parasympathetic system, but he was not clear whether Mr. Broderick attributed the dominance to the protein particles in the blood or vice versa. Why were the protein particles large in the parasympathetic dominant and small in the sympathetic dominant? Was it because of the dominance of the particular nervous system, or was the nervous system the cause of the size of the particles?

Mr. Broderick said he wanted to make it quite clear that the modern physiologic teaching was that the constitution or diathesis was due to what was now known as the vegetative system in contradistinction to the vegetative nervous system, and the build of the vegetative system was due to a number of things interconnecting the one with the other—the size of the protein particle, the calcium-potassium ratio ,and the hydrogen-hydroxyl ratio. If a patient was given large doses of alkali, his protein particles would be hydrated; if the vagus was stimulated, the protein particles would be hydrated, and at the same time the potassium would be increased in proportion to the calcium in the body cell. It was a little difficult—

in fact, quite impossible—to say which was the essential feature, because they all reacted one with the other. If one enlarged the protein particle, as could be done by certain synthetic chemotherapeutic drugs, one altered the reactions of acids and alkalies in the tissues, one altered the relation of calcium to potassium, and one altered the stimulatory threshold of the sympathetic and parasympathetic nerves. With regard to the question of sympathetic and parasympathetic dominants, there were very definite differences in the pathologic conditions from which they suffered. All the conditions which were known as the allergic conditions—asthma, hay fever, urticaria, mucous colitis, eczema, angioneurotic edema—occurred only in the parasympathetic dominant, the reason being, according to McDonagh, that any of the protein poisons which brought about those conditions simply acted by enlarging the protein particles to such an extent that they became precipitated in the capillary lymphatics of the tissues. If they happened to be the mucous membranes of the nose, hay fever resulted; if they happened to be the capillaries of the skin, urticaria resulted, and so forth. A sympathetic dominant was never an allergic. A person who got hay fever or asthma or any of the allergic conditions was a parasympathetic dominant, and if the members watched their own patients they would find—not in every case because other circumstances came in and upset it—that there existed a kind of immunity to caries in the allergic persons and that they got pyorrhea in the early years, other things being equal.

Mrs. Michaelis said she would like to hear further opinions, from the purely orthodontic viewpoint, on the question of the absence of caries in Class II cases. She happened to have a pair of models of a typical Class II case, which was badly mutilated by the loss of the mandibular first permanent molars through caries and the incisors were also carious. She did not know whether she was particularly unlucky, but in her hospital clinic she had not found her treatment of Class II cases made any more easy by an absence of caries, and she would very much like to hear the experience of other hospital clinicians. It seemed to her that the question of stomatitis and gingivitis in such cases could be a purely mechanical one. The mouth was kept open and therefore the gingivitis occurred, its cause being nothing more complicated than that.

Mr. E. O. Barber said he thought Mr. Broderick had neglected one of the most important people in connection with malocclusion, namely, the mother. On the analogy of caries being only the end-point of metabolic upset, malocclusion was, to his mind, an end-point due to a variety of causes. First, there were maternal hormones which were circulated in the mother's blood while the fetus was developing. It was a well-known fact that the jaws in the fetus did not develop at the same rate. The maxilla suddenly shot ahead, and then the mandible, and he thought the alternating growth could quite possibly be influenced by some parasympathetic disturbance in the mother, which, if continued, would probably cause the development of malocclusion. With regard to the testing of the blood of the child, he would suggest that the mother's blood should be tested first, and then it would be discovered whether the child was likely to be a marked Class II or a marked Class III case. Again, the maternal hormones might be an indirect cause of irregularities in the jaws, chiefly in their occlusion and not in the arrangement of the teeth. For instance, it was the practice nowadays, he believed, for mothers to arrange that their children should be fed by nurses. That again must have some effect upon the child, because the mother would naturally think of this before the child was born, with the result that the hormones would be circulating in her blood, and when the child was born the natural methods of feeding were negligible. The members had probably seen a number of cases at various times which showed the deleterious effect of bottle feeding. He felt that that was to a large extent parasympathetic. In the latter part of the paper Mr. Broderick spoke of the removal and deposition of bone material at the expense of the jaws. Why should the jaws be affected more than the rest of the body? Working on that basis, if the jaws were affected, then when dealing with a Class II case one would expect to find that the tibia, for instance, or the bones of the hand would be deformed in some way, but personally he had not experienced that. He believed that two German research workers had mentioned what they called the "congenital component," i.e., that a bone, no matter what it was, would always assume its normal shape and size unless there was some

very grave etiologic upset. He did not think that the majority of children whom orthodontists saw had been affected in the way described, and he did not think the matter was explained by parasympathetic dominance.

Mr. Gordon Taylor said he wished to present another picture, i.e., that of the edge-to-edge bite. He would not say that no caries was found in the case of an edge-to-edge bite, but there was found a resistance to caries; the teeth seemed particularly hard and well calcified. Then, later on, when the patients reached the early forties, pyorrhea was found. He thought the edgeways cases were the cases of traumatic occlusion which one heard so much about, but whether it was traumatic occlusion or whether there was something in the patient himself which was responsible for the gum trouble, he left to Mr. Broderick to say. Personally he had noticed that a large number of patients with gastric ulcer had edge-to-edge bites. He presented that picture of the edge-to-edge bite—resistance to caries, early pyorrhea, and gastric ulcer—and he would like Mr. Broderick to evaluate the picture.

Mr. Broderick said that, with reference to the bones of the jaw being affected and not the bones of the rest of the body, that was a question which, as he had said in his paper, he knew nothing about, a question of strains and stresses due possibly to other symptoms of parasympathetic dominants, such as an increase in lymphatic tissue, and so on, giving differences in size of air passages, which would tend to alter the shape of growing bones in the jaw more than in other parts of the body. Definitely associated, as Mr. Cutler had said in his paper, with parasympathetic dominance was an increase in lymphatic tissue, which would, he took it, throw a greater strain upon such a condition as the size of the mandible, the depth of the glenoid fossa, and so on. He could not go further than that. With regard to the association of gastric ulcer with edge-to-edge bite, gastric ulcer was essentially a disease of the parasympathetic dominant, because the secretory nerve to the stomach was the vagus, and increased vagus action would tend to give a hyperchlorhydria. One could not dogmatize too much in that connection, because the hyperchlorhydria might also be due to spasm of the pylorus preventing a regurgitation of juice from the duodenum, and the innervation of the pylorus was sympathetic. With reference to the question of gingivitis, there had been a time when he had definitely differentiated certain types of marginal gingivitis from the marginal gingivitis which was the first sign of a commencing pyorrhea. He would not be quite so dogmatic on that point today as he had been two or three years ago, because it was suggested that all inflammatory phenomena were brought about by a definite ratio of hydration to dehydration, and that infection took place only as that ratio was reached. The matter might be looked upon somewhat as a ladder, with pure dehydration as the bottom rung and pure hydration as the top rung. Though pure hydration and pure dehydration were very rare conditions, the pathologic changes in the protein particles had almost always a proportion of dehydration to hydration. Thus the bottom rung of the ladder would be dehydration, and then would come dehydrato-hydration, hydrato-dehydration and hydration. The inflammatory part of that ladder would be a certain ratio of dehydration to hydration. If one put against that ladder dental lesions, there would be caries with the lower rungs, pure dehydration, and dehydrato-hydration with dehydration much predominating. A little farther up one would get caries with gingivitis, then gingivitis, and then gingivitis and pyorrhea, and then, as one reached the top, one would get Gottlieb's type of pyorrhea, in which the gingivitis element was very small. Consequently one would expect to get more and more gingivitis as one got the parasympathetic innervation coming more into the picture, gingivitis becoming more and more pronounced until one reached the extreme parasympathetic dominants, when gingivitis would cease to exist.