Essay on the irregularities of the teeth : with special reference to a theory of causation and the principles of prevention and treatment / by J. Sim Wallace.

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ESSAY ON THE IRREGULARITIES OF THE TEETH

WITH SPECIAL REFERENCE TO A THEORY OF CAUSATION AND THE PRINCIPLES OF PREVENTION AND TREATMENT

BY

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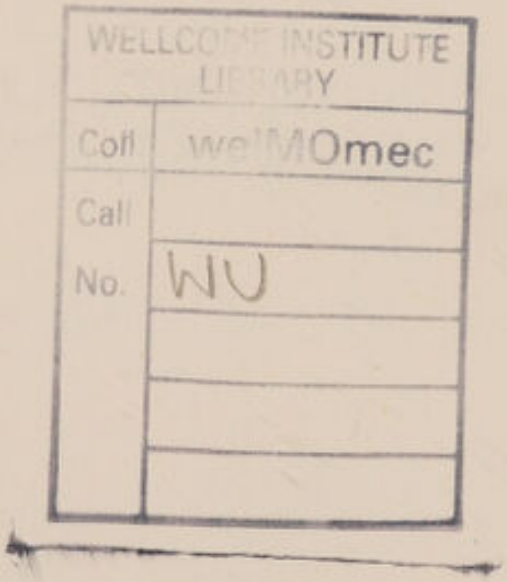
6–10 LEXINGTON STREET, GOLDEN SQUARE
1904



Printed by BALLANTYNE, HANSON & Co.
At the Ballantyne Press

PREFACE

THIS book is a collection of essays which appeared originally in the *Journal of the British Dental Association* (January and February 1900), and in the *Dental Record*, June 1901—August 1903.

Although written separately and under different titles, I trust that in combination they constitute a fairly coherent whole. Clustering round one central idea, they form a much more conclusive argument than the separate articles did.

I am much indebted to Mr. William Rushton, the Editor of the *Dental Record*, for his kindly appreciation and for the prominent position which he gave the separate essays in that journal.

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THE IRREGULARITIES OF THE TEETH

INTRODUCTION

It is with a little diffidence that I venture to bring forward a theory of the causes of the irregularities of the teeth, for although I may feel very confident that it is true, there is always the thought that the score or two of theories[1] which have preceded this have been advocated in the fullest confidence by their respective propounders. This reflection does not strike us till we find that we have tried to carry our own point just as our predecessors tried to carry theirs. If an apology is needed it might be pointed out that there may be extenuating circumstances, and in this case there is one at least of first-rate importance. Towards the close of last century there sprang up a school of biologists who denied that acquired characters were transmitted. The question being one of great importance and interest, I made as full an investigation of the arguments which had been advanced as seemed necessary for me to come to a definite conclusion. I was fascinated with the subject,

[1] Talbot, "Irregularities of the Teeth." Introduction.

and became a disciple of the new school. The question arose, however, that if acquired characters were not transmissible, then what became of the current assumption that the jaws were growing smaller on account of successive generations of disuse?

My studies had so thoroughly convinced me that acquired characters were not transmitted, I felt that some other explanation could be made which would account for the diminution in size of the jaws and for the irregularities of the teeth. The explanation, however, did not come at first. At last the idea struck me that there might be an intimate relation between the size and growth of the tongue and the size and development of the jaws, and that this would best explain the facts without any assumption of the inheritance of acquired characters. The facts with which I was acquainted were so easily harmonised by the hypothesis, that in a few hours I had roughly sketched out in my mind the theory that I am about to explain.

This is not my only justification for introducing another theory of the causation of irregularities. It is well known that "some theories are the very foundations of science; while facts are the building stones, theory furnishes the design, and it is the interpretation of facts in the light of theory, and the considered application of theory to practice that constitute true science."[1] If this be so, and no doubt it is,

[1] Professor Armstrong, Presidential Address: Educational Science. Brit. Ass., 1902.

then even the attempt to formulate one such theory has its justification. Further, a new theory tends to stimulate thought, and this is at present of particular importance, for current conceptions of the irregularities of the teeth are so confused that thought seems to be completely paralysed. A consideration of such facts would justify a score of honest attempts at a rational solution of the problems presently to be dealt with. I have endeavoured to put the theory forward as well as very indifferent health and the exigencies of daily practice will at present allow, and even without doing more, if the element of truth is there, some day it will take more definite and elegant form.

Of course what follows will reach but a small section of the dental profession in the immediate future. The progressive members are not too numerous, and lack of knowledge of the biological questions involved—especially the question of heredity—makes it impossible always to expect either intelligent appreciation or criticism.[1]

However, it is encouraging that the theory has already been adopted in general by a few scientists as well as by a few distinguished practitioners both dental and medical. One eminent surgeon has most ably corroborated my views in a recent paper, and has, I believe, considerably helped "to secure for

[1] Mr. N. G. Bennet has certainly made an intelligent and able though adverse criticism of my views (*Trans. Odonto. Soc.*, March 1901), but I think the fuller exposition about to be given will compel him to reconsider the position which he then took up.

them a more generous recognition than has hitherto been accorded."[1] But it is particularly gratifying to be supported by such a distinguished authority as Dr. Grevers of Amsterdam, for perhaps no one has made a more extended and painstaking investigation of the subject; and it will be conceded that but few are as competent to give a valued opinion as he.

A few chapters on treatment have been introduced to show the application of the theory to practice, and to indicate to the practical man the necessity of acquiring a knowledge of the subject.

In trying to establish my own views it has been necessary to make a sort of running commentary on current ideas which are antagonistic to mine. I have criticised more especially the statements in Messrs. Smale and Colyer's "Diseases and Injuries of the Teeth," and Messrs. Tomes "System of Dental Surgery," not on account of their being more deserving of criticism than many other compilations, but because they are the text-books generally used in most of the Dental schools in this country, and no doubt they represent current ideas fairly well.

[1] E. T. Constant, *Trans. Odonto. Soc.*, March 1903.

CHAPTER I

GENERAL OUTLINE OF THE CAUSES OF IRREGULARITY OF TEETH

In the following chapter I intend to direct attention to the forces which conspire to bring about a regular set of teeth, and to try to give an outline of the causes of irregularity of the teeth.

Firstly, I shall refer to the general law that functional activity is antagonistic to growth. I shall assume that the reader is acquainted with this principle, and need say no more on this subject at present than merely to mention that, during gestation, developmental activity is at its maximum and functional activity at its minimum. Akin to this is the fact that, when from disease or other cause a person is confined to bed during the period of growth, a considerable development in the length of the bones takes place. In general the increase in length of bone takes place independently of functional activity. Furthermore, although an organ or part of the body may be wholly or partially disused for generations, this fact does not tend to diminish the amount of growth in size or structural perfection, or the functional activity of these organs or parts in future generations (A. R.

Wallace,[1] Weissmann[2]). Thus, though the ladies of China have for generations had their feet bound up and their normal growth prevented, and though their feet have been practically functionally useless throughout life, their children are born with perfect feet, which grow and are as perfect and large (if they are not subjected to pressure from bandaging) as their mothers' feet ought to have been. I refer to the above principally to point out that the comparative non-use of the jaws at the present day is a wholly inadequate explanation of their want of development.

Were these the only principles we had to deal with, the jaws would grow to pretty much their normal size and shape independent of their functional activity. But there is another consideration which we must bear in mind, that in certain tissues and organs full development is not, as a rule, attained without a normal amount of functional activity.

This is perhaps best seen in the development of muscle. In this case the development is, to a great extent, dependent on the amount of use to which the muscle is put, as in muscle there exists the potentiality for a certain amount of hypertrophy or atrophy according as it is used much or little. In the case of bone there is no hypertrophy or atrophy in length under similar conditions. There is obviously some utility in this hypertrophy or atrophy according as the muscle is used or unused, and this power must

[1] Wallace, "Darwinism," p. 413 *et seq.*
[2] Weissmann, "Germ Plasm," p. 392.

be conceded to have been acquired by the germ plasm and the potentiality transmitted hereditarily. On the other hand, beyond the effect which greater use would necessitate in developing bone of attachment, and thickening it and strengthening it, the utility for the acquiring of the potentiality of hypertrophy or atrophy would be of little or no use in bone, and we find it is, as a matter of fact, non-existent as regards development in length. The reason for referring to the above will be observed after further consideration of other circumstances.

Another consideration to which I would call attention is the fact that in bilaterally symmetrical parts, variations are generally bilaterally symmetrical, and normal variations, as well even as abnormal ones, are carried out to the most minute details on both sides of the body. It seems as if the potentiality for developing such parts was originally one and the same process; the two sides remain as it were under essentially one denominator, though they are as absolutely different as the right and left hands. However difficult it is to imagine by what means the germ plasm brings about this remarkable bilateral symmetry, there is apparently something conceivable in it, and, as a matter of fact, we know that bilateral symmetry *is* brought about to a very great degree of nicety, though it is perhaps never quite perfect. It might be conceived that, if the jaws were formed by some such method as might be supposed to follow from metameric homology, a certain very definite

amount of concomitant variation might be common to both, and so might bring about the accurate antagonism of the teeth which is so necessary, but as the jaws originate from buds from the first visceral arch, neither bilaterally symmetrical nor metameric variation can help to bring about the perfect arrangement and antagonism of the teeth.

I think we are left with no alternative but to assume that, as far as direct hereditary influence is concerned in the production of the necessary arrangement and relative sizes of the antagonising teeth, there is nothing but correlation in growth to fall back upon.

When we consider that, in order to get an efficient masticatory organ it is necessary that all the teeth should articulate with the greatest nicety, we are brought face to face with one of two alternatives: either the correlated growth of the upper and lower jaws and teeth must be extremely exact and definite, which it is not, or there must be some controlling influence common to both, which, as it were, guides the teeth to their exact position and arrangement. Nature seems not to miss any means of arriving at the desired result, and I believe both methods are utilised. From some observations I think the concomitant variation of the upper and lower teeth, except in the case of the wisdom tooth, is fairly accurate. However, the arrangement of the teeth is undoubtedly modified by one common denominator, which is the tongue, together with the cheeks and lips. The provision, which nature has accepted to a

certain extent, of taking the tongue as a common denominator for the correlation of the arrangement of the upper and lower teeth, is the chief cause of the crowding and irregularity of the teeth of the present generation; because the tongue does not attain, as a rule, at the present day to its normal size, on account of its functional activity falling far short of normal. The food of the present day is ridded of its coarse and fibrous material, the amount of mastication to which it is subjected is relatively little, and the amount of use to which the tongue is put during the process is much less than when foods were subjected to the relatively great amount of mastication required before the advent of civilisation.

When we remember what has already been said on muscular hypertrophy and atrophy it will be obvious that the muscular fibres are not so thick and numerous as they would be if the tongue were put to ten times the amount of use which it gets when "civilised" foods are masticated.

I have paid some little attention to the size of the tongue in mouths in which there was a large and well-developed arch of teeth, and also in cases in which the arch was contracted, with the result that to all appearances those people who had large tongues had also well-developed arches of teeth, and in those cases in which the tongue was large, the ordinary diet was one which required a considerable amount of mastication.

I had intended making a series of measurements

of the breadth of the arches of teeth of savages, as I conceived that on account of the greater amount of use in mastication to which the tongue was put, and the consequent greater size of that organ, that the size, and especially the breadth, of the arches of teeth of savages would be greater than the size of the arches of teeth of the civilised, and more especially than those of the upper classes, who do not give their tongues a normal amount of use in mastication. Fortunately, however, I found that this had already been done, and as the measurements were made independently of the theory which I am putting before you, they may the more readily be accepted as substantiating it.

Dr. Talbot has collected a great number of measurements of the breadth of the upper jaw, or rather of the breadth between the outer sides of the first molars. In the case of the measurements of skulls of savage races collected in various American and European museums, the average breadth was 2·28 inches, while in the measurement of living persons, who were almost all civilised, the average breadth was 2·14 inches. I have not endeavoured to get results suitable for my argument by taking any special cases recorded by Dr. Talbot; he himself says, "In comparing the measurements of the uncivilised races with those of the civilised, it will be observed that the jaws of the former are much larger than those of the latter."[1]

[1] Talbot, "Etiology of Osseous Deformities of the Head, Face, Jaws, and Teeth," p. 67.

And again, "There is also a marked difference between the diameters of the jaws of dispensary patients and poorer patients and those observed in private practice among the wealthier classes."[1] He also points out that "the early Britons possessed [upper] jaws which measured from 2·12 to 2·62 in their lateral diameters, while the jaws of the English people measure from 1·88 to 2·44 inches."[2] Dr. Talbot also points out that among the Europeans the Cretins of Switzerland have large jaws.[3] This, according to my argument, is to be accounted for by the fact that the tongue among these people is large. The Cretins are doubly interesting in furthering the theory that the tongue gives rise to enlargement of the arch of the teeth, of the alveolus, and perhaps of the rest of the jawbone, as in other respects they are a small and ill-developed people, and they do not use their jaws much in mastication. The tongue is, however, pathologically large. The Esquimaux too have relatively broad and well-developed jaws, but in this case the size of the tongue, and so of the jaw, is brought about normally by their having to masticate an almost wholly fibrous (meat and fish) diet, which generally requires an excessive amount of chewing, being often eaten raw. The stature of the Esquimaux is otherwise small. Now, although Dr. Talbot arrives at the conclusion that the diminished size of the jaws at the present day is due to neurotic

[1] Talbot, "Etiology of Osseous Deformities of the Head, Face, Jaws, and Teeth," p. 66.

[2] Ibid.

[3] Ibid.

tendencies, the crossing of races, &c., his statistics are much more adequately explained by the fact of the diminished size of the tongue depending on the diminished amount of mastication among the civilised. Moreover, his conclusion is at variance with the law that crossing of races tends to reversion to ancestral type. I may state here that I fully admit hereditary, family, and racial differences in the size of the arches of teeth, though combating the theory that the diminished size of the arches of teeth in civilised races is due to anything but the diminished use, and consequent size of the tongue. I shall enter into this subject much more fully later, but in the meantime I must content myself with a mere outline of what I believe to be the true theory of the causes of the crowding and irregularity of teeth.

I shall now direct your attention to certan forces which play an important part in modifying the position of the teeth, namely, the forces arising from the increasing size of the tongue. It is well known that continuous gentle pressure on a tooth causes it to move away from the point of pressure, and when a tooth is thus moved the alveolus follows. I suppose all dentists will admit this, otherwise the mechanical treatment of irregularity would be sheer waste of time. The plasticity of the alveolar part of the jaws is in fact so pronounced, compared with other bones, that we must admit this to be a special hereditary characteristic. With my way of looking at the subject this is to ensure a regular arrangement of the teeth and

an exact antagonism, for, were the arches not to a certain extent controlled by the tongue, the slightest variation in shape of the upper and lower arches of teeth would make the dental armature useless for its normal functions.

The modelling of the dental arches round the tongue may now be traced. During the period of suckling the tongue is much used in the process, and grows, and the jaws, which at this time are almost all alveolus, grow rapidly under this stimulus. Owen's remark is suggestive; he says, speaking of the more intellectual as compared with the lower races: "The fore-parts of the upper and lower jaws, concomitantly with earlier weaning, are less produced, and the contour descends more vertically from the longer and more prominent nasal bones."[1] During the first six months, while the infant is suckling, the two halves of the lower jaw are separate, and the growth of the bone takes place in the fibro-cellular tissue connecting them. If the tongue is well developed by its activity in suckling, a stimulus is given to the development of bone in the fibro-cellular tissue. The consequence of this is a broadening of the jaw at its anterior part. As regards the lower jaw, the effect of this is to give rise to greater breadth in the neighbourhood of the mental prominence. I have, as yet, not been able sufficiently to verify this inductively, although the few cases I have investigated go to show that the jaw in

[1] Owen, "Comparative Anatomy and Physiology of the Vertebrates," vol. ii. p. 569.

the region of the mental prominence, that is, the part which is more especially influenced during the suckling period, is better developed in those who have been naturally suckled during infancy. Now, if the sucking process is made too easy, and the tongue does not get a normal amount of exercise, I think we are justified in the assumption that it will not grow so fully as if it were put to a normal amount of activity. At the present day ease in alimentation is fostered nearly from birth. When, in place of the mother's breast, a bottle and india-rubber teat are substituted, the hole through which the milk is to be sucked is made too large, so that the child may suck the milk quickly and easily. If the hole in the rubber teat is made small the child takes too long, and makes too much noise for the patience of the mother or nurse.

Now let us direct attention to the stage when the temporary teeth are all in position and completed as far as the crowns are concerned, that is, about the age of three and a half years. At this period the arch of the teeth is regular, and has been brought about in the following manner:—The vital forces bring about the general arrangement of the teeth, and as the teeth and jaws are correlated in their growth, the positions which the teeth come to occupy are to a great extent determined by vital forces. Nevertheless, if we examine carefully the individual teeth as they make their appearance through the gum, we note that they are not so perfectly arranged as after they are fully in position. That is to say, without the aid of a mechani-

cal force (that is, the tongue, especially) the arrangement of the teeth is imperfect. On coming through the gum the incisors may be found slightly rotated on their axes, or they may appear through the gum in a rather more anterior or posterior position than may be considered normal, and within limits they vary as regards time of eruption. Although the correlation in growth is sufficiently accurate for the lower teeth to appear at intervals more or less constant from the appearance of the corresponding upper teeth, yet this is not always quite exact, and the lower may not precede or follow the corresponding teeth of the upper jaw in the normal time of succession; that is to say, the correlation in the eruption and arrangement of the teeth of the upper and lower jaws is not perfect. Now let us consider what happens when, for example, some one or more of the incisors do not grow up to meet the corresponding tooth of the upper jaw in that most excellently regular arrangement which they as a rule arrive at when the first dentition is complete. Let us assume that one lower incisor is a trifle too nterior, and the other a trifle too posterior. The action of the corresponding upper tooth in biting soon presses more strongly upon the more anterior lower incisor, and this pressure is supplemented by the slight pressure brought upon the upper tooth by the lip. Should the pressure from the under tooth be so great as to slightly displace the upper incisor forward, then the greater part of the pressure of the lip is thrown upon this upper incisor, and presses it back-

wards. Then the other lower incisor which we have assumed to have erupted a trifle more posterior to its fellow gets greater pressure from the tongue behind it, and is not pressed upon by the corresponding incisor of the upper jaw until it has been moved forward by the pressure of the tip of the tongue. If there is any slight lateral rotation this is rectified in a similar manner. If, from muscular inactivity or other cause, the tongue falls short of its normal size, it is obvious that the teeth will not be forced out so much as they otherwise would have been. Up to this stage, however, the variation in the normal size of the tongue is slight, and so, notwithstanding what has been said about the development of the tongue during the suckling stage, only a trifling want of development of the jaw can be assumed to have been brought about by this cause. Now let us pass to the next stage.

Let us consider the stage when the deciduous teeth have performed their function and are about to begin to be shed. At this period it will be observed that there generally are slight spaces between the teeth. It is obvious that now the teeth occupy an arc of a larger circle than they did when they first came into position and were in contact. They consequently must have been translated outwards, and the alveolar part of the jaw must have grown outwards also. I do not say that this has been a purely mechanical process, due solely to the increasing size of the tongue, nevertheless the increasing size of the tongue is certainly a factor, if not the chief one. It is well known that the

teeth yield in position to a constantly acting force, and if the tongue did not grow normally, the crowns of the teeth would not be forced into this larger arc. Not only do the crowns of the teeth come to occupy a more forward position, or rather, a position in the arc of a larger circle, than they did when first they came into their fully erupted position, but the roots likewise occupy the arc of a larger circle. How this force affects the latter change may be elucidated by the following explanation: the tongue presses upon the backs of, for example, the lower incisors, and so tends to force the crown outwards; this force acts upon the tooth at a certain distance from its apex; the apex of the tooth is, as it were, fixed by the opposing upper tooth, and so the pressure tends to push the tooth bodily forward. To put it in mechanical language, the lower tooth is a lever, the fulcrum is at the apex, where it impinges on the upper tooth, and the power which acts outwards is the tongue, the resistance is the alveolus covering the anterior part of the root. In the upper jaw, the top of the crown of the lower tooth which is forced forward by the enlarging tongue is the power, the lip pressing against the anterior surface of the lower part of the upper incisor is the fulcrum, and the resistance is the alveolus covering the anterior surface of the root. I do not intend to indicate that this is the sole means of bringing about the outward translation of the tooth, but it acts as a guide to the vital forces in giving rise to the necessary amount of absorption of the posterior surface of the

alveolus covering the anterior surfaces of the roots of the incisor teeth, which in its turn stimulates a deposition of bone on the anterior surface of the alveolus. What part the developing crowns of the permanent teeth take in stimulating an outward translation of the roots of these temporary teeth it is difficult to say, but in any case the pressure of the tongue on the teeth is the controlling force, and though the vital forces might be supposed to produce a bodily translation of the tooth, it is ultimately dominated by the pressure of the tongue. I trust I have made it clear that the teeth must have been translated bodily outwards, and that, were it not for the growth of the tongue, the teeth could not possibly have undergone the change in position which is brought about.

During the few years that the deciduous teeth are capable of full functional activity, what must be the effect on the tongue of eating the soft pap, liquid extracts and refined foods of the present day, which require little or no chewing? I think it will be evident, from what has been said on the influence of functional activity on the growth of muscle, that the development of the muscular fibres of the tongue is not as great as if it had been used while chewing fibrous food-stuffs, which require at least ten times the amount of mastication. The consequence of this is seen in the fact that the deciduous teeth are sometimes not translated outwards, and the spaces which should develop between them do not form, and the alveolar arch is not as broad as it ought to be.

In the next stage the temporary teeth are shed and the permanent ones take their place, and if the tongue has developed normally, and the deciduous teeth have been translated outwards, then there is every probability of the permanent teeth taking up a regular position, even though there has been an irregularity in their eruption, as there frequently is. This is brought about by the same forces as those which have been described as bringing about the regular arrangement of the deciduous teeth. If, however, the tongue has not developed sufficiently, and the temporary teeth have not been translated outwards, the permanent teeth cannot occupy this contracted arch without irregularity, as the sizes of the crowns of the permanent teeth are considerably greater than the crowns of the temporary set (excepting the temporary molars). If the tongue has not developed by a normal amount of activity, the teeth at the side of the mouth are not forced outwards, but fall inwards. Then the posterior permanent molars begin to take up their position in an arch which is not quite large enough to contain them, and the teeth which have fallen inwards have this available space still further encroached upon by the tendency to forward translation which these molar teeth have. The result is inevitable, and is seen in V-shaped and saddle-shaped arches, &c. Such a condition often appears to be inherited, as parents, as a rule, bring up their children in much the same style as they were brought up themselves.

In further support of this theory, I would point out

that irregularities are most marked in the upper jaw, *i.e.*, the expansion of the upper jaw is not so great as that of the lower, and this notwithstanding the fact that the amount of available space for the teeth in the lower jaw is very markedly limited by the ascending ramus. This is caused by the tongue lying in the floor of the mouth, and although its normal size is diminished, yet it keeps up a certain amount of lateral pressure on the lower teeth and alveolus. I think this fact suggests the explanation of the external cusps of the lower teeth frequently falling outside the corresponding cusps of the upper jaw, and also the occurrence of underhung jaws.

There is a current assumption that the early extraction of the temporary teeth gives rise to contraction of the jaw, and although this belief is not shared by all authors, there is certainly much clinical evidence which appears to support it. It is a fact that in mouths where the temporary teeth have been removed early there is, as a rule, in later life a crowding of the permanent teeth which take their place, but the removal of the teeth is not the cause of the irregularity. The temporary teeth are generally extracted early because of their being carious, and caries is brought about by causes similar to those which bring about insufficient development of the tongue and the contraction of the jaws, viz., principally the elimination of the coarse and fibrous matter from the food-stuffs. Further, when the temporary teeth are prematurely extracted, the outward pressure of the tongue is diminished by the

expansion of that organ where the gaps exist, and consequently the remaining teeth are allowed to occupy a slightly smaller arch than they otherwise would have done.

Another fact of importance, when the teeth are not used to masticate more or less fibrous food, is that their upward growth from the alveolus is not completely checked by the opposing teeth; that is, they are not arrested by full functional activity. In childhood, if the food consist of broths, milk puddings, and paps, there is very little functional activity. The consequence of this is that the teeth rise, as it were, in their sockets, and the alveolus accompanies them. This is well seen in cases in which the molars only occlude, and there is an open bite. In this case the development of the alveolus at the front of the mouth is very great.

My own observations show that a want of full use of the teeth gives rise to high palate, and this is supported by the fact that among patients of the upper classes—who are brought up on soft, refined foods—a high palate is much more frequent than among the working-classes. This tends to augment irregularity, as the space for the tongue is vertically larger and the soft parts of the cheek press rather more on the buccal surfaces of the teeth than does the tongue on the lingual surfaces under normal conditions. More marked cases of high palate are presumably brought about for the following reason. Not only are the food-stuffs so soft that the downward growth of the

teeth and alveolus is not quite checked, but also nasal breathing is not fully performed. The mouth is kept almost constantly open, and so further tends to allow of the downward growth of the upper teeth. In these cases, too, the arch is always contracted, as the force of the tongue acts principally only when the mouth is closed, and this force, which normally holds the teeth outwards, is to a great extent diminished, and almost wholly lost as regards the upper jaw. Whether only disease, such as enlarged tonsil, is the cause of this mouth breathing, or whether the habit of nasal breathing is not sufficiently enforced through a normal period of normal suckling, I have so far been unable to find out.

There is another point to which I wish to refer. When the teeth are put honestly to perform their natural function, and when by the forces which have been referred to a fine broad arch of teeth has been brought about, there is a liability for slight spaces to exist, as in normally developed mouths ample, though not lavish, space is provided for the teeth. When there are slight spaces between the molar or bicuspid teeth, food is apt to lodge, and the teeth on the approximal surfaces are liable to become carious. There is a provision for obviating this, and through this provision the exquisite arrangement of the teeth which we so rarely see in civilised countries is made almost perfect. The molar teeth, after cutting the gum, grow upward, and, if spaces exist in front of them, are bodily translated forwards. I suppose all

dentists have seen numerous cases in which, for example, the second bicuspids above and below have been extracted in youth, the molar teeth have been translated forwards, and the space completely filled up. This change of position, when it occurs under normal circumstances, is not a tilting forward of the crown while the apex of the root remains stationary. The translation comes about, I believe, in the following manner. There is a forward force which is the resultant of the outward and slightly forward pressure of the tongue, and the inward and forward pressure of the buccinator muscle. (These are not imaginary forces, as the mucous membrane of the cheek at the side of and behind the hindmost molars is frequently marked and indented by its pressure on these teeth, and the marks caused by the pressure of the lower teeth on the tongue may also frequently be seen.) The resultant of these forces tilts the crown forward as we occasionally see it in an exaggerated form, and then, if the opposing teeth are not wanting, the posterior cusps occlude with the antagonising tooth. Then there is also the vital force which makes the tooth grow upwards to meet its fellow, but as the posterior part of the tooth is arrested by occlusion with the opposing cusps, the only result of this is the rising of the anterior part of the crowns, and by this motion the roots also are carried forward. However beneficent this force ought, under normal conditions, to be, under the very abnormal conditions which exist among civilised peoples, it becomes a cause of irregularity, for

if the normal arch has fallen in, and is already too small, this force only tends to increase the mischief; so much so is this the case that we frequently see a tooth, for example a second bicuspid, which has been forced inwards out of the arch altogether, while the remaining teeth occupy a more or less regular position.

I have not deemed it advisable to introduce special cases; it might easily be done, but it would be open to the objection that the cases were selected to confirm my views. I shall therefore content myself with referring to a case the models of which were taken by Mr. Merryweather and are now in the Museum of the Royal College of Surgeons. It is described by Mr. Tomes in the *Transactions of the Odontological Society* for April 1892.[1] The following extract from Mr. Tomes' "Dental Surgery" will recall the case: ". . . a bilateral asymmetry (which was ultimately met by the extraction of a tooth on one side) had asserted itself at a time when precisely the same teeth had been shed and replaced upon the two sides. Another respect in which the mouth was irregular lay in the height of the lower incisors. These had grown up too high, in spite of the fact that the upper incisors were vertical instead of being inclined outwards; and so the lower incisors, so far from having no opposing teeth, were driven to take a position sloping inwards."[2] He further says, "Thus two forms of slight irregularity

[1] Tomes, "Studies in the Growth of the Jaws," *Transactions of the Odontological Society*, New Series, 1892, p. 143 *et seq.*

[2] Tomes, "Dental Surgery," p. 60.

occurred which could by no possibility be referred to merely mechanical causes."[1]

Nothing is recorded about the amount of development of the tongue, and as the models were taken recently, one may be justified in assuming that the individual from whom the models were taken had indulged in a "civilised" diet, which means that mastication is reduced to a minimum, and the tongue does not quite develop to what might be considered its normal extent. We are justified in assuming that the tongue *was* rather smaller than what might be considered normal, as the arch of the teeth gives a fairly accurate measurement of it, as it occupies the space within the arch. Now what must be the effect of a small tongue on the incisors? The crowns are not forced or kept forwards, and the lower teeth, instead of meeting the upper lying at an angle which would bring the lower incisors into almost direct contact with the posterior bulge of the upper incisors, fall backwards and meet with no resistance till they grow upwards and are arrested by the pressure of the gum. (Normally the upper incisors are kept from being pushed forward by having the lower ends of their crowns held inwards by the lower lip, and the lower teeth from being forced inwards by the pressure of the tip of the tongue.) With regard to the bilateral asymmetry, this, too, *is* susceptible of a mechanical explanation, though not being sufficiently acquainted with the case I will only hint that the amount of

[1] Tomes, "Dental Surgery," p. 61.

mastication on either side was probably unequal, as it usually is.

From what I have said, it might be assumed that I believed the vital forces played a small part in the arrangement of the teeth, but this would be a great mistake. I only maintain that Nature does not scorn mechanical forces when it suits her purpose to make use of them. It is difficult to conceive what Nature could be supposed to have been doing if it were assumed that irregularity of the teeth had become an inherited characteristic. Surely irregularity in the arrangement of the teeth cannot be considered beneficial, and that being so, why should natural selection be supposed to have chosen such a disadvantageous peculiarity as a thing worthy of hereditary transmission? If it be said that irregularity of the teeth had come about by spontaneous variation, and the point being of little importance it was allowed to be continued, my reply is that variations from the ancestral type, when they are neither good nor bad, do not get stereotyped, but sink out of existence by continued amphimixis (*e.g.*, polydactylism); that is, in simple language, through dilution, as it were, of the characteristic by intermarriage.[1] The foregoing explanation of the common forms of crowding of the teeth is not meant to be an exhaustive explanation of all forms of irregularity, but merely to supplement the ordinary description with which it is assumed the reader is acquainted, and to direct his attention to the

[1] Weissmann, "Germ Plasm," Section "Amphimixis."

causes of the diminished size of the arch of the teeth and of the alveolus, among the civilised races at the present day. Where my explanation is contradictory to current theories I mean it to be so, and however heterodox the explanation may appear to be, I certainly maintain that it is in accord with biological principles, and that therefore it is the current theories on the causes of irregularity which really are behind the times, if they are not heterodox. I further hope that I have shown that there is some tangible cause of irregularity which might be combated, and that the subject may some day be extricated from the hopeless confusion that has hitherto surrounded it.[1]

[1] This chapter was published originally in the *Journal of the British Dental Association*, Jan. 1900.

CHAPTER II

CAUSATION: HEREDITY

In considering the causes of the irregularities of the teeth one naturally directs attention to those two great fundamental forces, Heredity and Environment, which go to build up the human organism. It will be convenient to consider those two forces separately, and first we may consider Heredity. In works on the irregularity of teeth heredity is put forward as one of the main general causes, but this cause is so frequently introduced when the causation is obscure, that one feels inclined to think that it is introduced in order to make a pretence of knowing, when in truth the authors neither know the cause nor perhaps what they mean by heredity. The cause is in any case attributed to an unknown quantity. With regard to the irregularities of the teeth, if we consider any of them hereditary, we are placed face to face with the stumbling-block that our ancestors a few generations back were free from them. Now if we say that certain irregularities are hereditary, we must admit that at some time or another the germ cells varied spontaneously in such a way that the development of these cells ultimately brought about irregularities in the

teeth and that these variations became transmitted. In opposition to this idea, however, we remember that such variations, should they have occurred, would be swamped, as it were, in a few generations by intermarriage. It is indeed very difficult to perpetuate any recently acquired variation; and unless there is for a considerable time a rigid application of natural or artificial selection or a geographical or other isolation of the particular individuals possessing the variation it is well-nigh impossible for the peculiarity to become hereditarily fixed. There are, no doubt, some peculiarities which presumably arise as what may be called by-products of evolution; peculiarities which under certain circumstances or environments are inconsequential, but which under a changed environment are quite otherwise. As examples of such may be taken alcoholism,[1] and possibly susceptibility to certain diseases. It may well be admitted that the human jaw has either, as a secondary result of the evolution of other characters or directly as the result of variation stereotyped by selection, diminished in size to such an extent that it can only just hold the teeth in regular arrangement; but it can hardly be admitted that the jaw has been reduced in size to such an extent that under normal circumstances it is rarely able to hold the teeth without irregularity. It must be remembered that irregularity of the teeth is not only a serious disfigurement but also a condition which eminently conduces to the occurrence of caries, and the many

[1] "The Present Evolution of Man," by Archdall Reid.

pernicious results, direct and indirect, which are thereby occasioned. The very constant association of ill-health and pronounced irregularities of the teeth indicates some intimate association of the two conditions. It is hardly necessary to insist further on the contention that irregularities of the teeth cannot have been brought about by the causes referred to.

I must dwell on this subject of heredity, because it is of importance from the point of view of prevention and treatment. If a defect is hereditary, the way to prevent it is to put an end to the working of heredity. If, however, the defect is not hereditary but due to other causes, the other causes may be prevented, and the patients allowed if they choose, to propagate their kind. As regards treatment, it has been asserted that those irregularities which are inherited are more difficult to treat than those which are acquired; but if it can be shown that they are all acquired, then those which presented most difficulty come into the class which are less difficult to treat. The assertion that certain classes of supposed hereditary irregularites are difficult to treat appears to me to amount to saying that in certain cases the operator does not know the cause, and cannot therefore intelligently direct his treatment; while in the other class the cause being known the treatment can be intelligently directed.[1]

I want particularly to draw attention to that great general principle of which the irregularities of the teeth are but an illustration—viz., that normal struc-

[1] Compare Tomes, "Dental Surgery," p. 108 and p. 115, 4th ed.

ture and constitution are inherited under given environmental conditions down to the minutest details, and such environmental conditions may therefore be regarded as normal; while, on the other hand, abnormalities of structure and constitution are not inherited. In other words, all structural abnormalities and diseases are the product of abnormal environmental forces which are too powerful for the innate or inherited constitution to overcome.

This may appear a rather sweeping assertion, but it is in accord with the general beliefs which the medical world is recognising more and more every day. Thus not so many years ago Sir William Jenner wrote: "That tuberculosis is transmitted from parent to child, is one of the best established facts in medicine."[1] Nowadays we hear about the effects of closed windows, unhealthy atmospheres, unhygienic surroundings and infection on the one hand, and fresh air, sunlight, and general hygienic treatment on the other. It is recognised that the natural and primitive environment of our ancestors has been changed by civilised man, and must, as far as possible, be brought back to normal. It may be seen on considering the subject from biological principles that this conclusion must be correct, for throughout the whole course of the evolution there has been an unflinching extermination of those who inherited disease or abnormality of structure which brought disease upon them; while, on the other hand, those inheriting a normal constitu-

[1] "The Practical Medicine of To-day."

tion or one in correspondence with the environment survived and propagated their kind.

In the far remote future the natural environment must change to such an extent that the present hereditary structure may not be adapted to it. This is, however, no argument for the infliction of those gratuitous changes of environment which are at present causing the destruction of countless lives or, to keep more closely to our present theme, for the bringing into existence of the irregularities of the teeth with their painful and disfiguring consequences.

Although I have gone, as it were, full tilt against the assumption that irregularities of the teeth are inherited while equally insisting that normal variations are inherited to the minutest details, it is possible to show that when the same cause of irregularity acts on different individuals these normal variations occasionally determine the particular *type* of the irregularity. This, however, is a very complex subject, and beyond a few illustrations little will be said. In these essays, indeed, this consideration is deliberately suppressed. Little good could be derived from introducing this part of the subject before the fundamental principles underlying the etiology of irregularities have been elucidated. Nor do I care at present to commit my present beliefs to print.

Before passing on to environment, the great factor in the causation of irregularities, I shall refer to a small and unimportant class of cases, namely, those

arising from abnormal development of the tooth or tooth germs, *e.g.*:—

(1) Irregularities due to Supernumerary and Supplemental teeth.

(2) Irregularities due to mal-development of the normal teeth, the mal-development varying from slight abnormalities in form to odontomes.

(3) Irregularities due to absence of individual teeth.

(4) Irregularities due to displacement during development not otherwise explicable.

The causation of this group of irregularities from the point of view of prevention is to me beyond explanation.

It will be gratifying to some readers to note that some cases of the inheritances of supernumerary teeth, for example, have, I believe, been recorded. Nevertheless, on account of intermarriage with individuals without this peculiarity, they are not generally transmitted, and when they are it can only be for two or three generations. If it did chance to happen that the inherited supernumerary tooth did not vary in the next generation (which is very unlikely) and brought about the same kind of irregularity which was present in one of the parents, then they could say that such an irregularity was inherited. I trust, however, that the admission of the inheritance of such exceptional cases will in no way be supposed to lend support to such erroneous ideas as are currently promulgated in

text-books. Thus Messrs. Tomes say, "Irregularity affecting a considerable number of teeth may be said to almost always involve material irregularity of the alveolar portion of the jaws, and usually this takes the form of inadequate width or curvature of the arch. Under this head fall V-shaped arches, saddle-shaped arches, disproportions between the two jaws, &c., and here inheritance comes in very strongly."[1] In my opinion it would be difficult to perpetuate a more paralysing idea, for as soon as we understand that such irregularities are not inherited, the sooner shall we find the causes which produce them and consequently the remedy for them. I hope to find Mr. Tomes modifying this idea, and contending for the general truth of the assertion that *irregularities of the teeth are not inherited.*

[1] "Dental Surgery," p. 108.

CHAPTER III

CAUSATION : IRREGULARITIES OF INCISORS

We may now direct attention to the primary cause of most irregularities—*insufficient mastication.*

An investigation of the various ways this factor works and the various results it produces will require to occupy our attention repeatedly, and on account of the complexity of the subject, it may be convenient to bear some typical irregularity in mind while referring to the chief factor (dependent on insufficient mastication) which brings it about.

I shall commence by considering those *irregularities associated with undue retention of the deciduous incisors.*

These irregularities are common, and are one of the first marked indications of the maldevelopment of the dental arches. Let us direct attention to the most important result of insufficient mastication with regard to this form of irregularity—I refer to the insufficient development of the tongue. During the years the temporary teeth are capable of full functional activity, what must be the effect on the tongue of eating the soft pap, liquid extracts and refined foods of the present day, which require little or no chewing? I think it will be evident, from what is known of the

influence of functional activity on the growth of muscle, that the development of the muscular fibres of the tongue is not as great as if it had been used while chewing fibrous food-stuffs which require at least ten times the amount of mastication. The consequence of this is seen in the fact that the deciduous teeth are sometimes not translated outwards, and the spaces which should develop between them do not form, and the alveolar arch is not as broad as it ought to be. Now as the position which the teeth take up is the resultant of two forces, viz., the position assigned by these forces which we call hereditary, and those which we call environmental, it is only to be expected that if these environmental forces are abnormal, so too will be the resultant position of the teeth.

Consider these factors with special relation to the form of irregularity under consideration, viz., the eruption of the permanent incisors internal to the arch of the temporary teeth, while the temporary incisors are still in position. It will be remembered that the developing crown of the permanent incisor lies on the lingual side of the root of the temporary incisor. Now if the temporary incisor is carried forward by the expansile force of the developing tongue, the permanent successor has room to erupt in a vertical or even upward and outward or downward and outward direction according as it is in the lower or upper jaw. Suppose, however, that the temporary incisors are not translated forward, then the initial direction of the developing crown of the permanent tooth is, as it were,

cramped by the temporary tooth; it is thus tilted somewhat backwards towards the tongue and on emerging through the gum is found to be inside the arch of the temporary teeth. The permanent successor having taken this abnormal direction, the absorption of the roots of the temporary teeth does not take place. The apex of the crown of the permanent incisor should, however, keep close to the lingual surface of the temporary incisor, stimulating absorption as it erupts and ultimately succeeding in position its temporary predecessor, and further cause the temporary incisor, by loosening, to induce the outer alveolar plate to be absorbed and the temporary tooth to be shed upwards and forwards in the mandible, and downwards and forwards in the maxilla. In other words, if the temporary incisors are not translated outwards through want of a sufficient development of the tongue, the succeeding incisors are tilted somewhat inwards, and erupt in the direction of the (abnormal) axis of the tooth; while if the temporary teeth are translated outwards, the permanent successors erupt vertically or even also slightly outwards and inducing absorption, succeed in position their temporary predecessors. We cannot believe that the temporary incisors are carried outwards by the "increase in size of the crypt of the permanent teeth behind them," as is suggested by Mr. Tomes. This might cause absorption of the roots; but the tongue is more advantageously placed to act mechani-

cally, and indeed, its gradual increase in size must translate the teeth somewhat outwards.

It may be objected that the absorbent organ controls the direction of least resistance which the permanent tooth will take, but as it will hardly be contended that this is dominated by the action of gravity, this, too, must be influenced at least partly by its immediate environment. If the root of the temporary incisor were to be absorbed independent of the succeeding tooth, and if the forces which I have alluded to did not give it an inward tilt, then we should have the permanent incisors erupting as often outside as inside the temporary teeth, but we do not.

CHAPTER IV

CAUSATION : OPEN BITE

THE fact that the irregularities of the teeth are chiefly due to those developmental defects which proceed from insufficient mastication involves the consideration that those separate developmental defects seldom if ever occur alone. I have endeavoured, and will endeavour to a certain extent to isolate the factors in order to elucidate the subject, but it is only by a recognition of the co-ordinated developmental defects that actual cases in practice can be explained. It is, however, necessary to show that certain irregularities can only be produced by more than one factor acting simultaneously. Take for example the case of *open bite*. I have previously[1] pointed out that on account of the insufficient development of the tongue the normal arch of the teeth is wholly less forward or less prognathous than when there is sufficient development. This fact must be taken in conjunction with another which I will now proceed to explain. It will be remembered that the masseter and the internal pterygoid muscles are inserted in the neighbourhood of the angle of the mandible, the one towards the

[1] *Dental Record*, Nov. 1901.

outer side, the other towards the inner. It will be remembered also that in those races which use their jaws most, the bone of the mandible is largely developed and everted in this region, while, on the other hand, when these muscles are weak, the bony attachment is not so much developed, and in edentulous mouths a large amount of the bone is absorbed altogether, thus making a more obtuse angle. That is to say, the mandible in this region in a well developed specimen is increased in size on the lower border of the body and the posterior margin of the ramus. Now since this development is dependent very largely on muscular activity, what must be the effect of insufficient development of the muscles during the growth and development of the jaw; surely it must nccessarily cause a diminished deposition of bone on the lower border of the jaw, and the posterior margin of the ascending ramus in the neighbourhood of the angle. In other words, the angle must be more obtuse. There is no necessity to assume the existence of rickets and bending of the bone[1] nor of the depressors of the jaw changing the direction of the growth of the jaw,[2] all that we require to observe are the actual facts and a simple recognition of the developmental stimuli. This, I think, fully accounts for the recognised obtuseness of the angle of the mandible in cases of open bite.

Not only does the angle of the jaw become more

[1] J. F. Colyer, *Trans. Odont. Soc.*, Dec. 1896.
[2] Tomes, "Dental Surgery," 4th ed., p. 164.

nearly a right angle on account of efficient development of the masseter and external pterygoid, but it also becomes somewhat everted, and this is a factor which brings about the broadening of the mandible, for it is known that the growth of this bone takes place not only by growth beneath the articular cartilage, but also by deposition of bone at the angle and posterior border of the ascending ramus, while it is absorbed on the anterior border of the ramus, and in general is moulded into its ultimate shape by these processes. If the initial stimulus to development at the angle is outwards, and backwards on the posterior margin of the ascending ramus, and downwards and outwards on the lower border of the body towards the angle, so must this cause the breadth and angularity of the mandible.

Let us now consider the factor first alluded to, viz., the posterior position of the whole arch of teeth combined with the obtuseness of the angle when the muscles of mastication do not develop the angle of the mandible and the backward development of the ramus, and downward and outward development of the body towards the angle of the mandible. It is evident that if the posterior molars erupted in their natural relation to the body of the jaw they would be elevated posteriorly to such an extent that on occluding with their antagonists on the upper jaw the anterior teeth could not be approximated. If they did take up a position such that the teeth could be approximated, the roots of these teeth would tend to

be forced out of the mandible in the neighbourhood of the angle. Nature, of course, cannot permit of such taking place, and a rising posteriorly of the alveolus must take place, and if a compensatory elongation of the teeth and alveolus in the anterior region of the mouth does not take place, then open bite must necessarily come about. It should be remembered, moreover, that cases of open bite are often associated with mouth breathing, and this as I have shown tends to allow the alveolus to increase in depth, and so tends to augment the liability and amount of the deformity.

Before the eruption of the second molar, mastication is performed by the teeth in position, but on the eruption of these teeth, which is accompanied by some discomfort to the patient during mastication, the tongue is called into requisition as the chief masticatory organ. The teeth in front of the second molar are unable at least comfortably to approximate, and the tongue is used to triturate the food so far as may be. In consequence of this there is frequently a quick enlargement of the tongue, and as the mouth is necessarily held slightly open, the tongue may be allowed to get between the upper and lower teeth, and so to retain the openness of the bite. Were it not for this, other compensatory developments might effect a closure of the bite.

Irregularities of the teeth in general come about very gradually, and as this particular variety seems to come on quickly, generally on the eruption of the second molar, it is perhaps necessary to say that it

essentially begins much earlier; for the first molar and bicuspids take up their position to a certain extent in relation to the body of the mandible, and

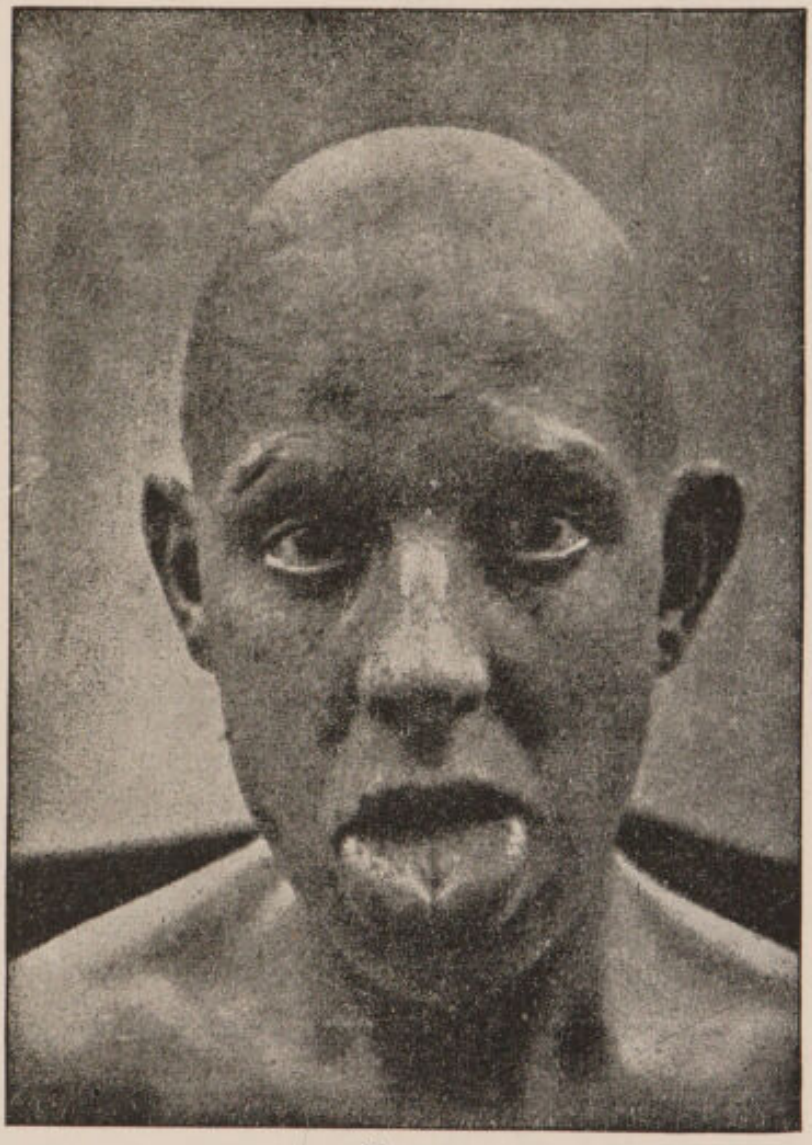

FIG. 1.

Figs. 1, 2, 3. Case of open bite. 1. Photograph showing enlarged tongue. 2. Radiograph. 3. Models. Taken by kind permission from Mr. Lane's paper. *Trans. Odonto. Soc.*, Jan. 1903.

from this they are necessarily somewhat higher than they ought to be, although in relation to the body of the jaw as it exists, they are approximately normal

But then it is to be remembered that the body of the mandible is directed more downwards from the ramus than it should have been, had the developmental stimuli to its growth upon the lower border towards the angle been adequate. It will be noticed that if my explanation of the chief factor of this class of

FIG. 2.

open bite is correct, the irregularity can only be generally expected to occur on the eruption of the second molar. It might occur with the eruption of the wisdom teeth, but this is unlikely, as so many other things may happen to this tooth, and other derangements of the dental arch come about in a crowded mouth before its eruption. Although I have

thus explained the irregularity known as open bite, it is not the only method by which it may come about, for, indeed, any quick enlargement of the tongue or the acquiring of the habit of sleeping with the tongue somewhat protruding, &c., might bring about a similar deformity.

It may here be added that the retarded eruption

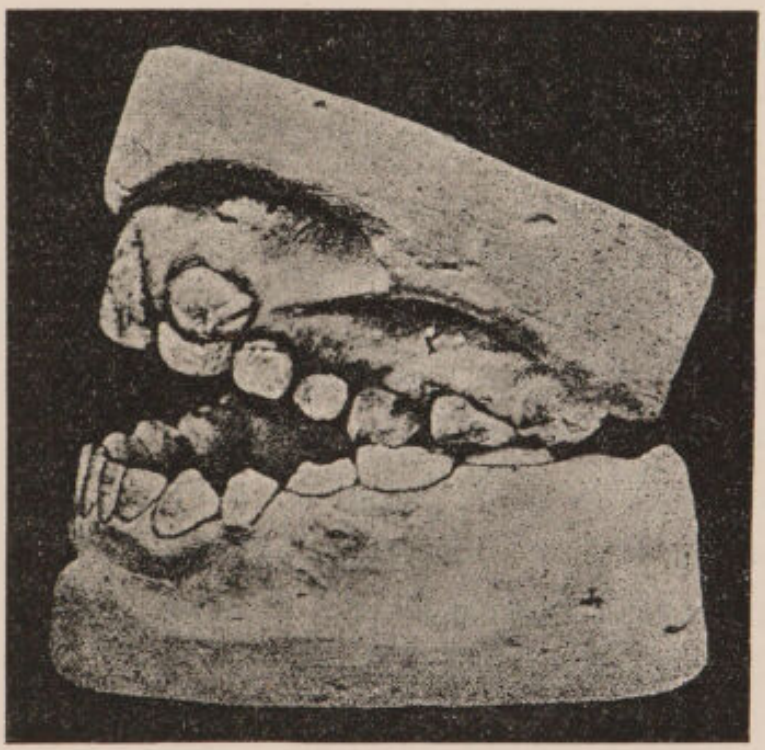

FIG. 3.

displacement and impaction of the wisdom teeth come about from similar causes to those described above.

In February 1901, Mr. Arbuthnot Lane read a communication before the Odontological Society on the Etiology of Superior Protrusion, in which he mentioned that the "functions of the bones of the face are three in number:—

"(1) To surround the passage by which air alone is transmitted to the lungs.

"(2) To sustain the strain exerted by the muscles of mastication, and to transmit and diffuse the resistance offered by the crushed food in the forcible approximation of the teeth during its attrition.

"(3) To surround and protect the eyes."

Further on in this communication he says: "In a normal skeleton the lower jaw is dependent for its perfect development upon that of the upper."

In *The Lancet* of February 15th, 1902, Mr. Lane published a similar article on "Cleft Palate," and in this paper he added a fourth function for the bones of the face, viz., "to accommodate the tongue," and further on in this latter article he mentions, "The pressure exerted by the tongue is an important factor in determining the form of the lower jaw." Whether this important change in and addition to his views were derived solely from cases he has observed, or otherwise, or both, is of no consequence; it may, however, be noted that so far as the lower jaw is concerned, at least, we have Mr. Lane's support for the theory I advanced in 1900,[1] and am now endeavouring to present more fully.

Although Mr. Lane now admits the effect of the tongue on the development of the mandible only,[2] Dr.

[1] "Cause and Prevention of Decay in Teeth." Chap.: The Causes of the Irregularity of Teeth.

[2] Mr. Lane now admits the effect of the tongue on the upper jaw, and for example attributes some cases of superior protrusion to im-

Harry Campbell says, "there can be no doubt that a large tongue, by the pressure which it exerts against the teeth, tends to expand the jaws," [1] and further, from independent observations in general he supports the theory.

perfect development of the tongue. *Trans. Odonto. Soc.*, January 1903.

[1] *Trans. Odonto. Soc.*, February 1902.

CHAPTER V

CAUSATION: NARROW PALATE AND GENERAL CROWDING

We may now direct attention to those factors which bring about an insufficient development of the maxilla with the attendant *general crowding of the upper teeth and narrow palate.* Pursuing the same line of argument as in last chapter, it will be noticed that the lack of development of the tongue through insufficient mastication does not cause both upper and lower teeth to be forced outward. Not only is there an insufficient expansion of the dental arches, but the lower teeth at the side of the mouth tend to tilt inwards as the tongue is not large enough to force them out. The effect of this inward tilt should be observed. The apex of the root remains approximately stationary while the crown moves inwards, and thus the planes of the masticating surfaces, instead of being horizontal, are somewhat tilted so that the inner edge of the plane is lower than the outer. In articulating with the upper teeth, with the outer cusps of the crowns of the lower teeth somewhat high, the plane of the articulating surfaces of the upper teeth is tilted and consequently the roots of the upper teeth

are forced inwards towards the middle line, thus narrowing the arch of the palate (Fig. 4). No doubt there is to a certain extent a counteraction. That is to say, the planes of the articular surfaces of the upper molars are approximately horizontal, and when they occlude with the lower molars which are tilted inwards, they tend to force the higher outer edge downwards and thus cause the roots of the lower

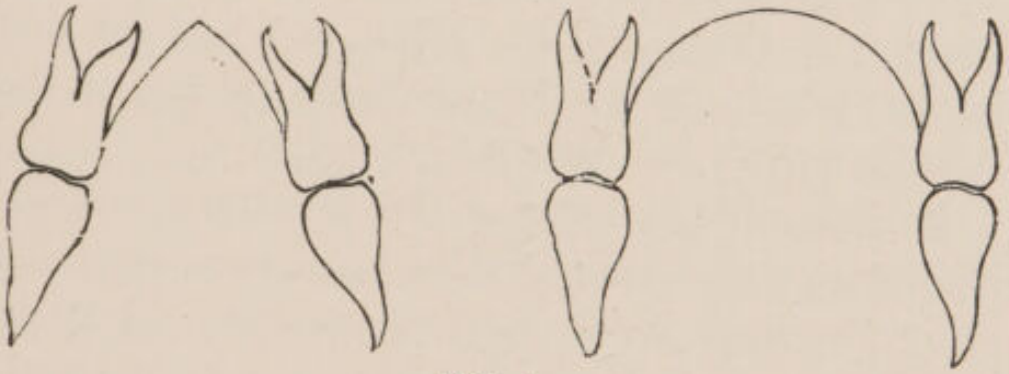

FIG. 4.

Diagram showing the inward tilt of the Lower Molars, and the effect on the vault and Upper Molars. The apices of the roots of the lower teeth are equidistant in both figures.

teeth to travel somewhat inwards. This may be seen to have taken place on almost any mandible, and the posterior molars often appear to be placed on a ledge of bone internal to the ascending ramus. Still these lower molars are somewhat tilted inwards, and the effect on the upper molars and on the narrowing of the vault of the palate is generally amply apparent. It occasionally happens that one or more of the lower molars are tilted inwards so far that the upper tooth occludes with the buccal side of the lower, and thus increases still further its inward tilt.

Let us proceed now to consider the state of affairs when the tongue is well developed and efficient mastication is carried on. In this case the molars and bicuspids are placed approximately vertical, and the tongue by its full development causes the arch of the teeth to be broad, but this is not all. The pressure brought to bear upon the upper teeth by the forcible closure of the jaws during efficient mastication is diffused upwards and outwards towards the malar bones and thence to the skull, and upward and inward principally to the ascending process of the superior maxilla, and thence to the skull.

Now the ultimate effect of this pressure and strain is to cause a thickening of these bones, more especially along the lines in which such pressure and strain is greatest. This thickening is caused by the periosteal deposition of bone, and, to cut the subject short, the malar bones are enlarged, the buttress of the superior maxilla descending from the malar is thickened and enlarged, and the ascending process of the maxilla is thickened and enlarged, and the eyes may even be forced to become a little wider apart by the broadening of the ascending process of the maxilla. It may here be noted that the maxilla is roughly a shell of bone, and, together with periosteal deposition to the outer surface, there goes an absorption of bone on the inside, thus efficient mastication causes an increased size of the antrum. But it is not only the outer surfaces of the bone that the heavy pressure and strain of efficient mastication stimulate to develop, but

it affects the deposition of bone in the articular sutures. Thus, then, there is a deposition of bone along the median suture uniting the maxilla and palate bones and a consequent broadening of the nasal fossæ, especially the lower part, and so the nasal fossæ are enlarged. Then, too, when we consider the effects of the external pterygoid muscles pulling the maxillary bones from the condyles of the mandible right and left alternately, are we not justified in expecting and finding that the various sutures running transversely across the base of the skull between the occipital and maxillary bones should be caused to ossify more fully, thus translating the maxillary bone forwards and increasing the size of the naso-pharynx in the region so frequently occupied by adenoids.

Adenoids and mouth breathing are generally and correctly supposed to cause narrowing of the palate, and I believe with Dr. Campbell that one of the predisposing causes of adenoids is insufficient mastication. Some rhinologists maintain that narrow nasal fossæ are predisposing causes of adenoids, and if the explanation of the cause of the narrowness of the nasal fossæ which I have just given is correct, then this predisposing cause of adenoids comes about from insufficient mastication. Others maintain that the narrow nasal passages are the result of the adenoids; but just as adenoids obstruct nasal breathing, so do they interfere with mastication, for it renders the act of mastication more difficult if the nose, and therefore respiration, is obstructed during the process; moreover, it causes the

jaws to be more or less permanently kept apart both day and night. Besides, the blockage of the nasal passages arrests their further development. (Von Ziem.) Thus the forces which I have described as necessary for the complete development of the maxilla are in abeyance, with the result that the adenoids indirectly cause the narrowing of the nose through inducing conditions similar to, but even worse than, inefficient mastication."[1]

Insufficient mastication, according to Dr. Campbell, predisposes to adenoids by the stagnation of lymph, and the less vigorous circulation of blood in the naso-pharynx. Lastly, it seems to me not improbable that the septic condition of the mouth induced by irregular teeth and the want of the natural cleaning of the mouth by masticating coarse and fibrous food may tend to keep the tissues chronically inflamed, at least after an inflammation has been set up—by a cold in the head, for example. The multitudes of pathogenic bacteria which are present in such mouths can in no way be conducive to the healing of tissue already weakened by inflammatory processes.

Dr. Scanes Spicer drew my attention to the fact that adenoids, mouth-breathing, and caries are intimately associated. He argues that nasal obstruction and mouth-breathing are factors in the etiology of dental caries and vaulted palate.[2] I dissent to a

[1] For a complete account of the views at present held by rhinologists the reader may consult Yearsley's "Adenoids," 1901.

[2] "On Nasal Obstruction and Mouth-breathing as Factors in the Etiology of Caries of the Teeth and in the Development of the Vaulted Palate."

certain extent from this view, believing as I do that they both arise from the same cause—viz., the consuming of food which does not necessitate mastication, although in so far as nasal obstruction diminishes the amount of mastication to that extent I admit the correctness of his deductions.

Let us now return to a consideration of the osseus frame which receives and diffuses the pressure and strain brought to bear upon the upper arch of teeth by the clenching and grinding of the lower jaw during mastication. If the molars especially are used in this process the resistance is maintained chiefly through the maxilla in the region of the malar process and the malar bones. More especially is this the case if the arch of teeth is broad, for to a certain extent in proportion as the arch is broad, so the antero-posterior diameter of the mouth is short. In this case the malar bones are pronounced and broad. If the arch of teeth is narrow, the maxilla thrown well forward, and the anterior teeth fully used, then a much larger proportion of the strain of mastication is transmitted upwards through the fore part of the maxilla and ascending process of this bone, which therefore is then more largely developed and broadened, while the malar bones are proportionately receding. It will be observed that this to a certain extent accounts for the general disposition of the osseous framework of the face, in, for example, the Mongolians, on the one hand, and the negroes and aboriginal Australians on the other. Having referred to the aboriginal Australians, perhaps

I might mention that in this race the squamous portion of the temporal bone is frequently so much enlarged that it articulates with the frontal, a condition which is usual in the gorilla and chimpanzee. Here again it will be seen that the tremendous strain from the mandible by way of the articulation used by this race develops the squamous bone so much more fully, exactly in the line of greatest strain.

Having now endeavoured to show that the development and forward translation of the maxilla is largely dependent on efficient mastication, it is an easy matter to show how the narrow, relatively high palate with the anterior teeth projecting must come about. The maxilla being insufficiently developed is small relative to the teeth, and the crowns of the teeth require for their accommodation the arc of a larger circle than is provided for them by the maxilla. They consequently radiate to a certain extent from the roots which are directed upwards and inwards. Then another force comes into play as each molar is formed above and behind the last molar in position (Fig. 5) and, stimulating the development of the bone on the posterior border of the maxilla in the neighbourhood of the tuberosity, would come downwards and backwards in the arc of a circle to its position as its time of eruption arrives, *if the maxilla had been translated sufficiently forward* by the forces stimulating the development of the maxilla and its forward translation.

In a normal state of affairs the maxilla grows with, and on account of, erupting teeth, by deposition of

bone on the posterior border, the amount being regulated by the erupting tooth itself, but when the

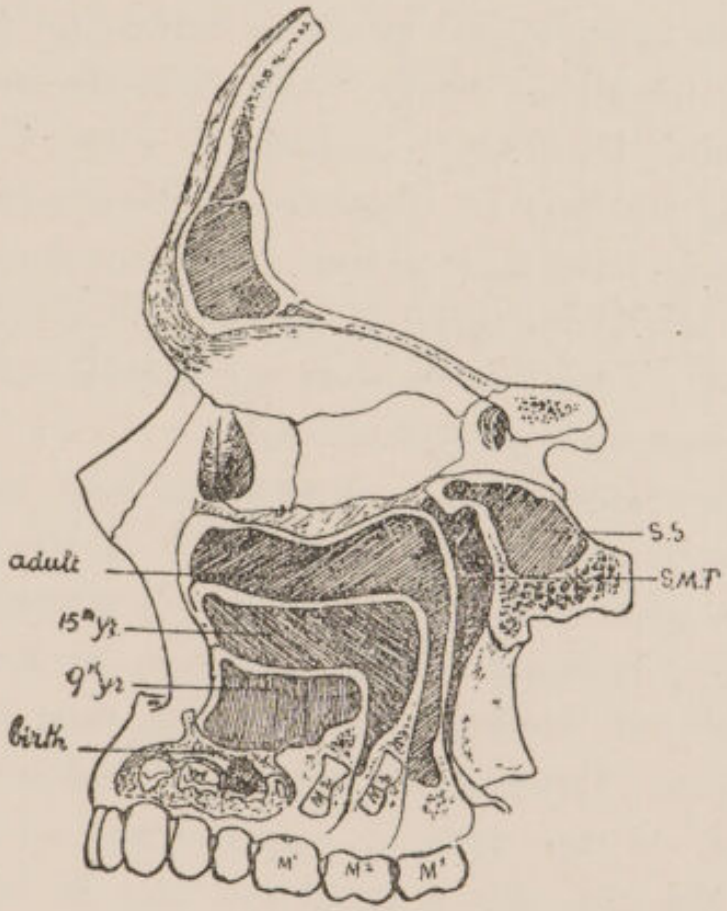

FIG. 5.

The above drawing by Arthur Keith, M.D., F.R.C.S., illustrates the position of the developing molars and the relation of the maxilla to the pterygoid processes. "The diagram is drawn to scale and is founded on material in the museums of the Royal College of Surgeons and of the London Hospital. Four stages are shown—(1) at birth, (2) at the fifth year, (3) at the fifteenth year, and (4) in the adult. . . . While the diagram demonstrates clearly the growth changes which occur in the jaw, it must not be forgotten that, in the body, the postero-superior border of the sinus is the fixed, and not the moving point as represented in the diagram."

maxilla has not been translated forward it simply cannot develop bone in its normal position, as there is no space between the posterior border of the maxilla,

and the pterygoid processes. The consequence is, the erupting tooth presses the tooth in front forwards and downwards, the downgrowth deepens the alveolus and may even bring about open bite, while the forward pressure tilts all the anterior teeth forwards, and even the maxilla itself may be likewise tilted forwards. The bicuspids may be translated bodily forward, but the incisors have their crowns only pressed forwards and perhaps a trifle upwards, the apex of the root often remaining, at least for a time, practically stationary while the crown is pushed forward.

If this explanation is correct, we may ask how "heredity comes in very strongly"? If we assume that the maxilla is not developed on account of a "hereditary tendency" for bone not to be developed by the stimuli which do develop bone, then we may believe this. However, the hypothesis need hardly be discussed, as the idea is preposterous. Then as regards the idea that a small jaw may be inherited from one parent and the large teeth from the other, it is evident that the size of the crowns of the teeth determines the amount of development of bone on the posterior borders of the body of the maxilla, and provided there is adequate forward translation of the maxilla by the developmental stimuli mentioned, then the size of the maxilla will necessarily correspond in size to that of the teeth.

More in pity than with satisfaction, I observed in the 2nd edition of Messrs. Smale and Colyer's text-book, that the idea I previously inferred that there is nor-

mally a relation between the size of the jaws and the size of the teeth[1] had been accepted, for in this same edition the old theory that large teeth may be inherited from one parent and small jaws from the other is still maintained, and so contradicts the deduction that the size of the jaw is normally correlated with the size of the teeth.[2]

[1] "Cause and Prevention of Decay in Teeth," p. 69.

[2] For an exposition of the various other theories which have been and are held, the reader is referred to Dr. Talbot's work on "The Irregularities of the Teeth," 4th edition, 1901.

CHAPTER VI

CAUSATION: OUTSTANDING CANINES, SUPERIOR PROTRUSION, ETC.

"WHEN once you interfere with the order of Nature there is no saying where the results will end;" yet this is precisely what we are called upon to say in tracing out the factors which bring about the irregularities of the teeth. So far we have seen that insufficient mastication gives rise to a corresponding insufficient development of the maxilla and mandible, but the results do not end here, and it is with some of the further results of this insufficient development that I intend to deal in this communication.

We may first refer to the irregularity known as *outstanding canines*. This is a very common irregularity. The upper canine is long and strong, and its coming into position a considerable factor for weal or woe to the dental arch. It will be remembered that before the eruption of the permanent teeth (say about the age of six years) the canine is directed downwards external to the arch of the incisors and premolars which form a continuous row without space for the canine. As the incisors on erupting pass downwards and a little forwards, and the first bicuspid erupts

vertically, a slight space becomes developed between the lateral incisor and the first bicuspid, while, if the maxilla is caused to be sufficiently widely developed, the canine at its time of eruption comes down into place between them. If, however, the arch is not sufficiently broadened, then the canine instead of erupting almost in the line that it will ultimately take up, must necessarily be tilted outwards and erupt in this direction. If the amount of the tilt is small then at a later stage the canine will take up its natural position between the lateral and bicuspid, because the lip presses on the outside of the canine, the root of which on section, is wedge shaped, so that the whole tooth is levered into its position, its wedge shape facilitating the process. A small amount of this levering and wedging may indeed be considered normal. In pronounced cases of outstanding canine, the position of the canine is markedly outwards, and then the lip presses with augmented force upon the buccal surface of the crown towards its tip, and the force of the wedge and lever is such that the canine pretty well must and generally does get forced into its position even though at the same time it may force many of the other teeth out of position to find itself accommodation. The maxillary canine, on account of its wedge-shape, its length, and the mechanical advantages which it has on eruption is the most powerful and important tooth in the series.

Now let us return to other effects of the insufficient

development of the maxilla and mandible. We may see these in typical cases of *superior protrusion.*

The first effect to which we may allude is the *augmentation of the natural curvatures* in the normal arrangement of the teeth. If the arc of a circle be composed of bricks, or teeth, or what not, held together by a matrix which allows of a slight amount of motion, and if pressure be applied in opposite directions at both ends of the arc in the line of the sector it will tend to augment the curvature of that arc, or to make the arc a relatively greater segment of a smaller circle. To refer to the diagram Fig. 6, the arc A B C becomes the arc D E F.

There are several natural curves in the normal arrangement of the teeth. We may refer to the most important.

The hindmost molar, as has been pointed out, is forced forward while the coming into position of the canine tends to force the bicuspids backwards; thus the downward curve of the molars and bicuspids of both upper and lower jaws tends to be augmented.

Similarly the curve formed on a horizontal plane by the upper incisors tends to be augmented, and the most noticeable feature of superior protrusion tends to make its appearance. In regard to the augmentation of the curve in the lower incisor region there is a somewhat complicating feature.

The lower incisors and canines form the arc of a circle with the convexity forward while the apices of these teeth form a curve with the lowest point over

the two central incisors. Now when the teeth get into this normal arrangement without *undue* crowding they tend to retain this position. If there is a rather greater amount of crowding, however, which is necessarily complicated with slight crowding in the bicuspid region, the canine being the centre of the curve formed between the bicuspids and the incisors, tends to be forced upwards, *i.e.*, the curve is augmented while the incisors, especially the centrals, are prevented from rising. As well as being forced to be somewhat depressed, the vertical curvature in the incisor region is thus augmented. Of course it would require a

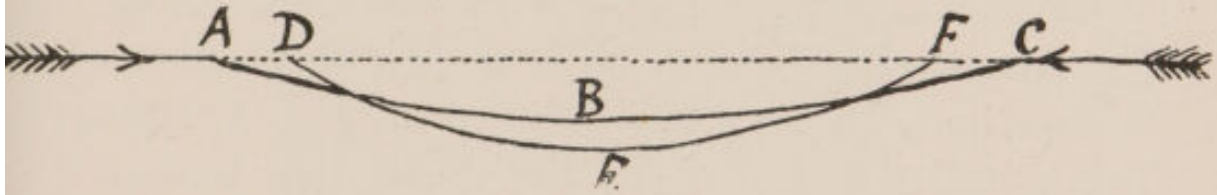

FIG. 6.

rather fine adjustment of forces to retain this arrangement, but it sometimes happens, astonishing though it may seem (and it has been commented on by some observers), that these incisors do not rise to meet their fellows on the maxilla. A case of *partial open bite* may actually be brought about. It may be remarked in passing that the habitual retention of the tip of the tongue between the tips of the lower incisor teeth and the back of the upper incisors may under similar circumstances produce a similar irregularity.

It may be asked why does the horizontal curve formed by the incisors so rarely get augmented like the corresponding curve of the upper incisors? The

consideration of this point involves another complexity. It will be remembered that the mandible in the anterior part is but little changed in general size after the closure of the two lateral halves at the symphysis about the age of six months, while on the other hand the suture uniting the maxillary and palate bones remains open during the whole of the time that the development of these bones goes on. It consequently happens that the maxillary bones, from lack of developmental stimuli, retain the developing teeth more inwards than if the maxillary bones had been developed outwards. Moreover, the crowns of the maxillary teeth are normally outside the lower ones, and the act of masticating or biting tends to force the lower incisors inward, while this force cannot possibly take effect in a similar direction in the case of the upper incisors.

The result of this is that the crowns of the incisors of the upper jaw tend to radiate to a certain extent. On the other hand, the lower incisors and canines in a somewhat deficiently developed jaw tend to have the crowns falling inwards towards the tongue, the initial point from which these teeth develop not depending for its breadth to such an extent on the stimulus brought about by efficient mastication. Thus even if the upper incisors have been carried forward, as in superior protrusion, to such an extent that the act of biting would not force the lower incisors and canines inwards, they can hardly be forced to tilt outwards, as the base (the apex of the roots) is wider than the arc formed by the tips of the crowns.

It may be noted that as the apices of the roots of the lower incisors and canines form the arc of a larger circle than the crowns at the point where they are in contact, and as the teeth are somewhat V-shaped with the apex of the V downwards, there is a considerable space for the canine to erupt. It consequently happens that the canine during eruption does not produce

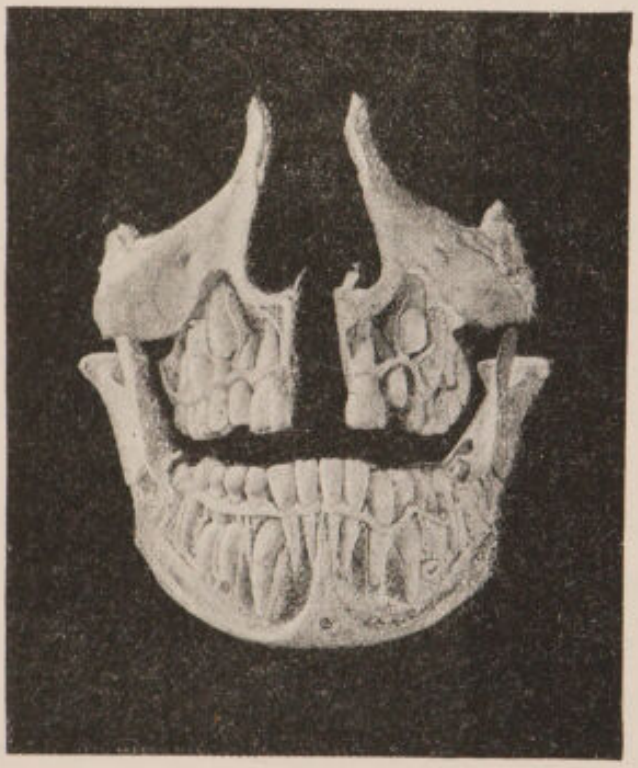

FIG. 7.

any pressure effects until it reaches nearly to its permanent position in the arch, thus a moderate amount of crowding does not produce pressure effects during the eruption of the teeth.

The case is distinctly different, however, when there is marked crowding. The lower central incisors take up their position, then the lateral incisors on erupting tend to crowd the two centrals together at the roots,

the crowns already being in contact, and the centrals take up the most elevated position. Then at a later period the canines on erupting tend to crowd the roots of the lateral incisors towards the centrals. This state of affairs has already been referred to by Mr. J. F. Colyer, who says, "When there is lack of space the canines encroach still more upon the roots of the laterals and force them in an inward and fan-shaped manner."[1]

Now observe that the incisors and canines form a curve, the apices of the crowns of the central incisors forming the *upper* part of the upward convexity, and according to what has just been said, the uprising of the incisors must be augmented by the crowding. That is to say, the opposite curve and effect is produced from what is normal.

The next factor, *the lower lip*, is generally recognised. This is essentially a secondary or tertiary factor; it does not act until other factors have already produced an irregularity. Thus, for instance, when the anterior upper incisors are crowded forward from the various causes already alluded to, the lower lip generally gets behind the upper incisors when the mouth is in a state of rest, and forces them still further forwards. The lower lip, too, may in such cases be used during mastication. The upper incisors having been crowded forward, there is a slight space between these teeth and the lower incisors, and the under lip is used to tuck in food as it were into the mouth. I have seen

[1] *Transactions of the Odontological Society*, November 1899.

this method of eating with its consequent effect on the upper and lower incisors, and think it is sufficient to account for the space occasionally seen between the lower incisors and the gum behind the upper incisor teeth.

We may here refer to thumb-sucking and toe-sucking which loom so largely in some books as causes of superior protrusion. It is possible that they *might* act as secondary factors in determining the kind of irregularity when crowding had already taken place, but that they produce such deformities as anterior protrusion is extremely improbable. Thumb and toe sucking is common among infants and exceedingly rare about nine years when the irregularities begin to appear. Moreover, regular teeth are perhaps quite as common among the children addicted to these habits as they are among those who are not. Some writers seem to have a craze for introducing most extraordinary factors to account for most ordinary irregularities. They seem to attach great importance to the fact that Mr. So and So has recorded a case due to such and such a cause. Not observing that Mr. So and So possibly had not the knowledge requisite to interpret the case properly, that he probably never knew nor even asked how the patient was fed, nor examined the size of the patient's muscles of mastication or tongue. And that even although he had known such things he was liable to error. It is not a safe policy to generalise from single cases, especially when wrongly interpreted, and if only one

case has been seen by one man, on a lonely island, it need hardly be introduced into text-books. I have no doubt that cricket balls or horses' hoofs and thumbs or toes and ill-conceived regulation plates, can all and have all produced irregularities or *displacement of the incisor teeth*, but to say they produced superior protrusion, a complex irregularity associated with definite structural changes and arrangements, would only show that "the most absurd dogmas readily find lodgment where no knowledge has been acquired of the order of nature."

CHAPTER VII

SUPERIOR PROTRUSION: SADDLE-SHAPED ARCH

We may approach the subject of the etiology of superior protrusion from another point of view, and consider the fact that when the teeth are put to but little use they rise as it were unnaturally, and the alveolus follows, thus making a high palate and a low floor to the mouth, which allows of a vertical expansion and lateral narrowing of the tongue.

The teeth are normally arranged round the tongue; they are of a definite size, and are almost invariably in contact with their neighbouring teeth. On the one side of the arch of teeth there is the tongue, on the other the cheeks and lips. Behind and to the outside of the hindmost molar there are the tissues of the cheeks and buccal mucous membrane, while on the lingual side of the hindmost molar the tongue normally presses. It may frequently be seen that the hindmost molar in position is pressed or held forward by these soft tissues—this pressure is the cause of anterior travelling of the teeth. If the tongue is large the incisors are held forward, and the cuspids, bicuspids, and molars well outwards—in fact a good broad arch of teeth is arranged around the tongue. The teeth touch, but are not unnaturally crowded.

Now suppose the tongue is hardly as large on the horizontal plane as is normal when this arch of teeth is coming into its complete form. Say, when the permanent canines and second molars are coming into position. On account of the smallness of the tongue the teeth are in the arc of a smaller circle than if the tongue had been larger. The whole arch cannot slip further backwards *en masse* on account of the forward force behind the hindmost molar. Indeed, the coming into position of the second molar augments the forward force. This and the coming into position of the canines causes a crowding of the teeth in the contracted arch. Assuming that the bicuspids have come fairly well into position, and that they have not been displaced, then in the upper jaw the most likely effect to be produced is a certain amount of anterior crowding, the central incisors generally taking up the V-shaped position. If the mouth is kept habitually open the resistance of the lips to the anterior position of the incisors is still less, and though this condition is often not present in the early stages, it would tend to hasten and augment the forward protrusion of these teeth. This cause has been generally recognised since it was pointed out by Sir John Tomes, but I think the pressure of the cheeks *on account of the openness of the mouth* can scarcely by itself be put forward as the cause of the falling in of the arches of the teeth, as the cheeks would equally press in the teeth—the mouth being kept closed—if the outward pressure of the tongue did not counterbalance the inward

pressure. When the mouth is open, however, the tongue is not held in the position which forces it to hold the arch of the teeth outwards. In other words, when the mouth is open the vertical diameter of the tongue increases, while the lateral diameter decreases and so permits of the narrowing of the arches of the teeth. So, too, enlarged tonsils may depress the tongue, and like results be produced.

At a later stage the upper teeth are so far protruded that they begin to rest upon the upper edge of the lower lip, and as the forward progression of the teeth becomes unimpeded or rather augmented by the lower lip, the anterior protrusion rapidly shows its characteristic deformity. The lower lip then usually takes up the work for itself, and throws out and expands the incisor teeth which bite outside of it, thus relieving the previous anterior crowding and the backward retention of the bicuspids.

So much at present for the upper arch of teeth. Now let us consider the lower arch.

On account of the small size of the tongue this arch is small, and the teeth tend to be crowded; the first molar and the second also, when it comes into place, tend to be pushed forward, while the incisors, which are not held sufficiently forward on account of the small size of the tongue, tend to take up a position which is not so forward as it would have been had the tongue been larger. The available space for the erupting bicuspids is encroached upon and their eruption is frequently retarded for want of space.

The first lower molar when it slips forward has a habit of tilting so that the anterior part of the crown is generally lower than the posterior part. An analogous tilt does not occur as a rule in the first upper molar. In the incisor region the teeth of the lower jaw rise (with the alveolus with them) till the apices of the crowns impinge against the gum. They are not arrested by coming in contact with the posterior bulge of the upper incisors, as normally should be the case.

Let us now consider the upper and lower arches of

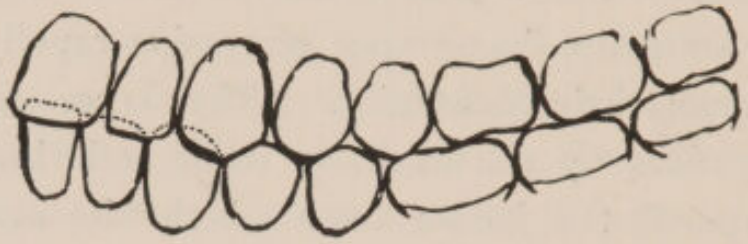

FIG. 8.—Normal articulation.

the teeth together. We know independently of what has just been said, that in a normal mouth the bicuspid and molar teeth, when looked at from the side, present a curve with the convexity downwards (Fig. 8). When the first upper molar is pressed unduly forward, either by the soft tissues referred to, or by the coming into position of the second molar, the downward growth of the teeth in the maxilla in this region would be increased. While on the other hand the upward growth of the lower teeth would be considerably retarded in this region. The accompanying drawing (Fig. 9) of a typical case in practice will show the state of affairs at this stage. It will be seen how

impossible it is for the lower second bicuspids to rise up to the normal level, and how the corresponding upper teeth must erupt or come down correspondingly more. Further, the tilting forward of the lower molars probably forces the upper teeth forward.

Passing on a stage further we see from what has been shown that the upper teeth slip forward while the lower teeth are held back, both in time of eruption and in place, and it will also be observed that when the bicuspids rise so as to meet the teeth of the upper jaw with which they should interdigitate, they rise and

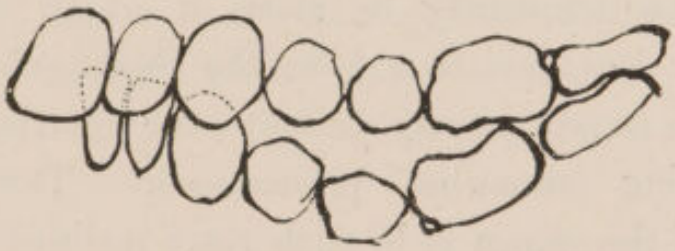

FIG. 9.—From a case of incipient anterior protrusion. Æt. 12½.

occlude almost directly with the corresponding bicuspids, instead of being a half a tooth in front. If, as frequently happens, they are a trifle more than half a tooth too far back, and the anterior planes of the cusps of the lower bicuspids occlude with the posterior planes of the cusps, of the corresponding upper bicuspids, then the forcing forward of the upper front teeth is augmented, while not only are the lower bicuspids thus forced back but as a result of this malocclusion the condyle tends to be forced back and the whole of the body of the maxilla gradually forced to take up a more posterior position than it otherwise would have. So, too, the normal stimulus for the

backward growth of the mandible is arrested. In this case we have not only superior anterior protrusion but also inferior recession of the teeth.

There are other concomitant abnormalities often associated with this deformity, but the above description, I think, not only shows the cause of anterior protrusion but also of the various other conditions typically associated with the deformity.

The *normal variations in shape and arrangement* of the teeth may to a certain extent determine the character of the irregularity. A variety of upper molar may frequently be seen in which there is greater or less deviation from the rectangular figure which the crown usually presents, the anterior buccal angle being somewhat pronounced. The mesial surface of the crown is in such cases inclined inwards and backwards, and the molars may have a somewhat imbricated appearance. When this is the case the second bicuspid when it erupts in a maxilla which has not been sufficiently developed, tends to slip inwards over the oblique mesial surface, and there is therefore a tendency for the *saddle-shaped arch* to make its appearance. Again, on account of the more strictly rectangular shape of the lower teeth behind the first bicuspid in a crowded mouth, there is not the same tendency for lateral deviations of these teeth. Hence irregularities of the lower teeth are most likely to occur in the front of the mouth.

Another secondary factor in the production of the particular variety of irregularity may be mentioned.

It is *atavism*. It may perhaps be thought that this is an impossible factor, as prehistoric man and apes have particularly regular teeth. Still, in the apes there is a diastema between the upper lateral incisor and the canine into which the lower canine passes when the jaws are closed. Now this lower canine acts as a wedge and forces the four upper incisors together in a regular way. In the human subject there is very frequently a slight spacing between the upper front teeth, and without crowding the lateral incisors may be somewhat irregular, perhaps, from the want of the long lower canine. There is another irregularity to which this atavistic peculiarity may give rise. If the maxilla is somewhat deficiently developed and the teeth are a little crowded, the diastema or space between the lateral incisor and the canine may, on the coming into position of the canine, allow it to slip forwards and to come into position in front of the tip of the lower canine. This, together with other factors already alluded to, may tend to the production of superior protrusion.

It will be observed that these two last factors, viz., the shapes of the teeth and atavism, must be considered hereditary, and they may serve as illustrations of the fact that though heredity cannot be called the cause of the irregularity, yet it may determine the type which may be brought about provided mal-environment necessitates some irregularity.

Perhaps another example of heredity determining the type of the irregularity might be mentioned. No

doubt brachycephalic and dolichocephalic individuals are predisposed to a somewhat different arrangement of the dental arches. I am inclined to think that the U-shaped arch is generally associated with dolichocephaly and is not an irregularity of the teeth at all, but nevertheless this may predispose to different types of irregularities under the conditions which cause such. With regard to dolicho and brachycephaly, however, it may be mentioned that they are not altogether hereditary themselves. Thus according to Professor M'Alister the following factors enter into the causation of brachy and dolichocephaly: 1. The development of the brain; 2. Dentition; 3. Muscular attachments; 4. Balancing.

CHAPTER VIII

IRREGULARITIES OF INDIVIDUAL TEETH

We may now further direct attention to some factors which, though in themselves of but secondary importance, it is necessary to mention in order to elucidate some of the causes of the varied complexities of the irregularities of the anterior teeth. These act principally by affecting individual teeth.

We may mention the influence which the shape of the crown of the erupting tooth has upon its direction of eruption. Consider, for example, the upper central incisor. It will be remembered that the crown is flat or slightly convex in front, while the posterior surface is somewhat concave and the basal ridge or cingulum may be well marked and present a blunt prominence. A vertical section will show an appearance such as is depicted in the following diagram.

Now it is obvious that if an object of this shape is forced downwards through a resisting medium it will not advance exactly in the line of the original force, for the resistance on the posterior is greater than it is on the anterior surface. The diagram indicates the effect produced on erupting. It will be further remembered that the mesial angle of the crown is sharper or less rounded off than the corresponding

distal angle. This, too, has its influence on the erupting incisor, causing the direction of the erupting crown to travel somewhat towards the median line. If this mesial angle is deficient and does not make the two teeth approach each other in their descent, there is a tendency for separation of the central incisors to result. The lateral incisors, for similar reasons, may come into position somewhat separated from the central incisors.

FIG. 10.

After the eruption of the incisors, even if there is a slight space between them, the mesial angles of the incisors tend to come nearer the middle line and so to fill up the space which may exist on eruption, for the vertical impact of the lower incisors on the somewhat oblique upper incisors tends to increase this obliquity till the upper incisors are all touching. A reference to Fig. 11 will make this obvious.

FIG. 11.

Then, again, the obliquely inward tilt of the upper incisors is partly due to the amount of intermaxillary development of bone carrying the developing teeth apart, especially the apices of the roots. The lack of separation of the roots is proportionate to the lack of stimuli to intermaxillary development. If we add to

this the fact that on account of lack of the stimuli to periosteal deposition over the developing canines, we see that the roots of the whole six front teeth may be cramped and cause the crowns to radiate somewhat. As the centrals and laterals erupt considerably before the canines they may erupt apparently with plenty of room, but really the roots are indeed excessively crowded. The forward direction of those teeth completely relieves the pressure of the parts outside of the gum, and the *superior protrusion* takes place *without apparent crowding*. Associated with such a condition as this, there goes a compensatory development of the alveolus on account of the incisors not meeting their natural antagonists, and further on account of this hypertrophy of the alveolus, the upper lip may appear rather short. It will thus be seen that hypertrophy of the alveolus in the incisor region and short upper lip are to be regarded as *results* of the forces which give rise to superior protrusion and not causes of it.

Moreover, if a little thought is given to the subject, it will be obvious that it is the lower lip which is of importance in retaining the upper incisors from protruding, and if the upper lip is short, the lower lip is all the more effectual in retaining the upper incisors in their proper position when the lips are closed.

It is of greater importance than I have briefly indicated that the effect of insufficient development of the maxillæ, long before the eruption of the teeth, should be recognised. A slight initial deviation may

ultimately give rise to a very different direction of eruption, just as the initial deviation which the pointsman makes carries the train ultimately to a totally different destination.

Here a word may be said on the total displacement of individual teeth. May it not be that some slight mechanical force may give rise to the initial deviation. Perhaps it may be found that dilaceration is frequently met with in cases of total displacement of individual teeth.

So far we have considered the several factors separately as far as possible, and, indeed, some of those secondary factors which we have just considered lend themselves to easy isolation. There is, however, a factor of very considerable importance, which in actual cases as they present themselves to us is generally mixed up with the various factors already described. I have, however, avoided mentioning it, for "scientific truths, of whatever order, are reached by eliminating perturbing or conflicting factors, and recognising only fundamental factors. When, by dealing with fundamental factors in the abstract, not as presented in actual phenomena, but as presented in ideal separation, general laws have been ascertained, it becomes possible to draw inferences in concrete cases by taking into account incidental factors. But it is only by first ignoring these and recognising the essential elements alone, that we can discover the essential truths sought."

This important factor is ill-health, which we may separate for convenience into *malnutrition and disease.*

Malnutrition varies much in degree, and when it is temporary or slight has, under normal circumstances, little effect. But if long continued, even though slight in amount, the results may ultimately be great. Children are generally plump, and the adipose tissue in and about the tongue under such conditions is greater than if the child is more or less emaciated. Now, of course, the size of the tongue, whether due to adipose tissue or muscular fibre, has the same effect in inducing the expansion of the arches of the teeth; and conversely, if the adipose tissue is abnormally small in amount so, too, will the arches of the teeth tend to be correspondingly ill expanded. In a general way it may be said that the amount of irregularity is proportionate to the amount of emaciation of the child from infancy onwards. Deficiency in mastication *alone* cannot bring about pronounced cases of irregularities.

There is another way in which malnutrition works its pernicious results. When the amount of nutrition is somewhat less than normal, some or all organs in the body must be deprived of a due proportion of nutriment, and on account of "the instability of the homogeneous" one or other organ is deprived most. What determines that the jaw in such cases shall fare worst is the simple fact that it is not so fully stimulated to development on account of the normal stimulus of mastication being abnormally small. Those organs making most demand on the limited supply fare best, and conversely.

No doubt actual diseases act through the blood in the way indicated, and it thus makes it difficult to say whether certain specific diseases acting on bone, such as rickets, conform to these principles, or whether beyond the general defective nutrition which brings about this disease there are also associated certain specific changes in the bones of the jaws. I do not know that there is any evidence to support this latter supposition, although the characteristic shape of the head and the yielding nature of the bones might produce some slight modification of the proper development of the jaws,

Disease may act more locally as when, for example, enlarged tonsils impede the circulation to the lower jaw, or when adenoids induce the habit of almost continuous open mouth and mouth-breathing. Another way in which disease acts is when caries of the teeth giving rise to pain prevents mastication, or when approximal decay lets the teeth approximate. When this latter occurs in the mandible and not in the maxilla, or *vice versâ*, there is a tendency to bring about mal-occlusion of the upper and lower teeth, when the permanent ones come into position.

CHAPTER IX

SUPERIOR PROTRUSION: UNDERHUNG AND EDGE-TO-EDGE BITE

A FACTOR of distinct and general importance in the production of irregularities is *the length of the neck.* As extremes may be mentioned the long, thin-necked types, generally with prominent narrow nose and receding chin, and, on the other hand, the short-necked, stout, or square-built types, with broad jaws and rather prominent chin. Perhaps it may be doubted if the generalisation that a long or a short neck should as a rule be associated with the other characteristics given respectively above, but a fair amount of observation will convince any one that such an association exists. Moreover, the truth is already recognised by artists in their portrayal of the delicate and diseased compared with the muscular and healthy. Normal variations within limit are, of course, to be expected, and the effect of such limited variations may be negligible as regards their influence on the dental arches; but marked extremes, usually the result of abnormal environment resulting in disease, cause corresponding abnormalities in the arrangement of the teeth. As illustrations of the long-necked types we may take the flat or narrow-chested consumptive, and of the opposite extreme the hunch-

back. In the former the chin is generally receding, in the latter it is, as a rule, somewhat prominent and may even be "under-hung." A condition which often obscures the relationship between emaciated states and the results which it brings about in the dental arches is the fact that protracted emaciation during the developmental period may be succeeded by something approaching obesity in later life. In such cases the results of the emaciation in youth may be indelibly stamped on the dental arches however much it may be obscured in later life by a layer of fat. Similar to this is the fact that in later life the tongue may enlarge without being able to produce similar effects to those which usually occur in early life.

It will be observed that a consideration of these facts makes it necessary to find the explanation.

The anatomical relations should be borne in mind, and especially it should be noted that the tongue has the hyoid or *os linguæ* for its base or foundation. Now, if the hyoid is continuously dragged downwards, so, too, the whole tongue will be dragged downwards. When the lungs and chest are not well developed and when the general health is below par, the ribs tend to fall. The muscles used in forced inspiration are seldom called upon, and their contractions are hardly what they should be in a state of health. If the ribs and sternum fall on account of such conditions as have been alluded to, then we get a long neck, and there is directly and indirectly an abnormal and continuous strain on the hyoid which ultimately dis-

places it downwards. The concomitant effects of the small tongue, or depressed tongue, which is so far its equivalent, become manifest. This, no doubt, largely explains the relatively greater frequency of irregularities in females of the upper classes, as among them the arms and muscles of the chest are not well developed from lack of exercise. It is not only by way of the base of the tongue that this drop in the position of the thorax brings about its effect on the jaws. To a certain extent, no doubt, a slight strain is thrown on the skin, and a similar effect is produced to what may be brought about by the drag of the skin caused by a cicatrix.

If a continuous drag is made on the hyoid and lower jaw on account of the depressed position of the thorax, then we have a predisposition to open mouth and mouth-breathing. In a state of rest the jaws are not firmly closed, but a small interval exists between the dental arches. When increased tension is made on the lower jaw, then of course the space between the dental arches is increased. These facts account for the observation that contracted jaws often occur without blockage of the nasal passages. No doubt, too, mouth-breathing may predispose to adenoids and the train of evil effects produced by them. All this is of much importance on account of its bearing upon its prevention and treatment.

Very different is the effect when the health is vigorous, and when athletic exercises augment the muscles of forced inspiration, and the lungs and the

thorax are well developed. Here we have no undue drag upon the hyoid. Indeed, the structures which go to form the thick neck tend to press the mandible forward and stimulate its development in that position. Good health and vigorous activity allow all relations to be well maintained, or tend to make them so, if they originally were not.

We referred to the case of the hunchback. Here the upper thoracic ribs are forced upwards, the distance between the sternum and hyoid is abnormally small, the tongue is thrown forward, the neck is abnormally thick, and actual protrusion of the mandible or underhung jaw may be brought about. But although a short thick neck predisposes to the underhung jaw, it may come about from quite other causes. Generally it is due to an initial backward deflection of the upper central incisors by temporary teeth. With this initial difference observe the course of events. The lower teeth are somewhat protruded, and the upper teeth are correspondingly pressed backwards. Now, therefore, we have the upper central incisors wedging between the teeth and the tongue, so as to force the central incisors and the alveolus, and then the lateral incisors of the lower teeth forwards, while succeeding teeth from above come down to wedge out the inferior arch of teeth. Ample room is thus provided for the lower teeth, while the upper teeth are cramped and retarded in their eruption. The lower teeth thus take up a position outside and more anterior than the upper teeth, and the lower jaw may

be still further pulled forward by the action of the inclined planes of the cusps as well as by the forces above described.

The edge-to-edge bite, although sometimes supposed to be produced from similar causes to those which produce the underhung jaw, is as a rule etiologically totally unrelated. In this form of occlusion the lower jaw is in the first instance thrown forward voluntarily, so as to crush the food between the front teeth. Partly by pressure and partly by wear the incisive edges come to have a horizontal and flattened surface. The curve downwards of the molars and bicuspids for similar reasons becomes obliterated and the cusps become worn away. This form of occlusion, therefore, can only be expected when mastication is excessive and the food of a quality which will subject the cusps to considerable wear.

We may now allude to current ideas such as are exemplified in Mr. Tomes' views on the causes of the underhung jaw and the edge-to-edge bite. Referring to the former he says: "The cause of this want of proper relationship between the upper and lower jaws and their respective teeth is in many cases very obscure. In certain families it occurs as an hereditary character. In certain cases the deformity may have been consequent upon the relatively tardy eruption or the inverted [*sic*] position of the upper teeth in infancy."[1]

The allegation that it is hereditary in certain fami-

[1] Tomes, "Dental Surgery," 4th ed., p. 158.

lies is, of course, no explanation. It merely amounts to saying that we don't know what produced it in the parent and the very same thing produced it in the child. With regard to the "other cases" he gives us no hint of what may have caused the tardy eruption or the "inverted" position of the upper teeth in infancy, nor in what way such tardy eruption or "inverted position in infancy" could bring about the deformity. Mr. Tomes gives a quaint and characteristic explanation of edge-to-edge bite in the following page. He says that "it may be regarded as differing only in degree from those cases is which the upper front teeth are inverted, and as dependent upon similar causes which have operated with less force." [1]

This explanation is therefore "very obscure." *Vide supra.*

[1] Tomes, "Dental Surgery," 4th ed., p. 159.

CHAPTER X

CLASSIFICATION

HAVING now completed the constructive part of this theory, by way of recapitulation I append a sketch of an etiological classification. I am encouraged to do so, as in the text-books currently used the classifications given are anything but satisfactory. In Messrs. Tomes' "System of Dental Surgery" classification is hardly attempted, and the only clue to connection throughout the section on irregularities is the occasional introduction of conjunctions at the beginning of paragraphs, when no other thing unites them. This may easily be verified by reading carefully the first few pages of the section on irregularities of the teeth.[1]

In Messrs. Smale and Colyer's "Diseases and Injuries of the Teeth,"[2] the divisions of the different parts of this subject may not be natural, but they are disjointedly elaborate. Here we have primary divisions marked with capital letters, A.B.C., &c., these are divided by large Arabic numerals, 1, 2, 3, &c., these again are divided by small letters, a.b.c., &c., which

[1] Tomes, "Dental Surgery," 4th ed., p. 107 *et seq.*

[2] "Diseases and Injuries of the Teeth," 2nd ed. See especially p. 94, 95.

again are divided by little Latin numerals, i. ii. iii., and then again by Greek letters, $\alpha.\beta.\gamma.$, &c. The starry Heavens are mapped with the aid of constellations and the Greek alphabet, but the irregularities of the teeth appear to be more numerous and varied than the contents of the universe itself.

IRREGULARITIES OF THE TEETH ASSOCIATED WITH
Normal tongue.
Normal vault.
Normal maxillæ and mandibles.
Developmental defects of teeth.
Irregularities due to Supernumerary Teeth.
Absence of Teeth.
Abnormalities of Teeth.
Spaced superior incisors.
Irregularities of Lateral Incisors without crowding.
Simple mechanical displacements due to extraneous forces.
Associated with Dilaceration.
Associated with Deflection.
Small tongue.
Insufficiently developed maxillæ and mandibles.
Narrow vault.
Crowded teeth.
Undue retention of deciduous incisors.
Irregularities of incisors.
Mixed bite.
Not involving or accentuating the natural curvatures of the dental arches.
Rotation of teeth on their own axes.
Outstanding canines.
Certain displacements of individual teeth.
Involving and accentuating the natural curvatures.
Associated with Secondary hypertrophy of
Maxillæ
Mandible
Superior protrusion.
Underhung jaw.
Minimising the natural curvatures. Edge-to-edge bite.
Saddle-shaped maxilla.
V-shaped maxilla.
Open bite.
Associated with concomitant changes in antagonising teeth.
Large tongue.
Broad vault.
Open bite.
General forward and lateral displacement of teeth.

CHAPTER XI

DESTRUCTIVE CRITICISM: HEREDITY—RACE CROSSING—SEXUAL SELECTION

PERHAPS the account I have given of the general causes of irregularities and their principal varieties may not carry complete conviction, but yet by some it may be granted that it approximates the truth more closely than the general causes which are currently advanced.

A criticism of these may be useful. The general causes usually advocated include heredity, sexual selection, race admixture, and civilisation.[1] With regard to heredity I have already dwelt on this subject, and intend here only to refer to it in the light of the "use inheritance" hypothesis. The idea is that the comparative disuse of the jaws in masticating tends on this account, after several generations, to bring about a corresponding diminution in size of the jaws. Mr. Spencer is at present perhaps the ablest exponent of this view, and unlike some who consciously or unconsciously follow his teaching he expresses his beliefs clearly. The following quotation sets forth the view:—

[1] Smale and Colyer, "Diseases and Injuries of the Teeth," 2nd ed., pp. 61, 63.

"There are, however, some modifications in the sizes and forms of parts which cannot have been aided by natural selection, but which must have resulted wholly from the inheritance of functionally-caused alterations. The dwindling of organs of which the undue sizes entail no appreciable evils, furnishes the best evidence of this. Take, for example, that diminution of the jaws and teeth which characterises the civilised races, as contrasted with the savage races. How can the civilised races have benefited in the struggle for life by the slight decrease in these comparatively small bones? No functional superiority possessed by a small jaw over a large jaw in civilised life can be named as having caused the more frequent survival of small-jawed individuals. The only advantage accompanying smallness of jaw is the advantage of economised nutrition; . . . if it did not cause a *frequent* survival of small-jawed individuals where large-jawed individuals died, natural selection could neither cause nor aid diminution of the jaw and its appendages. Here, therefore, the decreased action which has accompanied the growth of civilised habits (the use of tools and the disuse of coarse food) must have been the sole cause at work. . . . From generation to generation this lessening of the parts consequent on functional decline has been inherited."

The general criticism of the "use inheritance" theory we need not attempt here. It may merely be pointed out, however, that the upper jaw is essentially passive in its function, and no claim is made by the

believers in this theory that things having only a passive utility are explicable as the result of functionally wrought modifications. Thus, therefore, "use inheritance" offers no possible explanation of diminution in size of the upper jaw.

With regard to race-crossing also little need be said, as the contention that the small jaws of one parent can be inherited and the large teeth of the other has already been dealt with, and shown, let us hope, to be quite untenable.

Sexual selection, or, as it is sometimes called with doubtful elegance "Selective breeding," is put forward as a general cause of irregularity of the teeth. Mr. Tomes, although admitting that much can be said against the theory, argues as follows: "For if the type of face nowadays considered to be beautiful be investigated, it will be found that the oval, tapering face with a small mouth, &c., does not afford much room for ample dental arches. On the other hand, the type of face which we considered bestial has a powerful jaw development. Perhaps generations after generations seeking refinement in their wives may have unconsciously selected those whose type of face hardly allows the possibility of a regular arrangement of the full number of teeth."[1]

Now on æsthetic points there is room for considerable divergence of opinion, and I have no doubt there are many artists who consider a well-developed chin and mental prominence to be a characteristic which

[1] Tomes, "Dental Surgery," p. 112.

is certainly more human than bestial, and that the broad dental arches giving fulness to, and preventing the falling in of, the cheeks, and consequent prominence of the cheek bones, may help to beautify a face. So, too, full arches of teeth prevent the inane appearance caused by the falling in of the arch in the canine region. Nor is the oral orifice necessarily large when the oral cavity is large; indeed the oral orifice *appears* somewhat smaller when the arch of teeth is of a normal breadth. Add to this the fact that crowding of the teeth very frequently gives rise to anterior protrusion of the upper incisors, and then add the effects of the greater frequency of caries, toothache, probable loss of teeth, possibly suppurating roots, anæmia, digestive troubles, ill-health, ill-temper, &c., following in their wake, and we may be justified in doubting whether man did, generation after generation, select such types. But let us look at the question from another point of view. If there has arisen in man an unconscious preference for small-jawed women, this must have come about in one of two ways; either those possessing this instinctive preference have survived, and the others, who did not possess it, have fallen out of existence, or there must have been a superorganic evolution of an ideal of beauty which was more or less universally recognised. I think the former idea is out of the question, and the latter would have no appreciable effect, compared with the natural, inherent, powerful passion which attracts the sexes. Since Darwin's time, ideas on the

subject of sexual selection have been greatly modified, and with regard to mankind, further than the effect which it has in selecting types with qualities arising from full vitality, good health and its concomitants, it has little effect, and it must always be ultimately controlled by natural selection.[1]

I had thought the above would have been sufficient, but apparently it is not, and Mr. Tomes' view is quoted and approved by some who have read both arguments. Further thought and observation have made me take up a positive rather than a negative position, and now I am convinced that sexual selection, so far as it has any effect at all, tends to *prevent* the irregularities of the teeth. As in many other cases sexual selection and natural selection act hand in hand. By their joint action, and by rational feeding, we may hope that one day irregularities of the teeth may be as rare as they were in prehistoric times.

Let us return to Mr. Tomes' argument.

We may ask which varieties of irregular arrangements of teeth and small jaws excel in beauty the normal well-developed jaws and regular arrangement of the teeth.

Is it superior protrusion with the small lower jaw and receding chin? Or is it the irregularity giving rise to open bite? Or is it the underhung jaw? Or is it outstanding canines, or simply a general zig-zag crowding giving rise to variations in the dirtiness of individual teeth? If it is not one of these, then what

[1] "The Cause and Prevention of Decay in Teeth," pp. 70–71.

form of irregular arrangement is it that men prefer above all others to such an extent that they have allowed the women with well-developed jaws to perish barrenly.

Is it not much more in accord with human nature that the regular outline associated with regular teeth has had the preference? Those women whose irregular protruding or zig-zag teeth, with deficient chins and concomitant deformities, have rather been left than selected. It is not only that the irregularities are not beautiful in themselves, but the predisposition to caries to which irregularities lead, and the ill-health that is a very constant concomitant of irregularities and caries, lead frequently to the elimination of those with irregularities of the teeth. It may be replied, however, that as a matter of fact the jaw is becoming smaller. If sexual selection has anything to do with it, it comes in by selecting rather those types with a REGULAR arrangement of the teeth. Those types with large teeth are more liable to have irregularities, because large teeth cannot be arranged regularly round a moderately sized tongue. Thus sexual selection primarily diminishes the size of the teeth by eliminating those with large teeth and irregular arrangement and its sequelæ, and as a secondary result the jaws to a certain extent tend to become smaller on account of the relationship between the size of the teeth and the size of the jaw. But however much the size of the jaw is dependent upon the size of the tongue, it is not wholly dependent thereon, otherwise we should

not possess the prominence of the chin. There is, therefore, this difference which allows, to that extent of the regular arrangement of the diminished size of the teeth. The reason that irregularities of the teeth are on the increase is simply that the refinement in

food has been more rapid than the effects of sexual selection and natural selection combined. If we agree to the above explanation, it will be noticed that we shall be in accord with the general principle that sexual and natural selection are not antagonistic but work harmoniously together.

The accompanying illustrations, reproduced by kind

permission of *The Lady's Pictorial* and Messrs. Harrods, Limited, may serve to show that well-developed jaws may not look so very "bestial."

I doubt if the reader could improve upon the illus-

trations by converting the face into the "oval tapering" variety. The illustrations further show that small oral orifices may be associated with ample buccal cavities. All men are not dentists, and most are content to linger on the threshold without investigating internal dimensions.

CHAPTER XII

DESTRUCTIVE CRITICISM: CIVILISATION

CIVILISATION, as might be expected, is always put forward as a general cause of irregularities. It may be regarded as one of those delightfully vague suggestions which are thoughtlessly advanced, for, without explanation, it might as well be said that anything, from a steam-engine to a telephone or a top hat, is a cause of irregularities of the teeth. To be of any value it must be indicated *how* civilisation brings about the irregularities, and it must be shown that civilisation is a necessary antecedent and not simply a general concomitant of irregularities.

Knowing as we do that "thousands" of Chinese skulls have been examined and only one trivial case of irregularity has been observed, and knowing also that the Chinese belong to the most ancient civilisation extant, and further, having been taught that irregularities are frequent among Hawaiians, we must be careful about laying too much credence on the idea that civilisation is anything more than a frequent concomitant of irregularities.

Let us see *how* civilisation is supposed to act by those who endeavour to explain. That the maxillæ are too small to hold the teeth in their normal posi-

tion is observed, and this, it is contended, is *partly* produced through the arterial system. "The brain and the osseous structures of the face derive their main blood supply from the same source, viz., the common carotid arteries. The strain of modern education—indeed the whole environment of the individual—entails a greater call upon the brain than a primitive mode of living, and thus necessitates a larger supply of nutritive material to that structure. This increased supply is probably provided at the expense of the osseous structure, including the teeth, with the result that these structures degenerate. Modern food and cooking, by calling forth less effort in mastication, may also indirectly deprive the jaws of a certain amount of nutrition."[1] If the above argument be true, we may ask if the exercise of the limbs by diverting the blood to these members causes other organs to degenerate, or, in general, if the exercise of any organ or organs correspondingly causes the remaining organs to degenerate. No doubt, during the exercise of one organ, *e.g.* the stomach, a considerable amount of blood is diverted to this organ, and the other organs are, to a certain extent, temporarily depleted, but this is transitory, and in

[1] Smale and Colyer, "Diseases and Injuries of the Teeth," 2nd ed., p. 62.

It is just possible that this last sentence is really meant for an appreciation of the views I had previously published, as it does not appear in the first edition of Messrs. Smale and Colyer's book. But the authors do not mention whether the "indirectly" refers to the effect of successive generations of less effort in mastication, or whether they would maintain that these structures "degenerate" *de novo* in each individual.

the case of the jaws, if they were normally used, they in their turn would divert the circulation in their direction, and on the whole they would receive their due share of nutrition. In order that the strain of modern education should deprive the jaws of their proper supply of blood, it would be necessary for the strain to take place during the act of mastication. But it is doubtful if the strain of modern education is so very terrible. We know that irregularities of the teeth are at least as common among young women belonging to the upper classes as among men or young women of the less favoured classes. Yet their mental development at maturity generally does not rise above the level of second-rate novels, and they can scarcely read an elementary treatise on such important and everyday subjects as the mental development of children, or upon the principles of dietetics.

That it is through the arterial system in the manner suggested in the quotation is untenable for a different reason. The fact that a large proportion of cases of irregularity are associated with local *hypertrophy* of the maxillæ and mandibles shows plainly that bone-forming material is amply supplied even in cases of extreme irregularities. It is impossible to attribute the hypertrophy associated with superior protrusion to the diverting of the blood by over-pressure in mental development. Nor is it possible to believe that depriving the jaws of blood through lack of mastication could bring about these hypertrophies. If the small size of the maxilla and

mandible were due simply to deficient supply of blood on account of insufficient mastication, it would be impossible to explain the fact that the Cretins have ample dental arches, for the muscular activity of these people is notoriously meagre. When we recognise that it is principally through the tongue that the developmental stimulus of the maxillæ and dental arches is brought about the explanation is simple. Though Cretins are enfeebled, inactive, and diseased, they have abnormally large tongues.

We have now reviewed the four main causes which form the general foundation of the current theories of the etiology of irregularities of the teeth. We see that not one of them as presented nor all four combined throw the faintest gleam of light upon the general cause of the irregularities of the teeth.

The inversion of truth as to the causation of irregularities as taught is further illustrated by the remarks which are incidentally passed upon the tongue. That the pressure of the tongue, lips, and cheeks ought to regulate the teeth if they are irregular is sometimes suggested, but the continual recurrence of case after case in which these soft tissues have not brought about a regular arch of teeth has prevented this (in these civilised countries erroneous) view from gaining much acceptance. In 1845 Stockton[1] wrote "The comparative ease by which with pressure the incisors or bicuspids may be made to alter their position would naturally suggest the idea that the

[1] "Dental Intelligence."

tongue, lips, or cheek might in some measure influence their original direction. But as these are possessed by every one, while certain individuals only have their teeth unevenly arranged, we must look for some other accessory, and this may be found in the form of a palate, certain peculiarities of which are found in connection with similar forms of the dental arch." Stockton held that this form of palate was caused by pressure of the tongue. It is somewhat curious that writers on the subject never appeared to notice that the tongue varies in size, and that whereas a large tongue expands the arch by the pressure it exerts on neighbouring teeth, a small tongue, such as one almost invariably sees in this country, does not sufficiently expand the arch and does *not press* upon the neighbouring teeth, and does not press upon the palate. The small tongue *brings about* the irregularities of the teeth by *lack of pressure*, and indeed the irregularities that the pressure of the tongue has been held to regulate are irregularities *brought about by* the absence of the pressure of the tongue.

Among uncivilised races, in which the teeth are regular, of course the tongue regulates slight irregularities in the eruption of the teeth, but unfortunately such is not the case when the tongue is small and when teeth are irregular. It will readily be conceded that 32 inch cubes can be arranged regularly round the arc of a circle or a polygon 32 inches long, but it becomes a peculiarly difficult task to arrange these 32 cubes regularly round an arc measuring only

30 inches. So, too, the tongue, cheeks, and lips may regulate 32 teeth when the tongue is above a certain minimum, but when below this minimum such result cannot come about on account of the mathematical impossibility for the teeth to be arranged evenly in the size of the arc formed by the edge of the tongue.

CHAPTER XIII

THE PREVENTION OF IRREGULARITIES

THE prevention of the irregularities of the teeth is a subject which has hitherto been regarded as quite outside the range of serious consideration. This has no doubt come about from the maintenance of ideas of causation which it would be impracticable to counteract. If, however, we accept even in a general way the theory of causation which I have attempted to submit, then the prevention of irregularities becomes an important subject, and we may venture to believe that it is capable of being carried out with the happiest results.

Although the working out of the theory of prevention naturally devolves upon us as dentists, yet in the early stages at least the carrying of the theory into practice must devolve upon the medical practitioner or those who supervise the bringing up of infants and children. The prevention of irregularities should commence indeed before the eruption of the teeth.

It is unnecessary to advocate that an infant should be breast fed; this is quite well recognised. But as it frequently happens that artificial feeding *must* be resorted to, and as it has been noticed, or at least it ought to have been noticed, that irregularities of the teeth are a frequent sequel of artificial infant feeding, it will be

as well to state that according to this theory artificial feeding is not the cause of the irregularities, as irregularities are not a necessary consequence of artificial feeding, nor is artificial feeding a necessary antecedent of irregularities.

The artificial feeding of infants may almost be regarded as an exact science, and it is only the want of knowledge or the neglect of the necessary precautions which gives rise to the harmful results so often observed. Under the heading, "Artificial feeding perfectly safe with due care and proper knowledge," Dr. Cheadle says: "I believe that, by proper management and precautions, all difficulties of the transfer from the breast to artificial feeding may be got over with absolute safety and in all respects satisfactorily, so that the child shall escape gastric troubles and shall thrive."[1]

An infant is a delicate organism, and as due care and the proper knowledge are frequently wanting, the infant does not thrive, but suffers from infantile dyspepsia, malnutrition and its sequelæ. Now we have already said that the irregularities of the teeth were roughly proportional to the emaciation of the child, because the tongue which shares in the general emaciation does not give the developmental stimulus to the growth of the jaws which it otherwise would. Unfortunately the harmful results of ill-feeding in infancy shatter the child's constitution, and it is doubtful if it often ever becomes thoroughly robust. It is somewhat

[1] "Artificial Feeding and Food Disorders of Infants," 4th ed., p. 45.

strange to notice how persistently children retain their unhealthy and half-starved appearance.

The prevention of irregularities therefore commences by the carrying out, for the first year or so, of the principles of hygiene and dietetics as currently advocated.

Here I may refer to one of the bogies of superior protrusion, "the infant's comforter." I know that it is supposed to be a pernicious invention. It is no doubt an abomination unto the dentist, but mothers are well aware that it is an ever present help in time of trouble. I doubt if there is any good evidence to show that "the comforter" is a cause of superior protrusion of any other irregularity. It is true that in the sucking of a comforter air may be sucked into the stomach and give rise to some annoyance, but this might be remedied by having the part usually grasped by the lips somewhat elliptical or flattened. On the other hand, it is continually gnawed and sucked. The gnawing helps to develop the muscles of mastication and the sucking helps to develop the tongue. Now after the teeth have cut the gum and the child is beginning to be fed on pap instead of chewable food, possibly the gnawing and sucking the comforter is, under the circumstances, one of the most beneficial things the child could do as regards the development of the jaws. However, I do not wish particularly to advocate the comforter, but will simply say that something to gnaw, as for example a piece of soft leather, is in my opinion an excellent thing for an infant to exercise his jaws and teeth upon.

Gnawing and sucking is an instinct with all children, and the satisfaction of this instinct is no doubt beneficial, so that after some teeth have appeared the food should be of a consistency such that it will demand the use of the teeth. Sugar-cane is a useful adjunct in the dietary of a child, but it is unnecessary to return altogether to primitive foods. Even highly artificial productions, such as stale bread or crusts or toast, will suffice as part of the diet, but vegetable foods rich in carbohydrates should be so dry or of such a consistency that they will absolutely necessitate mastication and insalivation. The recommendation in otherwise excellent treatises of a diet consisting almost wholly of "bread well soaked" in milk and the like"[1] shows a complete disregard not only of the physiology of mastication but also of the whole of that important part of digestion which takes place in the mouth. Meat, fish, and poultry, tender or otherwise, according to the age and capabilities of the stomach, should be given in large pieces cut thin. Flat pieces about one inch square generally *necessitate* a certain amount of mastication. It is difficult to swallow large flat pieces of meat without mastication, but when finely minced little or no mastication is called forth. With young or delicate children the most tender meat may be given, and in order to have it specially easily digestible, yet of a consistency necessitating mastication, it may be given more or less raw. If the child tends to swallow without mastication, cut

[1] Hutchison, "Food and the Principles of Dietetics," p. 457.

the thin pieces *larger*. Only in extreme cases is the giving of raw meat juice a necessity, and then it should only be a temporary expedient. The harmfulness of inefficient mastication as regards gastric digestion has long been recognised, and, curiously enough, in order to make things right, food, at least for children, is generally practically masticated before introduction into the mouth; but to my mind this only augments the cause of the evil for which it is intended to make amends. In other words this preparation of food, as exemplified for example in minced meat and mashed potatoes, only further induces the child never to acquire the habit of mastication.

This is not all. The physiology of digestion is not a piecemeal business. All parts of the process are intimately co-ordinated. To illustrate this fact, which physiologists have not fully appreciated until recently, we may mention that if the œsophagus of a dog is cut, and arranged in such a way that food swallowed is passed out at the cut end instead of passing into the stomach, the psychic effect caused by the mastication of the food produces a very considerable flow of gastric juice, definite in amount. The entrance of food into the stomach, too, causes a definite amount of gastric juice to be secreted. Food introduced into the stomach unaccompanied by mastication and concomitant psychic effect only stimulates a partial secretion of the gastric juice.[1]

[1] Pawlow and Thompson, "The Work of the Digestive Glands," chap. iv.

Then, too, the amount of saliva secreted has its effect on gastric digestion. Not only does it promote the digestion of starch in the early stages of its lodgment in the stomach, but probably the permeation of the proteid with the alkaline saliva renders such food more subject to the ingress of the gastric juice. The saliva does not contain mucus, carbonate, and phosphate of soda, &c., for idle purposes. Perhaps our semi-atrophied salivary glands may predispose to indigestion. I have heard on very good authority that the alkali in the masticated food allows of the propepsin secreted by the gastric glands to permeate the food and form pepsin in the substance of the food in the nascent and therefore most active condition. However, to administer to children with teeth food which does not require mastication is to ignore a primary fundamental and important stage of digestion. This point need not be elaborated, for it is hardly necessary to insist upon the fact that good digestion awaits not only on appetite but on mastication, and if we swallow food without mastication active digestion is not stimulated, and the seeds are sown of indigestion, irregularities, and caries of the teeth, appendicitis, &c.

I have referred to these facts because chronic indigestion with emaciation is one of the worst troubles for producing irregularities. It is even more harmful than insufficient mastication.

To recapitulate: The food of children should be of a chemical composition such as is found in milk, and such as is advocated currently in text-books dealing

with this subject, but the physical characters of the solid food should diverge from that of milk in proportion to the number of teeth erupted; that is, it should be the opposite of that currently advocated. When for example we read, "a rusk or slice of stale bread well soaked," we should read, "a rusk or slice of stale bread well dried or toasted."

CHAPTER XIV

THE PREVENTION OF IRREGULARITIES— *continued*

AFTER the child has cut all its temporary teeth there is no need to give it any soft food at all. It is erroneous to think that with the foods ordinarily at our disposal it is a difficult matter to select a diet which will necessitate a fair amount of mastication.

From the following a selection may be made which will satisfy most children:—

Breakfast: Fish (various kinds variously prepared). Toast. Crescents. Rolls. Oat cakes. Brown bread. Fruit, *e.g.* apples.[1] Bacon. *No porridge.*

Dinner: All kinds of meat (not minced). Poultry. Fresh vegetables. Salad. Bread-rolls. Rice-pudding, made as in China, with every grain solid and separate. Fresh fruit. *No sloppy milk or custard puddings.* Nuts. *No nutritious soups.*

Supper: Toast. Rusks. Bread-rolls. Oat cakes. Meat. Fish or poultry. Fruit. *No bananas.* As

[1] Apples stimulate a very great amount of mastication before being swallowed.

regard liquids, water is the ideal; milk should be avoided.

Now let us consider the effects of such a diet in regard to the arrangement of the teeth. It is one which will necessitate a considerable amount of mastication. The muscles of mastication will therefore become well-developed. They must like other muscles increase in bulk on account of increased activity. For the same reason the supra-hyoid muscles increase in bulk and strength, and the effect of this is to hold the hyoid up and force the tongue more firmly upwards in the cavity of the mouth. The extrinsic muscles of the tongue too share in the augmentation, occupying an increased space below, at the side of and behind the tongue, and tend to push it upward and forward. The intrinsic muscles of the tongue are also developed, for each contraction of the muscles of mastication is accompanied by a complex movement of the tongue, which sorts the food and throws back the coarser part on to the crowns of the teeth, while passing the more thoroughly triturated and insalivated part backwards to the pharynx. The salivary glands are also more fully developed, and these add their little in filling up the space behind the mandible, and help to hold it well forward.

By way of recapitulation we may quote Dr. Campbell on the "Influence of Mastication on the Jaws." He says: ". . . It is manifest that the conditions of the jaws and neighbouring parts of a young adult, who from youth upwards has been accustomed to

masticate efficiently, must be very different from that of one whose masticatory muscles have all the time been but feebly exercised. In the one we shall expect to find well-developed masticatory muscles, tongue, jaws, and nasal passages, well-grown and regular teeth, large salivary glands, and a healthy nasal, nasopharyngeal and pharyngeal mucous membrane, with a minimum tendency to hypertrophy of the lingual and pharyngeal tonsil (adenoids); while in the other we shall anticipate defects in these respects. And, as a matter of fact, we do actually find these differences in these two classes of individuals."

It is difficult to calculate the amount that the tongue increases in size due to the increased muscular activity referred to. Nor is it easy to estimate the force that the augmenting tongue—held upwards and forwards by concomitant muscular development—exercises upon the dental arches. One thing is certain, the expansile force of the tongue will not cause the teeth to become loose or tender, nor will it give rise to the ugly irregularities which we see so frequently associated with a small tongue and insufficient development of the muscles of mastication.

There are other subsidiary effects of a diet which requires considerable mastication. The teeth do not rise unduly in their sockets, and the alveolus does not tend to become disproportionately deep. The cusps of the teeth get worn down and the vertical diameter of the mouth is diminished. Increased rubbing of the teeth on their approximal surfaces diminishes the so-called

mesio-distal diameter of the teeth, thus reducing the whole length of the arch by at least one or two millimetres.

The very constant association of mouth breathing and the powerful influence which this has in bringing about irregularities of the teeth, makes it imperative to direct attention to its prevention.

The causes of mouth breathing may be divided into two groups, exciting and predisposing.

The exciting causes are all those which give rise to blockage of the nasal or nasopharyngeal passages, especially adenoids, colds, and catarrhal inflammations. With regard to these, their causes and prevention must be sought for in medical works devoted to these subjects.[1] The predisposing causes are, I believe, all those conditions which tend to arrest the full development of the thorax and muscles of the neck, for when the thorax is ill-developed and the health is below par there is an undue strain thrown upon the hyoid and the supra-hyoid muscles. In fact, the mandible is pulled down and thus there is a tendency for the mouth to be held open. This of course predisposes to mouth breathing, and what is perhaps of more consequence, it tends to provoke the exciting causes, and these again tend to increase predisposition.

The rationale of this is, therefore, that the proper way to prevent mouth breathing is to develop the muscles of mastication which hold up the mandible, the supra-hyoid muscles, the muscles of the neck, and

[1] See especially Macleod Yearsley's "Adenoids."

those connecting the thorax with the arms. The exercises which should be recommended to achieve these ends are therefore chiefly masticatory and respiratory. About masticatory exercises we have already said enough. The respiratory exercises may either be solely directed to increase the capacity o the thorax, or may be combined with other exercises involving the use of the arms. From what we have already said, however, it is evident that in some cases such exercises should be carried out as far as possible in a more or less horizontal position. This may be easily done in the case of simple respiratory exercises. For artificial exercises, which will involve the other muscles referred to, certain forms of dumb-bell exercises may be prescribed. Perhaps most beneficial of all, however, are games involving the use of the arms, gymnastics and swimming. Of course all these exercises must be carried out in the fresh air with the teeth clenched, and the breathing conducted through the nose.

It should be particularly remembered that efficient mastication tends to broaden the nasal passages, and that narrow nasal passages predispose to the blockage of the nose and the occurrence of adenoids. The common exciting cause, cold in the head, must also be counteracted, and colds when caught should be got rid of as quickly as possible; for, as has already been mentioned, the fact that the blockage of the nose arrests its development is proved. Although some

fanciful theories about negative[1] and atmospheric[2] pressure have been advanced to account for this arrest of development of the nose, we may be content with the simple idea that the abeyance of its function of transmitting air is itself sufficient to arrest its development, for with each inspiration there is a stimulation of the flow of blood *when there is no obstruction*. On the other hand, the abeyance of the rhythmical stimulation of the flow of blood is perhaps sufficient to account for the arrested development when the passage is permanently blocked.

[1] Mr. Mayo Colyer, *Trans. Odonto. Soc.*, May 1899.

[2] Mr. Lane, who advocated the *atmospheric pressure* theory (*Trans. Odonto. Soc.*, Feb. 1901), seems to have given it up (*Trans. Odonto. Soc.*, Jan. 1903).

CHAPTER XV

TREATMENT OF IRREGULARITIES

A RATIONAL theory of the causation of irregularities may be useful in several different ways. It may be of importance in co-ordinating the multitudinous complexities and reducing the whole to organised principles, so that the various parts may be easily comprehended and remembered. It may be of importance in laying the foundation of a system by which the irregularities may be prevented; or lastly, it may be of importance in being a guide in the maze of conflicting considerations and diversities of method which present themselves to those whose business it is to treat the conditions. It is with this last that we shall now be concerned.

We need not fear that the principles arrived at will lead us astray, for it is almost solely on account of want of guiding principles that the failures in practice come about, and if any reasonable principles can be introduced they may be preferred to none.

The empirical treatment which has become established cannot be despised, for in the main it has stood the test of experience, and if our principles show much tendency to diverge from this, we may be justified in doubting their accuracy; but if we can show that the failures which have occurred are primarily those which

have run counter to these principles, we may be justified in treasuring them and trusting to them when the proper line of treatment might otherwise be doubtful. The organised knowledge we have all gained in our systematic courses has no doubt been the principal factor in making our practice so far excel the practice of the unqualified dentist, and if the attempt to further organise our knowledge of the irregularities of the teeth prove successful, so correspondingly may we expect that our practice will improve.

The first essential in the treatment is a clear appreciation of the abnormality in arrangement with which we have to deal. It is not sufficient to be told that the "thoughtful practitioner" will take models and study them carefully. It is necessary to direct attention to how a correct diagnosis may be arrived at.

There are several elements which must be considered. Firstly, we have to note the general position of the dental arches in their relation to the rest of the face. Without any error in occlusion it may occupy a relatively forward position, producing a general alveolo-dental prognathism. This is rather an ugly abnormality, and is brought about by the teeth being pushed gradually forward by the posterior molars coming into position without a corresponding development of the body of the mandible and maxilla. In order to have this abnormal arrangement it is necessary for the front teeth to have taken up a regular position to begin with, and to have their relative positions sufficiently finely balanced to let them be carried

forward *en masse*. The only irregularity in position relative to the teeth themselves is the oblique position of the incisors and the narrowness of the arch.

The peculiar appearance which is associated with this is not only due to the narrowness of the dental arches and their consequent protrusion, but also to the fact that the bodies of the maxillæ and mandibles are somewhat small—insufficiently developed through lack of mastication. Accompanying this we generally find a somewhat large oral orifice with everted lips.

This arrangement, however, is rarely seen in ideal separation as has been described, but it is almost invariably associated with the other element in the diagnosis—namely, *malocclusion*. With regard to malocclusion we may divide this into partial and complete. Partial when some of the teeth, generally the molars, occlude normally, and complete when the upper and lower teeth occlude in front of or behind the normal positions as regards the opposing teeth.[1]

The depth of the alveolus or palate must be noted, and a careful estimate made of the size of the tongue.

After having recognised the exact nature of the irregularity it is necessary to consider the case as a phase in the development, or rather mal-development, of the dental arch. Of course the age of the patient must be considered, not only with regard to possible absorption and deposition of bone during the treatment, but also with regard to the possibility of the

[1] The various malocclusions of the teeth and their diagnosis is given in Dr. Angle's excellent work on "The Malocclusions of the Teeth."

facial bones remoulding themselves when once the irregularity has been corrected. For without a general remoulding of the bones receiving the strain of mastication, certain results cannot be accomplished.

The past history of the patient is of great importance. Whether the patient has been in as good health and robust as could have been wished, or whether it is likely that the general condition can be reasonably expected to be sufficiently ameliorated to bring about a substantial gain, especially in weight. As will be shown later, upon this frequently depends the important question as to whether expansion or extraction will prevail in the treatment of the case.

The next consideration is to have a thoroughly clear appreciation of the object of our treatment.

There are four distinct objects—namely, to improve the appearance; to improve mastication and articulation; to prevent caries; and to leave the teeth at the end of the treatment in a state of equilibrium.

As one or other or some of these objects are frequently neglected, we may say a few words on each.

With regard to the improvement of appearance of the patient, it is hardly possible for the operator to overlook this, as it is with reference to this that the patient is almost invariably presented. To those who have not studied the subject the abnormality in the arrangement of the teeth is the sole point to be considered, but the general facial contour must receive the most careful consideration, for the principal factors —outside the inherited type—which dominate the

contour of the face are associated with the development of the jaws and dental arches. We have already noted the effect of mastication on the muscles, and the effect of the muscles of mastication on the growth of the facial bones, and the effect of the full development of the tongue on the dental arches. Thus we note the powerful effect which a normal or artificial development of these parts may have on the facial contour.

A consideration of the lines of facial beauty in their varied forms is rather a large subject, but if the operator will recollect the general mould of the face among those who have normal and well-developed dental arches, and in his treatment try to approximate them, or if he will consider and avoid abetting the weak, misshapen, or deformed jaws resulting from ill-health and the various irregularities, the object of his treatment will not be much amiss. If, however, he must have a stereotyped ideal, let it be one which not only attracts the operator but has been the work of a master. Should types such as this be chosen it must, however, be remembered that artists sometimes go to extremes, and recognising, for example, the diminution of the facial angle as we ascend in the animal world, they have at times been led to the production of types which are physiological impossibilities. Moreover, the beauty which is generally most desired is that which appeals to "the man in the street," and not to the Royal Academician, who may perhaps live in an age and atmosphere of degeneration and antiquity. However, types frequently seen in England and elsewhere

appeal with much more force to many than any Greek ideal ever produced.

The most frequent defects are that the body of the lower jaw is too small, the length from the angle to the symphysis being too short, the breadth, especially at the angle, is wanting, and above all, the arches are very seldom broad enough, so that the even curve of cheeks is lost, and in marked cases the haggard look of the emaciated is simulated too closely. Corresponding to this the maxillæ may be small and the nose appear unnaturally narrow and prominent, due to the sinking in of the maxillæ and cheeks on either side. All these defects can be ameliorated. Smooth sounding statements which encourage apathy in the treatment of cases should be tabooed. We read, for example, "A narrow arch may be accompanied by a narrow face with a small mouth and correspondingly small features, all of which are in harmony."[1] Now if the face is narrow and the features small, *ipso facto*, they are not in harmony. They may be in harmony with each other, but unless the patient is dwarfed and laterally compressed they are out of harmony. Nor does expansion of the arch and face augment the size of the oral orifice; indeed, a large oral orifice is almost necessarily associated with a narrow arch and crowded anterior teeth. Perhaps even more affectedly thoughtful is the whimsical reference to irregularities "which

[1] Smale and Colyer, "Diseases and Injuries of the Teeth," 2nd ed., p. 71.

are, so to speak, a part of the general scheme of conformation of the face and jaws." [1]

With regard to the improvement of articulation nothing need be said here, an impediment in speech could not be overlooked.

The improvement of the masticatory apparatus is frequently partly overlooked, although all successful efforts at improving irregularities which restore the normal occlusion improve the masticatory apparatus. The harmful effects of injudicious extractions are recognised, and this is the chief source of the derangement of occlusion of the grinding teeth. Our endeavour should be to approximate the normal arrangement.

The treatment of irregularities with the intention thereby of preventing caries is of great importance, yet it is so generally overlooked that the so-called regulating the teeth only induces caries, and the supposed successful results are often actually photographed with satisfaction, while the interdental spaces would apparently seem to have been constructed with the object of ruining the teeth by the lodgment of food. The teeth should touch and leave V-shaped spaces between them as in the normal articulation.

Lastly, we must bear in mind the necessity of foreseeing how we are to bring about a state of equilibrium. This is an important part of the subject and always partly neglected. Although teeth are regulated and retained with a retention plate for years, if they are not left in a state of equilibrium, they will gradually

[1] Tomes, "Dental Surgery," 4th ed., p. 108.

become displaced immediately the retention plate is removed. How the arch of the teeth could be expanded and expected to remain in the expanded position without the pressure of a correspondingly augmented tongue is one of the strangest expectations which any class of mechanical men have yet harboured.

The idea apparently entertained by some, that after a time the teeth may become fixed in the jaw with cast-iron rigidity is contrary to the notorious fact at the very foundation of the treatment of irregularities, that teeth may be moved by pressure.

To establish equilibrium there are four factors to be borne in mind:—

1. The retention of each tooth by its approximal teeth.
2. The retention of each tooth by the occluding teeth.
3. The retention of each tooth by the tongue on the one side, and
4. By the lips and cheeks on the other.

If a state of stable equilibrium is not brought about by attention to these factors, or if it does not come about by good luck, the case will inevitably relapse and the ultimate result will simply be a testimony of failure and bad treatment. How often do we hear of the relapse of cases? And what may be inferred from the fact that some distinguished dental surgeons, having observed the course of numerous cases, come to believe that in the great majority it is best to leave

the natural forces, whatever they may be, to do what they will or at most supplement them by "judicious" extraction?

We have classified irregularities according as they are associated with:—

1. A normal tongue and vault.
2. A large tongue.
3. A small tongue and narrow vault.

With regard to the first group, all that is necessary is to bring the irregular tooth or teeth into normal relation with the approximal teeth, and the occluding teeth and the tongue and cheeks will do the rest. A plate should not be used to regulate such teeth, as it would augment the pressure of the tongue on the teeth and induce inefficient mastication. Sometimes it is unnecessary in such cases to do anything beyond removing the cause, for example, a supernumerary tooth.

With regard to those irregularities associated with a large tongue, for example, general alveolodental prognathism and some cases of open bite, it is absolutely necessary to diminish the size of the tongue. For this it may be necessary to consult a general practitioner. If the tongue is not reduced in size by appropriate treatment, we may try to reduce the arch by "cutting in the bite," or by mechanical appliances till our hair is grey, immediately the appliance is removed the case will relapse. Nor will it suffice to leave the case alone till compensatory development of the alveolus allows a normal occlusion, for such would destroy the beauty of the face.

Group 3. — Irregularities associated with a small tongue and narrow arch introduce us to the commonest, most important and difficult cases with which we have to deal.

When the tongue is small it is useless simply to expand the arch and regulate the teeth, for immediately the regulating appliance is laid aside the teeth fall back into their original or some other mal position, as a state of equilibrium has not been secured. It is *necessary*, if the arch is expanded, that the tongue should be correspondingly augmented.

The results desired may often be gained without extraction in three ways:—

The tongue may be increased in size.

The vertical depth of the mouth may be diminished to compensate for and create a lateral expansion.

Hypertrophied tonsils may be removed.

With regard to increasing the size of the tongue, this is partly a general medical and partly a dental question. If from an investigation of the history of the patient, and the present mode of life, it be considered likely to be possible to ameliorate the general health and to increase the weight of the patient, then it should be done at once. With regard to this point it may be mentioned that few mothers have got any idea what is robust health in their children. They are so accustomed to seeing their emaciated forms, and to believing that they are constitutionally delicate, they seldom realise that it is their own persistent bad

management that is the constitutional defect of the child. The point for us to consider, however, is whether the error which has brought about the emaciated condition can be remedied, for, if it can, there is a practical certainty that the tongue, together with all other muscles, will increase in size. Then we must consider the subject from the dental point of view. If the narrow arch is associated with a malocclusion which only allows of a simple opening and closing of the mouth, and prevents real mastication, we may be justified in anticipating that the correction of the malocclusion and the learning on the part of the patient of the art of mastication will augment the size of the tongue. Further, we can, after correcting inlocking of the maloccluding teeth, augment the size of the tongue, and otherwise benefit the case by insisting upon a diet *necessitating* mastication.

With regard to the diminishing of the vertical depth of the mouth, I have already advocated general decuspidation,[1] more especially in relation to the prevention of caries. The operation must, however, not be carried too far, for during the eruption and arrangement of the teeth the cusps are of great importance in regulating the arrangement, and the amount of decuspidation should not much exceed what might normally have taken place.

Decuspidation can hardly be recommended except in cases of trivial irregularities associated with slight narrowing of the dental arch.

[1] *Dental Record*, April 1902.

Another method of reducing the vertical depth of the buccal cavity is by the application of a fronto-mandibular apparatus after the nature of the skull and chin cap.

With regard to the excision of hypertrophied tonsils, it may be said that this does not directly increase the size of the tongue, but over and above the general benefit to health and comfort in breathing, it removes the downward pressure on the back part of the tongue, and thus allows it to rise up and occupy its more anterior and normal position.

Perhaps it may be considered that these methods are inconsiderable in the great majority of cases. *If* it is so, then correspondingly general expansion for regulation is sheer folly.

CHAPTER XVI

TREATMENT OF IRREGULARITIES—*continued*

It frequently happens that cases of irregularity are presented to us, in which the insufficient development of the maxillæ and mandibles is so great and the normal period of developmental activity is so nearly over that the attempt to restore the full development of the bones of the jaws and the normal relations of the teeth and dental arches is out of the question.

When the dental arches occupy normal relations to each other, and to the maxillæ and mandibles, then the normal developmental stimuli bring about gradual changes, which at each successive stage leave the relations normal. It is otherwise, however, when the normal relations are considerably disturbed, for in this case the abnormal relations may only be further augmented by the very force which in normal circumstances should have kept the relations normal. This fact is well established with relation to certain effects of the cusps of the teeth on occlusion. However, in discussing the various kinds of abnormal arrangements of the dental arches, we noticed that, without any error of occlusion, we may have the arches abnormally narrow and the anterior teeth especially, occupying a position relatively too far forward. This condition, when pro-

nounced, is sometimes referred to as double protrusion. Now—leaving aside other considerations—if the tongue were augmented in such cases the relations are such that the deformity would only tend to be increased. As this is somewhat complex it will be necessary to spend a few lines on its elucidation. For simplicity we may limit our attention solely to antero-posterior relations of the front teeth. In the normal arrangement the upper incisors are directed downwards and slightly forward, while the lower incisors are placed vertically. The accompanying diagram shows how the pressure of the tongue forces the crowns of the teeth forwards, while the resistance of the lower lip—primarily on the upper incisors, and secondarily through this on the lower incisors—prevents tilting and so crowns and roots alike are carried forward; thus as the tongue augments in size, the teeth and their roots retaining their normal relations, carry the bodies of the maxillæ and mandibles forward, thus maintaining their relative positions also. The case is different, however, when the incisors are already directed too obliquely forward. If in this case the tongue or an expansion plate were to be used to expand the arch anteriorly, it would increase the obliquity of the incisors and take place without a

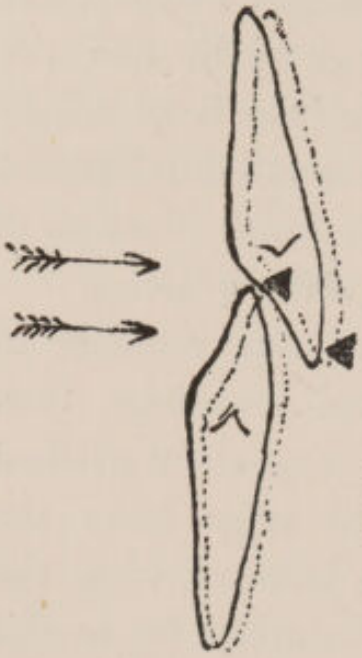

FIG. 12.

corresponding forward development of the bodies of the mandibles and maxillæ. For the obliquity of the incisors renders the actions of the lower lip in holding them in their normal relations either insufficient or it has exactly the opposite to the desired effect. Especially is this the case when there is considerable pressure from behind along the teeth themselves.

Furthermore, when the incisors are directed obliquely forward to too great a degree, or when there is bunching of the incisors, this indicates that the molars and bicuspids have been translated forward and the available space for the front teeth lessened. In such cases either general expansion or local expansion would only augment the fundamental error. Even Dr. Case's valuable method for regulating, which definitely controls the obliquity of the teeth, would without extraction be harmful, for then the whole arch would occupy a too anterior position if the molars and bicuspids had already got translated forward, as is usually the case. Much more might be said to show that, in the majority of cases, general expansion without extraction is unscientific and impracticable, and what applies to general expansion frequently applies correspondingly to local expansion or what is called "making room."

This leads to the conclusion that in perhaps the majority of cases presented to us after the irregularities are well established, the first, sometimes the last, and frequently the most important part of the treatment is *extraction.*

The particular tooth to be extracted will occupy

our consideration later. Meanwhile the general fact of the necessity of extraction must remain under consideration.

There are points in the diagnosis of cases which present considerable difficulty, and what frequently appears to me to present most, is to decide when a tooth is to be regarded as too forward. The tooth to which attention may be given probably with greatest advantage is the first bicuspid. We may note that occlusion from the first bicuspid backwards is, in the majority of cases, normal,[1] the irregular arrangement being limited to the canines and incisors. Now in these cases, space may either be lacking on account of the travelling forward of the bicuspids, or the arch may be so narrow that the canines and incisors cannot be accommodated evenly, or there may be a combination of both of these conditions. The following points are perhaps of most importance in attempting to formulate an opinion:—

The direction of the axes of the teeth.

The space between the first bicuspid and the lateral incisor.

The fact that the molars and the bicuspids almost invariably do travel forward, if the arch is broken by irregularities in front of the arch.

When we consider the above it becomes apparent that unless we are fortunate enough to get the case in the earliest stages, extraction is almost invariably indicated.

[1] Angle, "Malocclusion of the Teeth," 6d. edition, p. 44.

Let us assume that the four first bicuspids are extracted in an hypothetical case. What further treatment is necessary?

In the first place the fact of the insufficient development of the maxillæ and mandibles must be recognised and the teeth brought into normal relations with each other and the tongue and lips. Having done this, then the various developmental stimuli of the jaws should be encouraged. The body of the mandible would then be carried forward as in a normal arch, and the maxillæ would likewise be similarly influenced. Over and above the development of the maxillæ from stimuli below, a stimulus should be given from above, that is to say, enlarged tonsils or adenoids should be dealt with by the surgeon if necessary, and breathing exercises should be carried out if the child shows any tendency to mouth breathing.[1] A fronto-mandibular apparatus may be applied at night to prevent mouth breathing, and ensure pressure of the tongue. Further general hygienic treatment should be carried out, and above all, the mal-conditions in which the child lives should be altered.

It may be said, even assuming that by these and other methods we accomplish our purpose, the results would always fall short of the ideal, inasmuch as the patient lacks four teeth and all the concomitant structural conditions associated with and necessitated

[1] See "Respiratory Exercises in the Treatment of Disease," by Harry Campbell, chap. xx.

by the existence of the full number of teeth. No doubt this is so, and if any method could be devised by which a strictly normal arrangement could be brought about, we would not by any means demur. But unless the case is presented in an early stage, no such ideal will probably ever be attained.

It is always a serious matter deliberately to sacrifice a sound tooth, and perhaps a few further words in justification of the procedure may not be out of place.

The extraction of the first bicuspids could hardly be objected to on the score that the number of teeth left to perform the act of mastication would be insufficient. Nor should the tendency to caries be increased, as we shall hope to show that the relations of the teeth are most perfectly secured, and the difference of whether a second or first bicuspid abuts on the canine is only the difference between Tweedledum and Tweedledee. Nor should the facial beauty be in the slightest way impaired. Indeed, on all sides there would be a distinct gain in beauty, for by the means suggested the normal stimuli to normal development are allowed to act normally. Even if it were assumed that the upper incisor teeth might become vertical instead of directed slightly forward, and if the under incisor fell back so as to be inclined slightly backwards, this would tend to make the oral orifice seem small just as does the oral orifice of the edentulous. There is a certain amount of give and take in the force exerted by the tongue, so that if the front teeth fell back even unduly far, there should be a corre-

sponding augmentation in the breadth of the arch. That is to say the narrow arch should become cured, and all the defective appearance due to this deformity vanish. So, too, the restoration of the respiratory function tends to develop the nasal passages, the antra and the body of the maxillæ, while the complete restoration of the masticatory function, especially in the molar region, tends to develop the body and angle of the lower jaw. This is important, for a weak and narrow lower jaw looks insipid.

There are many considerations which may influence our choice when we have arrived at the conclusion that a tooth or teeth must be sacrificed. Each case has, to a certain extent, to be judged on its own merits, but nevertheless there are certain conditions so constant in every case of irregularity that we may lay down the rule that if the molars and bicuspids have travelled forward sufficiently to cause bunching, or anterior protrusion of the incisors, or outstanding canines, then a bicuspid tooth, very generally the first, must be extracted.

We should perhaps remember that it is in all cases of a more or less advanced nature with which we are dealing, or to be a little more definite, cases in which the patient is about twelve or more years of age.

The extraction of the first bicuspid tooth for regulation purposes has gradually become recognised as the most suitable tooth to remove, and various cogent arguments have already been brought forward by some of the most successful operators in support

of this procedure. It would hardly be necessary to say more on the subject, were it not the case that some writers have recently advocated the extraction of upper lateral or lower incisors, when it would be preferable to keep to what is called the "orthodox treatment," viz., the extraction of the first bicuspid. It is not my intention to repeat the arguments which are so well brought forward by Dr. Angle,[1] but if possible to supplement them by arguments of a different nature.

We have already alluded to the effect on development of the jaw which is produced by the bringing into normal relations of the front teeth, but important though this is we need not discuss it further.

The next point to which I would refer is the fact that in our nearest allies there is a diastema in the lower jaw between the first bicuspid and canine, and in the two most perfectly developed jaws that I have seen in practice it was present. It is important to recognise that a diastema in this position is not liable to give rise to a tilting of the teeth behind it, nor is the space between the first bicuspid and canine, especially of the lower jaw, particularly subject to caries. Nor is the loss of masticatory surface of any moment, especially as it is desirable that increased stress of mastication should be thrown upon the other teeth. It is in fact the position for a diastema to exist. It neither interferes with the cutting function of the incisors nor the masticatory function of the molars.

[1] *Loc. cit.*, pp. 201–202.

And even although a permanent gap were left it would be in the position in which least harm would result from its presence.

It might be, and has been, argued that the "susceptibility" of the first molar to caries in some mouths would be a sufficient reason for its extraction, but independent of other cogent reasons, the idea that the first molar is specially "susceptible" to caries is only a strong argument in favour of changing the diet of the patient, and for recognising the causes of the insufficient mastication which have led to the production of the irregularities. Strictly speaking the first molar is, as a rule, no more "susceptible" to caries in one person than in another, so long as its environment is prevented from becoming pathological.

It must have been noticed by every one how rapidly the first molars are destroyed by caries between the ages of six and twelve, and how much less "susceptible" they generally are after that age. There is nothing specially the matter with the teeth as a rule to account for this, but there is invariably the fact that after the cutting of the first molar the deciduous teeth commence to loosen. Very frequently the temporary teeth are more or less carious and tender, and in general the conditions are such as to prevent the child from putting the teeth to the physiological activity which is necessary for their welfare. This, therefore, only accentuates the supreme importance of insisting that a patient who appears to show

a so-called "susceptibility" to caries should have the tender teeth removed or otherwise treated, *and should be compelled to masticate food which requires to be masticated, for without mastication the masticatory organs can never be preserved.*

CHAPTER XVII

TREATMENT OF IRREGULARITIES—*continued*

So far we have avoided the introduction of certain considerations which in many cases complicate matters. Nor is it my intention to consider many of these complications, but there is, however, one which is of such frequent occurrence that a few words may be said with regard to it. We frequently have cases in which a tooth or teeth are not saveable. Generally it is the first molar. In such cases it is obviously important not to sacrifice any other tooth in the same arch on the same side. As it is usually the first molar which we find hopelessly decayed we may limit our attention to cases in which we are compelled to sacrifice it.

For reasons which are already well established when one molar tooth is to be extracted, the corresponding tooth above or below must also be extracted, even though the latter is free from caries. Let us assume this has been done. The great danger following this is that the second molars, especially the lower one, should tilt and disorganise the occlusion. The object of our treatment, therefore, is to prevent the tilting. It will have been observed that in such cases the second molar tilts forwards and generally inwards. This may be prevented in two ways. The patient

may be compelled to masticate food which throws a considerable pressure upon the second molar. By this means if the tooth commences to tilt in the ordinary way, by far the greatest pressure in mastication comes to bear on the postero-external cusp, and consequently prevents its tilting. The greater the force in mastication the more the tilting is prevented. Moreover, if the tooth commences to tilt inwards, the tongue, by increased exercise in mastication broadens, and thus its pressure helps to force the tooth to take up a vertical position.

The other method which I would advocate but which should always be supplemented by that already described, is to apply a band to the second molar and to the canine, solder a tube to the outside of the molar band, and apply traction by means of a drag screw. It will be observed that this is the apparatus illustrated by Dr. Angle when describing stationary anchorage. The only difference is a somewhat Irish one, as the intention as well as the result is to pull the "stationary" anchorage forward.

The consideration which naturally next demands our attention is the question of "anchorage." The study of the irregularities of the teeth is a serious subject, but fortunately writers on the treatment have introduced words and ideas which infuse a considerable amount of amusement. As an example of this the important principles of anchorage may be considered. Anchorage is divided into "simple," "stationary," and "reciprocal." By "simple" anchorage is

meant that form in which force is applied generally by means of a plate to several teeth in different directions, so that in reality it is not anchorage at all. It is merely compound force, but the force being so complex its resolution seems to baffle analysis, and is consequently called "simple." By "stationary" anchorage is meant that form of anchorage in which the "anchor" tooth moves bodily. As a rule the anchor tooth is a molar, and it moves not only on account of traction from before, but from the pressure

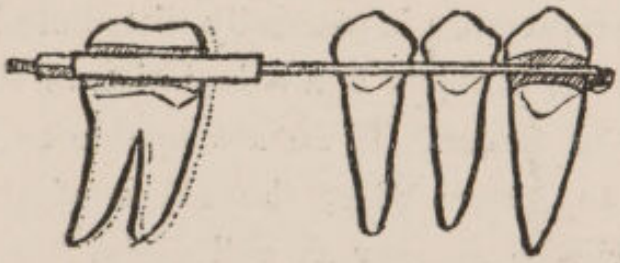

FIG. 13.—To illustrate the motion of "fixed anchorage," and to prevent tilting of the second molar.

which naturally translates the molar teeth forward. Here it may be mentioned that what is known as the "travelling" of the teeth is somewhat misleading. It is based on the assumption that teeth have some inherent power to move of themselves, whereas they are really translated forward by pressure from behind.

By reciprocal "anchorage" is meant that force is applied to two points in such a way that both move in opposite directions.

I have "elucidated" the current ideas of anchorage, because it is of great importance in the treatment of irregularities to note that "to every action there is

always an equal and contrary reaction." When you force one tooth in one direction you force another tooth or teeth or something else in the opposite direction. It is want of recognition of this simple principle that has permitted many an operator to suddenly realise that he has—among other things—moved the "anchor" teeth, and more or less ruined his prospects of successful treatment of the case.

It is obvious if force is directed upon any particular tooth that a point of equal importance to us is the effect of the counter-pressure. When a plate is used the counter-pressure is generally distributed on several teeth, and the problem is a calculation of the probable resolution of forces. If we are unable to realise this fact and to gauge what the effect of the counter-pressure will be we may as well desist from treatment altogether. A few lessons on the composition and resolution of forces will probably help even those who are anchored. It is not enough, however, to simply gauge our pressure and counter-pressure, we must remember the forces which are acting in translating, it may be the "anchor" or other teeth. Such forces can be used or depended upon, either to augment or diminish movement in the direction of the force or the counter force. If we had a respectable treatise on dental anatomy I feel certain that much good would be derived from an accurate study of it, but as at present we have little more than an indiscriminate collection of the facts which comparative anatomists found useful for the classification of the mammalia

—living and extinct—we are at a great disadvantage.

The fact that reciprocal pressure or reciprocal tension is the essential feature in mechanical appliances for the regulation of the teeth may be illustrated by a reference to a few types of appliances.

Coffin's expansion plate shows the reciprocal pressure in its simplicity. The lateral expansion is the same

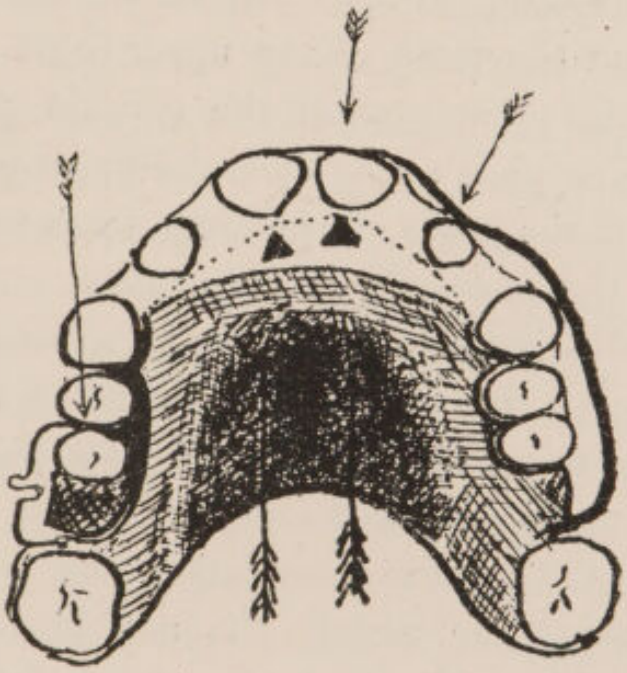

FIG. 14.

on one side as the other, and the idea of anchorage is absent. Appliances which have been proved by experience to be useful often illustrate other important points, which for want of recognition oft-times subject the appliances to undue condemnation. When a Coffin's expansion plate is put into the mouth, independent of other things, it causes the tongue to press the lower teeth outwards, and as

has been pointed out, when there is general crowding there is an undue inward inclination of the lower teeth. The roots of the upper teeth are directed too far inward also. In other words, the apical portions of the roots of the upper teeth are much crowded. When the tongue presses more heavily upon the crowns of the lower teeth it tends to set them more vertical, and thus by acting on the upper teeth if the occlusion approximates the normal tends to throw out the roots of the upper teeth. Further, under similar circumstances, the outward pressure of the expansion plate acting upon the upper teeth about the level of the necks of the teeth, tends to force the apices of the roots of the upper teeth outward, the cusps of the lower teeth acting to a certain extent as a fulcrum. But this is not all; one of the recommendations to my mind of the Coffin's expansion plate is that it presses upon the whole alveolus as well as upon the teeth, thus stimulating the development of bone along the middle line and broadening the maxillæ bodily. Cases are recorded[1] of this taking place to a marked extent, and what takes markedly in some cases takes place in all cases more or less.

It is a sheer want of appreciation of the principles underlying successful regulating appliances which have given rise to such ideas "that with the majority of appliances the tooth for all practical purposes may be considered to swing on its apex," or that "in expansion, then, the crowns are made to occupy a greater

[1] "Kirk's Operative Dentistry," p. 698.

arch, but the apical portions remain in practically the same crowded position." [1]

The most essential adjunct to all mechanical appliances is to have them working co-ordinately with the natural forces which regulate the teeth. One might almost be inclined to think that such an obvious fact had been deliberately neglected when an array of appliances [2] are figured consisting chiefly of plates covering the occluding surface of the teeth. Not only is mastication hindered by such appliances, but all the natural forces for the normal development of the dental arches are disorganised.

Messrs. Smale and Colyer further write: "The normal direction of a tooth is slightly outward . . . The effect of expansion under such conditions is to drive the tooth in a still more outward direction and completely disturb the occlusion." [3] No one will doubt the accuracy of this if the expansion plate figured by these authors in the same page is used. To cover the occluding surfaces may be justifiable when the occlusion is abnormal, but it is wholly unjustifiable unless we wish *on that account* to disorganise it.

The next form of mechanical appliances to which we may allude is a simple upper plate with wires projecting through a space from which a tooth has been extracted, and thence directed forwards so as to exert a backward pressure upon some front tooth or teeth (Fig. 14). This appliance is one which, with

[1] Smale and Colyer, "Diseases and Injuries of the Teeth," 2nd ed., p. 113.

[2] Ibid., Figs. 123 to 129 inclusive.

[3] Ibid., p. 114.

modifications, is frequently used with considerable success in reducing the anterior protrusion of some teeth. It is specially necessary to allude to this, as it might be thought that the pulling back of the anterior teeth would give rise to a corresponding pulling forward of the molar teeth. Fortunately, however, the counter-pressure does not fall wholly upon the molar teeth but upon the descending portion of the anterior part of the palate. The anterior part of the plate not only affords the necessary counter-pressure but also acts as a fulcrum to a certain extent, and thus the forward inclination of the incisors is reduced, while the roots of these teeth are made to assume a more anterior position. The recognition of this fact is important, for among other things it does away with the necessity of wearing a special apparatus for retracting the incisors at night, and another for retaining them by day. Moreover, if the upper molars do move forward somewhat they only do so while communicating this forward movement to the lower teeth, with which they are naturally locked in their normal occlusion. This forward pressure on the lower teeth may be of considerable service, for the lower jaw has in such cases been forced into a too posterior position on account of the abnormal occlusion of the upper teeth. This applies to many ordinary cases of anterior protrusion of the upper teeth, but unusual circumstances may prevent the forces acting in exactly the manner described.

In cases in which the malocclusion is of such a nature that the upper teeth occlude equal to one bicuspid tooth in front of the normal, as is usual in most cases of superior protrusion, an apparatus has been used which pulls back the upper arch by pulling forward the lower arch. Thus the superior protrusion is rectified, while the concomitant inferior recession of the lower teeth is also rectified. This, of course, illustrates well the effect of reciprocal tension, and, if other things permitted of it, would be an ideal method of correcting the deformity. But we must remember that an unnatural force originally caused the deformity, and forced the upper teeth abnormally forward. Further, the force which originally caused the teeth to move forward may still be acting on them, thus, though the *occlusion* might be corrected, both upper and lower arches would occupy a too anterior position. This difficulty has to a certain extent been observed, and "is easily overcome, and the time of treatment greatly shortened by combining this form of anchorage apparatus with occipital by means of the head-gear and traction bar in the usual way."[1]

Jack screws, drag screws, wedges, &c., might be discussed to show that we have invariably to deal with reciprocal pressure, and the idea of anchorage should be dismissed as quickly as possible from the mind.

There is a rather different form of reciprocal strain which seems to lead to no good result. It crops up in the most unexpected places, and warps the under-

[1] Angle, "Malocclusion of the Teeth," p. 259.

standing to an almost unlimited degree. I refer to that sentiment which has for its motto, "Our country, right or wrong." We read, for example, in the first edition of Messrs. Smale and Colyer's "Diseases and Injuries of the Teeth," that "There is a method [the use of fixed apparatus] freely used in America which is only mentioned to be condemned." Then follow some thoughtless arguments in support of this statement. In the second edition of this same work the statement is omitted, and at least one-half of the figures illustrated for the student's guidance consist of those condemned apparatus! The other half of the figures are examples of clumsy plates, which we must only mention to condemn on account of their covering the molars, hindering mastication, inducing caries, disorganising the articulation, and preventing that most necessary adjunct to successful regulation—the helpful action of natural developmental forces.

I do not intend to pursue the subject further at present, and in conclusion will venture to hope that what I have written may at least stimulate thought, for "The whole question of the etiology of malocclusion is almost a *terra incognita*. . . . Without the ultimate solution of the etiology of malocclusion in its various aspects, therapeutic measures must be empirical and defective, and that just in proportion as its etiology lacks recognition."[1]

The extreme importance of the habit of reflection has long been recognised; but at the present, when

[1] *Dental Cosmos*, Leading Article, Feb. 1903.

we find students and teachers often more or less crammed with facts and detailed observations, its extreme importance is ten times more urgent. I cannot do better than conclude with a confession from Lord Chesterfield to his son. He wrote: "I adopted the notions of the books I read, or the company I kept, without examining whether they were just or not; and I rather chose to run the risk of easy error than to take the time and trouble of investigating truth. Thus, partly from laziness, partly from dissipation, and partly from the *mauvaise honte* of rejecting fashionable notions, I was (as I have since found) hurried away by prejudices, instead of seeking for truth. But since I have taken the trouble of reasoning for myself, and have had the courage to own that I do so, you cannot imagine how much my notions of things are altered, and in how different a light I now see them, from that in which I formerly viewed them through the deceitful medium of prejudice or authority."

APPENDIX I

THE DIMINUTION IN SIZE OF THE JAW

THAT the human jaw is gradually becoming smaller is a fact which is universally recognised; but the cause of this diminution in size is not so very apparent. By those who believe in the transmission of acquired characters it is instanced as a case in support of their views.[1] By those who deny this inheritance of acquired characters it is assumed to be explicable according to the principles they maintain; although, as far as I have seen, there has not as yet been an adequate explanation of the fact by them.

Before entering upon the discussion a few facts and figures may be useful.

The size and prominence of the jaws may be indicated by Prof. Flower's gnathic index, which is well known, viz.:—

$$\frac{\text{Basi-Nasal line} \times 100}{\text{Basi-Alveolar line}} = \text{gnathic index,}$$

or shortly

$$\frac{\text{B.-N.} \times 100}{\text{B.-A.}} = \text{gnathic index.}$$

The following may be taken as examples:—

Prognathous.	
Native Australian.	Gnathic index 104.
Mesognathous.	
Chinese.	Gnathic index 99.
Orthognathous.	
English.	Gnathic index 96.

This gnathic index gives, of course, the relative sizes of the jaws to the head, and we need not concern ourselves with the absolute measurements. In the present inquiry the size of the jaws relative to the skull is of chief or sole importance.

[1] Spencer, "Principles of Biology."

Another set of measurements which are perhaps less generally known is what Prof. Flower calls the dental index; that is, the relative length of a line taken from the posterior surface of the crown of the wisdom tooth to the anterior surface of the crown of the first bicuspid (in the upper jaw) and the length of the basi-nasal line. If the former line be represented by *d*, the dental index will be as follows:—

$$\frac{d \times 100}{B.\text{-}N.} = \text{dental index.}$$

This index gives the sizes of the teeth relative to the general size of the skull, perhaps better than any other measurement which may be devised.

As instances the following may be taken:—

Microdont.
British. Dental index 41.3.

Mesodont.
Chinese (male). Dental index 42.6.

Megadont.
Australian. Dental index 45.5.

The basi-alveolar line is about $2\frac{1}{3}$ times the length of the dental line; and, if we multiply the dental index by that number, the result is approximately the gnathic index, *i.e.*, the diminution of the dental and gnathic index is approximately identical.

			Gnathic Index.
Thus	English . .	$41.3 \times 2\frac{1}{3} = 96.3$	96
	Chinese . .	$42.6 \times 2\frac{1}{3} = 99.4$	99
	Australian .	$45.5 \times 2\frac{1}{3} = 106.1$	104

To be somewhat more exact from the figures, it will be seen that the dental index diminishes rather quicker than does the gnathic index. This does not support the belief that the jaws diminish in size more quickly than the teeth.

It might on *a priori* grounds be assumed that the size of the body of the jaws is directly correlated with the size of the teeth, and this we see is actually the case.

If now we compare the *position* of the teeth in prognathous races with that of orthognathous races, we observe that they are placed somewhat differently. The following figure

drawn from Owen's "Comparative Anatomy and Physiology" will show at a glance the more anterior position of the dental arch in the aboriginal Australian.

It will be observed that prognathism is dependent on the prominence of the alveolus in the incisor region on the more forward direction of the incisors, on the size of the body of the jaw, and on the more anterior position of the arches of

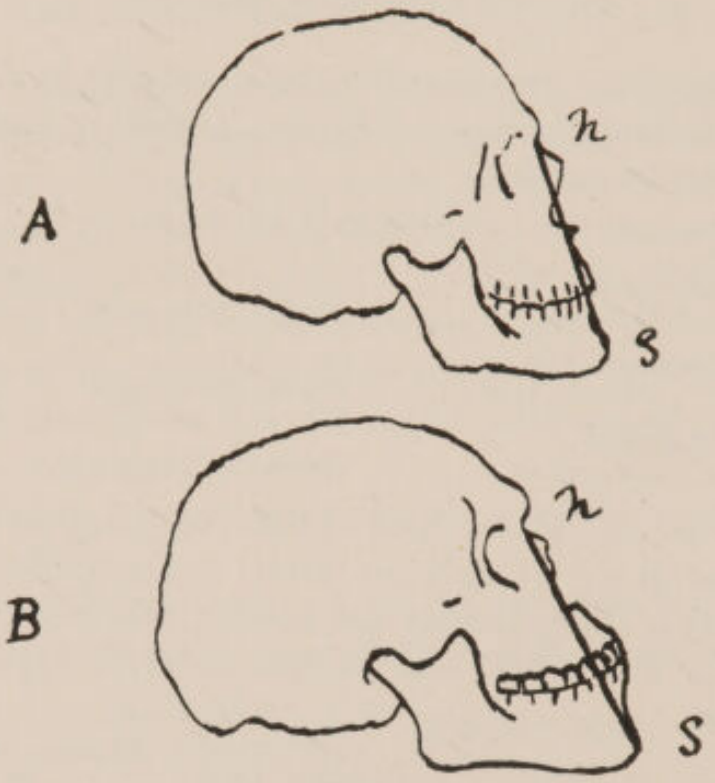

FIG. 15.

Skull of European A and Aboriginal Australian B. A straight line is drawn from the nasion to the symphysis menti, to show in B the more anterior position of the dental arch.

the teeth relative to the body of the mandible and the bones of the face.

Besides the differences already mentioned there is a considerable difference in civilised and savage races in the shape and especially in the massiveness of the mandible, due largely to the effects of muscular attachments and actions.

From the continual use of coarse and fibrous foods in savage races the muscles of mastication are greatly aug-

mented in size. The amount of difference in this respect between the uses of the civilised and the uncivilised may be judged from the recent experiments of Dr. Black, who finds that man living on "natural food would be able to close his jaws with a force of three hundred pounds, whereas in a civilised state and depending upon artificial preparation of foods, the amount of stress that would be borne by the individual tooth without severe pain or injury is reduced to one hundred pounds, or less in a state of apparent health."

A comparison of an aged jaw in which the teeth are lost with one in which the teeth are in full functional activity, shows at a glance the parts of the mandible which are chiefly augmented by muscular development. The subserviency of the alveolus to the teeth is also seen.

FIG. 16.

Side view of two mandibles, adult and aged. The shaded part shows the extent of the bone in full functional activity. The unshaded part shows the mandible reduced from loss of teeth and functional inactivity.

It will be seen that a large part of the angle of the jaw has been absorbed, and the anterior condyle is reduced in size.

Not only are the changes shown in the figure brought about, but the massiveness of the jaw as reduced by at least one half.

A similar change is observed in those parts in the neighbourhood of the insertion of the masseter, temporal and internal pterygoid in childhood and adolescence. That is with the increase in size and strength of the muscles there goes an increase in length, breadth, and depth of the ramus, and this change takes place in proportion to the muscular development.

It may be noticed that in the aged jaw the length does not diminish, and as I have said before, the length of the body of the jaw is largely dependent on the development and size of the teeth.

We are now in a position to point out the causes of the diminished size of the civilised jaws.

There are four principal causes, viz. :—

(*a*) Diminution from muscular inactivity, or as it might be put with stricter accuracy, incomplete development from lack of the necessary stimulus of muscular activity.

The incomplete development from this cause is of course generally recognised not only in the case of the jaws but in all bones to which muscles are attached. The increased development from muscular activity is chiefly in the neighbourhood of the attachments of muscles. It is difficult to say to what amount the jaw-bone might develop in the civilised races were it subjected to the muscular strain which is normal among savages, and, as this may be considered a point or the point at issue, it will perhaps be well in the meantime to limit our attention to what actually does take place. A reference to Fig. 16 shows this sufficiently clearly. In addition to the stimulus to growth of muscular activity we may add that of increased strain. It is known that the arrangement of the trabeculae in long bones is due to the direction of strain, and this force no doubt influences slightly the development of the jaw.

The next cause of diminished prognathism in the civilised is (*b*) the more posterior position of the whole arch of the teeth, due to the diminished size of the civilised tongue.

When the mouth is closed the tongue fills the cavity of the mouth, and thus the size of the arch of the teeth gives a fair indication of the size of the tongue. Measurements have been taken of numerous skulls, and a marked diminution in size in the civilised has been observed.[1]

It is well-known that the position of the teeth is easily changed by mechanical means; if a slight continuous force is applied to any or several teeth they are moved till the pressure is equilibrated by an equal and opposite force. The whole system of the regulation of the teeth employed by

[1] Talbot, "The Etiology of Osseous Deformities of the Head Face, and Jaws."

dentists is dependent upon this fact. If a tooth or teeth are thus made to alter their position the alveolus adapts itself to the changed position. Since this is the case it is impossible for the teeth to be other than prognathous when the tongue is large or *vice versâ*. The question as to the cause of this enlargement of the tongue is simply that it, like other muscular structures, when it is much used, develops more fully. I have pointed out elsewhere[1] how very much more the tongue is used when coarse and fibrous food is masticated than when the refined foods of civilised peoples are masticated or swallowed. However, whatever be the cause of the diminished size of the tongue the fact undoubtedly remains that it is smaller, and that the teeth and alveolus occupy a position which is largely dependent upon its size.

The third principal cause of the smallness of the civilised jaw is (*c*) the size of the teeth themselves. That the teeth of the civilised are smaller than are those of the more savage races is established by actual measurement.[2] The crowns of the teeth are developed in the substance of the jaw-bone, and it is known that the active development of surrounding parts are thus stimulated to growth. This is remarkably verified by cases in which the number of teeth are reduced in number.[3] It is evident that this stimulus for the development in length of the body of the jaw is independent of muscular activity. It is important to observe that the teeth of the civilised have diminished in size, as they are passive structures, are formed quite independent of use, and do not augment in size by functional activity. Nor is it maintained by "transmissionists" that such diminished size can be held to be due to inheritance of acquired characters. Thus Mr. Spencer, in referring to spines and other structures in plants whose functions are passive, says that this evolution is inexplicable except as results of natural selection. So, too, with structures

[1] "Physiology of Mastication," *British Journal of Dental Science*, November 1900.

[2] Flower, *Journal of Anthropologient Institute*, March 1885.

[3] Tomes, "Dental Surgery," 4th ed., p. 65.

having only a passive utility in animals he says he "never dreamed" that they were explicable as the result of the inheritance of functionally wrought modifications.[1]

The fourth important cause of the diminution in size of the jaws is the upright posture. When the erect posture is assumed the weight of the thorax and viscera is thrown to a certain extent on to the hyoid and thus tends to drag the tongue downwards and backwards.

The diminution in size of the teeth by natural selection, however, presents a somewhat difficult problem. It may be questioned by some whether slightly smaller size of teeth can possibly have been of sufficient survival value to have caused the extinction of multitudes of men, and so to have brought about a diminution in the average size of civilised teeth. When we consider merely the extra weight of larger teeth, and the extra nutrition and muscle required to carry them about, we would certainly come to the conclusion that this has not been the cause of the diminution. It is not, however, always in a direct way that changes are brought about. Consider for example the case of such savages as the Australians. In them we find a relatively small cranial capacity 1197. Compare this with the cranial capacity of an Englishman, viz., 1427. Remember that the cranial capacity of the remote ancestors of the English were no larger than that of the Australian, and we see that assuming the size of the teeth to remain the same while the cranium increases in size, we have a certain advance towards the microdont type, for the basio-nasal line may be assumed to augment with the general augmentation of the cranium. The survival value of increased brain capacity will hardly be questioned.

Consider the matter from a slightly different point of view; assume that it is of considerable survival value that the brain of man should be highly developed and well nourished. A certain amount of nutrition flows along the common carotid; in one case let us assume that a larger amount is diverted to the cranium, and that this develops fully; in

[1] "Principles of Biology," vol. 1 (new and enlarged edition).

another that a larger amount goes to the teeth. It is evident that if the brain is of great survival value the teeth may suffer, those inheriting the one peculiarity surviving, while those inheriting the other become extinct.

This latter assumption I have introduced more to indicate how indirect methods may effect a diminution in size of the teeth rather than as an actual statement of fact as to the exact method which has in reality taken place.[1] In addition to the factors which directly or indirectly bring about a diminished size of the teeth, we may also have the factors panmixia and germinal selection.

Now what does all this indicate with regard to the size of the savage and civilised jaw? Simply that to a large extent, its particular size is not due to heredity, but is largely a characteristic redeveloped in each generation as the result of the action of the environment. This is quite in accordance with the recent investigation of biologists. "Botanists and zoologists have conclusively shown that the bodies of animals and plants are subject to a very great change as the result of changes in the environment. Such changes are, indeed, not inherited, at least as a rule, but are simply redeveloped in each generation as the result of the action of the environment. Specific characters we have supposed to be inherited, but the more this matter is studied the more prominent has become the question as to whether many or most of the so-called specific characters, instead of being matters of inheritance are not simply acquired by each individual."[2] Much more strongly does this then emphasise the recognition of the fact that racial differences, frequently, are almost solely dependent on differences of environment.

The essence of the conclusion, therefore, which we reach is, 1st. That the diminution in size of the jaw is due to differences in environment, and the actual hereditary diminished size

[1] I have already discussed the principal cause of the diminution in size of teeth in "The Cause and Prevention of Decay in Teeth," pp. 71 and 72.

[2] H. W. Conn, "The Method of Evolution," 1900.

of the teeth and correlated diminished size of jaw. 2nd. That this hereditarily diminished size of teeth can in no way be accounted for by the disuse of the teeth, as the teeth are formed unlike many other structures absolutely independent of use or disuse. Nor have we any grounds for the assumption that disuse of the teeth may induce a hereditary tendency to diminished size of the teeth as they are passive in themselves in their function.

APPENDIX II

SOME ANTHROPOLOGICAL SPECULATIONS

THE special study of one branch of science often modifies our opinions on correlated branches. So even the study of the irregularities of the teeth tends to make us modify our ideas on certain criteria, upon which anthropologists lay much stress, and make us doubt if they are of the importance they are wont to attach to them.

To me, at least, it seems probable that many of the causes of the irregularities of the teeth are similar to the causes which account for the changes in the jaws and associated parts as we ascend from anthropoid apes, through primitive man, to the existing types of the present day.

We have referred to numerous characteristics which are generally supposed to be racial and inherent. These on analysis were found to be largely the *results* of different habits necessitated by the different stages of civilisation to which the particular face has attained, together with the concomitant differences which tradition, climate, and general environment have impressed upon essentially similar hereditary potentialities. As an example of this may be taken the prognathism of the negro. It is said that this character is not nearly so pronounced in the negro of America as in his African ancestor. That in fact he has in the course of a few generations, become more or less orthognathous.[1] It is ridiculous to contend that he has become an hereditary racial type differing from his relations in Africa. For if he were thrown back into the state of civilisation in which he originally existed, his descendants would at once return to the

[1] Talbot, "Etiology of the Osseous Deformities of the Head, Face, and Jaws."

same type from which he originally sprang. Now it is contended by anthropologists that gnathism is one of the most important (inherent) racial characters as marking the stage of evolution to which any particular branch of the human family has progressed, while in reality I am convinced it is more correct to say that orthognathism is the result of a civilised environment, and only to a small extent the result of hereditary racial characters.

No doubt, however, characters which are changed or adapted to changed environment produce concomitant modifications, and, by giving rise to modifications, throw the established relations into strained relations, which in their turn may predispose to disease and premature death. Thus natural selection steps in, and ultimately modifies the hereditary structure, or in the words of Mr. Lloyd Morgan, natural selection "would work along the lines laid down for it in adaptive modification. Modification would lead, variation follow in its wake."[1]

Another example is furnished by the narrow and prominent nose of the highly civilised. In this case, we have the prominence, due *partly* to the lack of anterior development of the maxillæ, and to the lack of development along the suture separating in the maxillæ.

The only exception to the fact that platyrhinism is associated with, and roughly proportional to the amount of mastication is the case of the Esquimaux. This may be accounted for by some influence of the extremely cold air which he breathes, or by some other atmospheric condition associated with their methods of ventilating their houses, although it is probable, too, that there is some relationship between cranial development and capacity and leptorhinism.

It is possible, too, that a special characteristic of the semitic race, which by the way is by no means universal among them, comes about from similar causes. Their method of speech too often suggests nasal stenosis. The reason that such defects are more prevalent among them is no doubt due to the fact

[1] "Habit and Instinct," p. 318.

that they are essentially town dwellers, and they more frequently fall a prey to the mal-environment. Of course I do not contend that Jews have not any hereditary racial characters, but only that what is generally supposed to be their chief one is probably in many cases to a great extent rather the result of their environment.

Another example may be mentioned. In certain races the outer canthus of the eye is tilted upwards. From casual observation I believe that this is a characteristic even among well-developed English children. The usual depressed canthus is, as a rule, more pronounced in narrow-faced and thin people, and no doubt this feature, which is by no means as merry looking as the raised outer canthus, might seldom exist among us if we had been fed on foods which necessitated mastication and supplied the body with its physiological requisites.

Another speculation which seems to offer ground for consideration is the effect of the upright posture in bringing about a diminution in size of the jaw. There is a marked difference in the size of the jaws of the higher apes and those of the aboriginal Australians, and yet their food may not be so very different as regards its physical qualities. It seems possible that the drag on the hyoid, produced by the erect position, may largely account for the diminution in size. It should be remembered, too, that the anthropoid apes make very much more use of their arms than any men. Thus the muscles of the trunk and neck are much more fully developed, and prevent any undue drag on the hyoid. The normal relations would no doubt be maintained among children if they were allowed or encouraged to play their own little games, frequently involving a more or less horizontal position. This society will not permit, and even though it sacrifices the health of the child it would be considered ridiculous to advocate games which might dirty the knees or wear holes in trousers. It is rather more in keeping with modern civilisation to drill in erect and strained positions or to sit bolt upright working with books or "behaving." Still, the day may

come when the phylogeny of the race may be considered in relation to the ontogeny of the individual.

Another speculation seems worth recording. Much importance has been put by transmissionists on the fact that the teeth and jaws have become relatively small in man, and especially civilised man. For they contend that the weight of the jaws could hardly be considered of sufficient survival value to have been subject to the effect of natural selection. Leaving other objections to this idea aside, I would here only call attention to one neglected consideration. Perhaps man was descended from a small anthropoid.[1] Now if man has been derived from a smaller form it follows that natural selection not acting particularly on the jaws and teeth, acted in such a way as to increase the size of other parts. But if the skull and other parts increased in size, then without any change in size the jaws and teeth became relatively smaller.

[1] Dr. Campbell informs me that man very probably *was* derived from a small anthropoid.

THE END

Printed by BALLANTYNE, HANSON & Co.
Edinburgh & London