The Significance of Tooth Form*

(Continued)

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Having studied various types of animal dentures which indicated principles fundamental to masticatory function, we are now in a position to study the more complex omnivore, man. Our task will be to determine whether or not the same principles are operating and in what manner they reveal themselves.

In structure, the omnivorous tooth presents characteristics of each of the other two great classes. Like the carnivore, its functioning surfaces are covered with unbroken enamel which is not true of the herbivore. On the other hand we find teeth that present occlusal surfaces which permit of more than a shearing action. Thus we have the possibility of two different masticatory habits combined in one denture—although it seems safe to say that neither is as efficient as in the pure types. Man is not as efficient a meat eater as is the carnivore, nor as efficient an eater of fibrous vegetation as is the herbivore. Closer examination and analysis reveals that the marginal ridges of his cusps are in reality a series of shearing blades feeding each other, while the cusps themselves and the irregularity of their surfaces must act similarly to the rough projections on the herbivorous tooth.

Other points that seem significant are that the teeth of the buccal segment resemble the herbivorous types in general form except that a canine is present. In man this tooth is an important unit while in the ruminant it is usually suppressed or entirely absent. The incisors are of neither carnivorous nor herbivorous type but more nearly resemble the rodent in action.

The hardness of the surfaces and their enormous extent, cut wear to a minimum, so that we do not readily find a means of adjustment to this demand. We know that wear occurs on the occlusal surfaces and at the inter-proximal contact points and we know further that this wear must be compensated for, but we do not find either continuous growth or continuous eruption of the teeth.

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An examination of the functional excursions of the various teeth reveals that the incisors work by the passing of two blades. This should not be considered as a true shear such as the sectorial tooth however, but rather as chisels similar to the rodent-forms. The edges remain parallel to each other throughout the stroke. While this reduces their efficiency as cutters it makes possible a grasping function that is absent in the shear and one has only to watch a monkey or any animal with similar incisors to realize that this group of teeth constitute an additional hand.

The canine in the omnivore varies greatly in its development but is a very constant unit in all of them. In some of the apes it is developed almost as highly as in the cats, but since there is a marked difference between male and female of the same species in this regard it is probable that sexual warfare and not mastication, is the factor behind such robust development. Even in man it is extremely stable in its eruption and location, as witness of its importance, and the author believes that in *all* forms it serves the function of guiding the excursions of the buccal teeth.

As we pass from the canine to the premolars and molars we enter a new field of activity that is as clearly marked off from the former as though a diastema existed, as it does in all other forms. These teeth are not only multicusped, but they are multirooted to take care of a different type of load, and the roots show something we have not seen before. In the sectorial teeth we found two main roots but these were set mesio-distally to each other, while in the ruminants we found block-shaped roots of almost the same size as the crowns which they supported. The support of the crowns in the omnivore tends to separate into roots and these roots show a tendency to spread not only mesio-distally but bucco-lingually as well. This would seem to indicate again a mixture or combination of stresses on this type of tooth that is not met with in the others.

In this present essay we are interested in these stresses. Therefore, before going further it might be well to endeavor to build up a concept of how stress is borne by the teeth and the nature of the modifications that may be met with. There is a great deal of confusion on these matters at present, mainly for the reason that the problem is not grasped in its entirety. We hear it said that teeth should meet in such a manner that their axes are in line with the blow struck, and again, that the tongue on the inside and cheeks on the outside hold the teeth in a balance. Both of these statements are true as far as they go but they are only the simplest beginnings of the full problem.

Everyone knows that it is impossible to drive a nail unless the blow of the hammer falls very close to the long axis of the nail and this simple example might serve to illustrate the position that teeth would have to assume if there were no other factors in the picture. If however, we give the nail sufficient support on the weak side so that this support, plus the strength of the nail, balances the force of a blow in a different axis, the nail will be driven. In other words we have two weaker units of support combining to balance a strong force. Similarly, we can change the direction of our blow again and, by adding a third factor of support, balance a greater blow from this *new* direction.

In the case of the teeth we have an infinitely more complex picture than this and one which involves factors that are not all of a physical nature. We must consider first of all the functioning parts of the tooth. All other items must be conformed to give them maximum efficiency. The forms of the crowns, the forms and arrangement of the roots, the distribution of the fibres of the membrane, the distribution of bone, both locally and generally, the arrangement of the teeth with each other in arch form, the pressures and tensions of musculature and accessory functions. Then we have those intangible factors that we may only speculate upon but which influence the state of balance. We talk of 'inherent growth force,' of 'metabolism,' of 'blood chemistry' and of 'normal cellular response to functional stimulation'; all fine terms, but terms that label without explaining. Nevertheless we are steadily becoming more conscious of their influence. If we consider this problem *solely* from the mechanical aspect we are faced with a number of paradoxes that cannot be explained. Why, for instance, if action and reaction be equal and opposite, should the maxillary teeth and their support differ so radically from those of the mandible? Why should teeth which function against each other move ever closer together rather than away from each other? Why should growth always seem to be *against* force rather than with it? These are all insurmountable obstacles in the path of the purely mechanistic concept of occlusion.

On the other hand it would be absurd to entirely eliminate mechanics from the explanation. Function of the teeth involves force, muscles involve force, and pattern and arrangement are surely mechanical factors. The fact that must be grasped is that in living forms mechanics are conditioned by the response of living matter. Let us endeavor to enumerate some of these forces and factors and see what part each may play in the complete picture.

Our logical starting place is with the incisal edges and occlusal surfaces of the teeth. These are the edges of the tools—the functioning parts, and everything else must be considered as contributory to their efficiency. We have seen the mechanics used in their function as revealed by form and it now remains for us to study the role of the various elements of their control.

The forms of the crowns of the various teeth first engage us and we find these designed to best serve the needs of function. The incisors are chisel-like with bulk enough to stand the blow and curvatures sufficient to shed food. The canines are still of a form that relates to piercing but it is interesting to note that they are no longer the straight tapered teeth of the carnivore or apes; they now taper both ways from the contact line and present, like the incisors, shedding surfaces. They might still be considered as independent teeth but they are more intimately associated with the buccal teeth, through their guiding function, than with the incisors. The fact that they present true contact points is significant and will be referred to later.

The bicuspids or premolars next receive our attention. While of much greater importance than in the carnivore they fall far short of attaining the role played in the herbivore. Their occlusion, especially that of the firsts, is frequently restricted to the buccal cusps and their roots do not attain the size that we would expect of a heavily functioned tooth. They are among the teeth most frequently suppressed or missing, and are among the most easily displaced. Their contacts however seem important when we think of the striking modifications of their forms so frequently met with. The premolars are the first teeth to show double cusping and they are in a line that lies in a different plane than the incisors and canines.

The molars show very clearly by their form, their size, their location, and their support that they are extremely important in mastication. In general shape they resemble the herbivorous tooth, but the presence of cusps belies a true herbivorous function.

While their cusps make possible the efficiency of inclined plane mechanics, they do not meet as plane against plane but as convex ridge on convex ridge. These convexities lead to a functional stroke which in reality is a meeting of traveling points and thus we see that the first law of the shear is being complied with. The ridges run in a number of directions so that not one but a great number of shears may be brought into action. The function of any given shear is not as efficient as in the true flesh eater but the presence of such a large number makes possible a more generalized cutting of the mass. We have mastication instead of a mere chopping.

From a mechanical standpoint it makes no difference whether shearing blades are arranged vertically, horizontally, or in any given position and the same is true of two grinding surfaces. In animal dentures, however, we always find bladed teeth functioning in a vertical plane and grinding teeth functioning in the horizontal. The reason for this probably lies outside the field of masticatory efficiency and has some connection with economy or with other functions. It is significant however that the omnivore, possessing teeth capable of both functions, exhibit functioning parts that lie in planes between the other two, namely inclined at angles of 45° or less according to type.

In the eating of fibrous vegetables man is not as efficient as the true herbivore. It should be remembered however that none of the omnivore eat such things as grasses, etc.; their vegetable diet being composed of grains and plants capable of being broken up sufficiently without the need of extreme maceration. The cusps and the unevenness of their surfaces are sufficient for this purpose.

If we analyze the masticating stress on any given tooth by examining the functional stroke, we very soon come to realize that such stress does not fall in a line with the long axis of the tooth. For example let us examine the incisors. These teeth pass each other in function and are pressed tightly against each other if they are to operate efficiently. The uppers receive the pressure from the lowers in such a manner that they would tend to be displaced to the labial, while the lowers would tend to go lingually. Since the force in this direction is probably as great or greater than that operating in the line of the long axis we see at once that either there must be additional elements of support or that there is an unmechanical factor present that defies natural physical laws. We believe that both of these conditions obtain, but we shall concern ourselves first with the mechanical.

For the function of mastication, as differentiated from mere seizing and cutting, a complex tooth had to be developed. This tooth, according to some authorities, was an accumulation and refinement of other simple teeth into an efficient unit. This has been more completely carried out in the elephant than in any other form. In this animal the entire buccal segment is composed of but one tooth although such a tooth may consist of as many as thirty-two plates. In many of the ruminants the buccal segments are composed of five or six teeth, but these teeth are so securely fitted together, mesio-distally, that it is frequently impossible to determine their individual borders. Since, in the carnivorous forms, we find teeth separated from each other by appreciable intervals it would seem that there was some connection between a proximal contact and the herbivorous diet.

In man we have an animal with an unbroken dental arch and thus we have an accessory factor of support that must be reckoned with. Any tooth in a normal dental arch receives the support of all the others in the same arch. That this support is a definite factor in the stabilization of the individual tooth is clearly shown by the drifting of teeth following the loss of one of the units and it is equally well founded that the teeth move ever closer together through function in order to take up wear and preserve contact with each other. This immediately raises a question as to the source of the power that would accomplish this purpose.

If we examine the relation of the functional edges or surfaces of the teeth to their long axes we find a very logical answer. The incisal edges of the upper central and lateral do not lie at right angles to the long axes of their respective roots. When their edges come into a normal functional position the apices of their roots lie to the distal of a perpendicular from such a line. The lower incisors, on the other hand, stand almost vertically. Now we know that the masticatory stroke in such teeth travels from a lateral position to centric so that its force would tend to displace these teeth toward the opposite side of the mouth. We are therefore brought to the conclusion that the teeth on the *opposite* side of the maxillary arch, occupying as they do a position more in line with the blow, are responsible for the bracing of the functioning side through the medium of the contact points. This same arrangement is not found in the mandibular teeth for the reason that function in this arch has a tendency to drive the teeth ever closer together, while that received by the upper is a spreading blow—in short the mandibular arch is a 'contained' arch.

For the moment we are going to skip the canine and premolars and analyze the molars. When we examine these teeth we find again that their roots have a distal curvature or in other words that their occlusal surfaces do not lie at right angles to the axis of their support. From the standpoint of pure mechanics we would know that the functioning of these two teeth against each other would produce a vector of force in a forward direction. When we see what happens to these teeth following a loss of contact anterior to them we realize that this vector actually exists. This force acts in a straight line through the contacts and emerges from the denture at the canine area. This probably explains the instability of the contact relations of this tooth.

In addition to this force we have others working on the molars. The lateral excursion of the mandible results in a buccal thrust on the maxillary and a lingual thrust on the mandibular teeth and mechanics will only partly explain the phenomenon that keeps these teeth from moving away from each other. The mechanical factor is musculature, which is our next consideration.

The dental arches should be thought of as lying between two walls of musculature. On the inside we find the tongue and it has been implied by some that a true balance exists between this organ on the one hand and the lips and cheeks on the other. This is not so. The tongue should be considered as a mere scaffolding supporting the lower teeth but not sufficiently strong to successfully antagonize the outer muscles. The arrangement of the teeth in an unbroken arch is a potent factor that resists the lingual displacement of the teeth by the lips and cheeks. Thus we have at least two forces, namely, *tongue* and *arch form* that resist the force being constantly exerted to drive the teeth lingually. As proof of this condition we would submit the clinical evidence of the collapse that follows the loss of contact anywhere in the dental arch, but particularly in the cuspid area.

The analytical study of the labial and buccal musculature in man reveals numerous interesting side-lights. The buccinator muscle arises from the pterygo-mandibular raphe posterior and lingual to both upper and lower dental arches, crosses their respective alveolar processes and takes additional attachment from the surfaces of the mandible and maxilla as far forward as the first molar tooth. From here forward it runs free. Mechanically, this muscle under normal tonus, would mold the anterior portion of the dental arch into a semi-circle, but it does not do so. All of the powerful accessory muscles running to the lips such as the caninus, triangularis, zygomaticus, etc., have their insertions into the corner of the lips or discussate to the opposite lip at this point. The zygomaticus and zygomatic head of the superior quadratus arise from the surface of the zygomatic arch and thus exert traction from a wider base than that of the dental arch. This, therefore, affords a 'relief' point that helps to break up the evenness of the tension exerted by the buccinator. This, however, is only one weak factor that lends to the flattening of the anterior segment and the prominence of the canine.

The only mechanical restraining force working on the incisors is the backward pull of the musculature, especially that of the lower lip, and if this tension is lost the decussating muscles at the corners of the mouth quickly overpower the relief muscles and reduce the canine prominence. We can see from this fact that the forward vector of the buccal segment and the force of backward pull on the incisors must meet at the canine area. A meeting of two such lines of force would lead to a bucco-labial displacement of the keystone—for the canine should be looked upon as a keystone—and thus we see that it is the interplay of a number of forces that contributes to the stability of this very important tooth.

We have neglected the bicuspids or premolars up to this point because they do not appear to play more than a passive role in the picture. Their crowns have a strong tendency to sit directly over their roots—which parts are relatively weak, and their occlusal surfaces lie at almost true right angles to their axes. One would assume that the blow on them during mastication gave little or no additional vector of force besides that received in the line of the axis. Their main importance lies in the fact that they contribute to the integrity of the arch through their contacts and act as *transmitters* of force only.

But teeth are only as strong as their support and we must therefore look deeper than this if our concept is to reflect the complete picture. The mechanical items concerned with support are the size and forms of the roots, the peridontal membrane and the alveolar bone. As has been pointed out earlier, a tooth is suspended in its alveolus and resists force by a *pulling* on the fibres that connect it with the surrounding bone. We will therefore find that roots are formed to give the greatest surface for fibrous attachment at those areas when the stress is heaviest. A few examples will serve to illustrate this point.

The lower incisors, receiving support from the tongue lingually and the upper incisors labially, in addition to their labial inclination, are well balanced except to take care of the mesio-distal thrusts of lateral movements. We find their roots flattened in such a way that much greater attachment is possible on the mesial and distal than on the labial and lingual. The lower molars exhibit this same tendency. The maxillary incisors, on the other hand, tend toward a triangular form. Force on these teeth is great in a labial direction and with the apex of the triangle pointing palatally it is possible for this tooth to use much more than half of its root surface for resistance.

In such a paper as this it would be impossible to give an adequate picture of the mechanical possibilities that lie in the arrangement of the fibres of the peridontal membrane. Only careful microscopic study will do this. However, it is possible to derive great benefit from the study of dried specimens so far as the arrangement of alveolar bone is concerned. Such a study quickly brings us to realize two things: first, that the apex of a tooth is of relatively little importance from the standpoint of support; and second, that bone is built and organized best at those sites where function will create the strongest *pull* on the attached fibres.

The resultant of force at the apex of a tooth during function has been a controversial question and the author is not unmindful of the fact that many will not agree with him. He would submit the following observations to support his contentions. A microscopic examination of the apical area reveals a lack of organization and a diminution in the number of fibres that would seem to indicate that they were not primarily concerned with the support of stress. This is the nutritive area and its fibres are mainly concerned with the protection of the delicate vessels and nerves that course from bone to tooth in this location. The second observation may be made on any collection of dried human skulls.

If, as some claim, the tooth under stress acts like a two-armed lever, with a fulcrum somewhere between the apex and the gingival line, and if such stress leads to a tensing of fibres, it would logically follow that tension near the gingival margin on one side would be accompanied by tension at the apex on the opposite side. Masticatory force on the upper teeth leads to a buccal or labial thrust so that bone would have to resist from the gingival on the lingual side and from the apex on the buccal side. Instead of finding heavy bone in both of these localities as we might expect, we find it only on the lingual. The apices on the buccal are frequently exposed to view—especially those of the first molar and canine, and this in otherwise normal dentures!

A study of cross sections of the two jaws reveals that in the upper, the main site of resistance to the pull of the membrane is the palate, and that heavy bone is not normally built on the buccal. In the lower the reverse is true. We find the labial plate in the anterior segment to be very compact and strong in spite of its thinness and also that it tends to be bulkiest at the gingival edge. In some cases a definite bar of bone is laid down at this level. As we go posteriorly we find the roots of the buccal teeth lying close to the lingual surface of the mandible while the heavy bone is piled up on the buccal, or side of tension.

This then completes our scrutiny of the purely mechanical factors that are contributory to the maintenance of the teeth in function, and it should be apparent that these forces would tend to place and hold any tooth or groups of teeth in such a position that all of these forces would be in a dynamic equilibrium. Such an equilibrium may be changed by an alteration in the intensity of any particular force or group of forces, whether it be an increase or a decrease. That such a change in force does not always result in changes in the position of the teeth is well known to any orthodontist and this observation has tended to discredit the belief in the effectiveness of dynamic factors in the creation of malocclusions. Such disbelief is not well founded, however, as I shall attempt to show.

Reference was made in the early part of this paper to certain items, widely talked about but poorly understood, and it is in the realm of such speculations that our non-mechanical factors lie. Certain bodily reactions *seem* to act in defiance to physical laws and in no tissue is this better exemplified than in bone. Bone is built *against* lines of force, not with them and its main role is to *resist* force. Thus a stress that should displace a tooth according to *mechanics,* under normal physiological reactions actually strengthens the bone to better resist. The quality of bone and of its reactions depends on a vast number of conditions, only a few of which are known and none of which are understood. Any so-called constitutional factor is apt to adversely affect the growth, development or physiological reaction of bone, and when this happens any unbalanced mechanical force may become effective enough to cause trouble. In short, it would seem that a local environmental or mechanical influence is not, in itself, always sufficient to cause abnormality. The ground usually must be prepared for it.

Another interesting observation that is forced upon one in any comprehensive survey of normal animal dentures, is the varying degree of importance between all of these factors. In some cases we find, as in the rat incisor, that there is no mechanical factor that could possibly explain the position of this tooth in space. Here we have a physiological reaction that almost completely dominates the picture and it is interesting to note that with a disturbance of this tooth the animal must die. This particular tooth is one of the most remarkably persistent organs imaginable and its integrity is guarded by every resource of the entire ecomony of the animal. The canine of the fighter is another such tooth, strong and stable in its position without any mechanical aid. On the other hand, the buccal teeth of the herbivore may be mutilated and an adjustment will be made in the position of the remaining teeth that does not seem to markedly affect efficiency. The problem of variations between the various factors of balance is one of the main issues facing the dentist today if he is to solve the questions of etiology in malocclusion and peridontaclasia. We insist that the answer does not lie exclusively in either the mechanical or the physiological field; it will be found to be a combination of both and further, that the relative importance of the two will be found to vary even between members of the same species.

And now our last consideration is of the mechanism that activates the function of the parts we have been considering, namely, the tempero-mandibular joint and its musculature. We have heard so much about the mechanics of mastication and so much effort has been expended to prove that the mandibular stroke works on certain planes, angles, arcs, etc., that it is worthwhile to see if there is any evidence to support such conceptions.

We have seen in all of the animal forms studied so far that simultaneous function on both sides of the denture is a physical impossibility and further, that function at any one time is usually restricted to one of the three units of which these dentures are composed. This observation alone casts grave doubts on so-called "balanced occlusion" in man, since he would be the sole exception in the entire animal kingdom. A point of evidence against the belief that such balance involves a bearing point in the condyle is that we do not find it operating in any animals except those where single pairs of teeth are called upon to operate, such as the sectorials of the carnivora or the incisors of the rodent.

Many theories have been advanced purporting to show that the condyle path determines the masticatory stroke and that, in function, man has a bearing point in the joint and one on either side of his dental arch. To support this belief we have been deluged with a series of articulating devices, each one designed along mechanical lines that will permit of three point balancing. Most of them claim to reduce this vexing problem to a mathematical certainty and we are introduced to arcs, angles, curves, etc. as determiners of mandibular movements.

When these same laws or machines are applied to natural dentures, no matter how ideal, they always fall down in some particular; either the condyle is a little off in relation to the denture or one or more dental points are at variance with the law. These discrepancies are explained away as 'individual variations,' but we would submit that unless a *mathematical* principle works with mathematical precision it cannot be called a law. We further advance the belief that *no* articulator will ever accurately reproduce the movements of any mandible so long as such machines are based on the present conception. The teaching of such rules is a perfectly proper thing if it is restricted to the making of artificial restorations and is understood to apply only here. The labeling of such doctrine as biological law is a vicious thing because it closes the mind of the student to the truth and it has led to such conditions as the wholesale grinding off of cusps, etc. And all this is an effort to make natural dentures conform to a man-made law. This is 'painting the lily' if anything ever was.

The tempero-mandibular joint in man does not have anything to do with the determining of the masticatory stroke. Except in extreme movements and in full protrusion, the head of the condyle is never in contact with the fossa. On the other hand the type and arrangement of the teeth in the arch have *everything* to do with mandibular movements as any good orthodontist or oral surgeon will testify.

Man's denture, like that of every other animal, is in reality two dentures, a left and a right; and while the continuity of the two sides may contribute to greater economy it is not indispensible to masticatory function. This is shown in those forms where the mandible is divided at the symphysis and connected only by fibrous and elastic tissue.

If we examine the anatomy of the joint we cannot help but be impressed by its self-sufficiency. The masseter on the outside and internal pterygoid on the inside might be compared to suspensory structures or strings on an inverted maypole. The temporal lies between them in the frontal view and is fastened close to the joint, giving power for closure without affecting balance. The external pterygoid is not concerned with closure. This muscle is present in all animals and its function is the drawing of the mandible toward the *opposite* side. Thus the left joint determines function for the right side. In man this muscle does even more than this.

Omnivorous teeth, being locked in occlusion, antero-posteriorly and transversely, must be unlocked to move laterally. This is equally true of the herbivores. Further than this, one side must be kept out of function while the opposite operates. The external pterygoid, pulling the condyle forward onto the articular eminence, not only rotates the jaw but depresses the non-functioning side of the mandible in space. Then the teeth on the functioning side are brought into contact and the teeth *and only the teeth* determine the path of the mandible back to centric position. The entire load is carried by the teeth themselves and the joint becomes the servant instead of the boss of function.

All clinical evidence and every bit of true scientific investigation supports the truth of these assertions and one has only to read the work of Hildebrandt, of Prentiss or of MacMillan to be convinced of their soundness. In addition to this, one has only to observe the great variety of mandibular movements encountered in practice and to study the areas of wear on the teeth, to realize that the joint is a mere activator, not a determiner of function. The creation of new areas of movement following operations to relieve ankylosis is further proof of the same nature.

The author would go even further than this. A study of animal forms has led him to the belief that ideal occlusion, or that occlusion which gives the greatest efficiency with the least expenditure of power and material, calls for the *successive,* not the simultaneous meeting of teeth. Stated more simply, that each tooth, especially in the buccal segment, carries the full load of occlusion in succession from the canine back. This does not imply that the load is even in intensity on all teeth or that the remaining teeth do not lend their support through contacts. It means that occlusion should be thought of as a wave of force that centers momentarily on each tooth in the segment. Further than this, such contact should always be of a point to point nature, never surface to surface. Such a mechanism could only operate if the occlusal surfaces of the mandibular arch were set on a slightly larger arc than those of the maxilla and if the jaw were permitted to rock ever so slightly, antero-posteriorly and laterally.

Whether this view is new or not the author does not know. Whether it is received or not is immaterial. But one thing is important and that is the grasping of a different concept of this entire function than that which now obtains. The mandible should be thought of as a bone suspended in a mesh of musculature, capable of adjusting itself to a wide range of functional positions and depending on the form and arrangement of the teeth rather than on the joint for this positioning.

We have now covered as many of the factors involved in the function of mastication as the scope of this paper will allow. In fact, we have seriously overstepped the bounds and for this we crave forgiveness. To sum up the argument the following points should be recalled:

1. The forms of the occlusal surfaces and incisal edges of all teeth have been brought into being by long continued function and crowns have been modified to support these tools.

2. The demands of economy and of accessory functions have left their mark on tooth form until no two teeth in the denture are alike.

3. The reaction of teeth to disturbances reveals that these organs receive support from a number of sources and these sources are of two kinds, mechanical and physiological. Under the first are listed tooth form, relation of crown to root, root form, contact point support, musculature, etc. Under the second are listed the peridontal membrane, the supporting bone and the non-mechanical reaction of both of these to the stresses of function.

4. All of these forces, dynamic and static, must balance if the teeth are to be maintained in positions of efficiency, but the importance between the two groups of factors and between the individual factors of either group seem to vary in different species and even between individuals of the same species.

5. The temporo-mandibular joint is built to serve and not to control the various masticatory movements. The joint on the right side positions the mandible for the beginning of its stroke on the left and vice versa, but once the stroke has started the teeth determine the path.

6. It is the author's belief that man's denture conforms to all of the fundamental principles shown in the lower animals rather than to a set of man-made rules that have been advanced to increase the efficiency of artificial substitutes.

7. Finally, it is his earnest belief that these empirical "rules of thumb" constitute one of the most serious barriers in the way of advancement of all dental science today and that all thinking men should endeavor to relegate them to their proper position of importance.

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BIBLIOGRAPHY

BRODIE, A. G.—"Differential Diagnosis of Joint Conditions in Orthodontia." The Angle Orthodontist, Vol. IV, No. 2, April 1934.

HILDEBRAND, G. Y.—"Studies in the Masticatory Movements of the Human Lower Jaw." Skandinavisches Archiv Für Physiologie Supplement Zum 61, Band, Berlin und Leipzig, 1931.

MACMILLAN, H. W.—"Unilateral versus Bilateral Balanced Occlusion." J.A.D.A. July 1930.

MACMILLAN, H. W.—"The Case Against Traumatic Occlusion." J.A.D.A. November 1930.

PRENTISS, H. J.—"A Preliminary Report upon the Temporo-Mandibular Articulation in the Human Type." Dental Cosmos, LX. 1918.

IDEM.—"Regional Anatomy, Emphasizing Mandibular Movements with Specific Reference to Full Denture Construction." J.A.D.A. X. 1923.