

# The Suitability of the Human Masticating Apparatus from a Comparative Viewpoint.

By

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After reading some of the older odontological literature the impression is often gained that human beings have the most excellent masticating apparatus of all creatures. This view has no doubt a corollary from the belief that the human body was the most excellent creative work, and must therefore also have the most perfect masticating apparatus.

The perfection of an organ depends on its functional suitability. It may be of interest therefore to analyse the question of the suitability of the human masticating apparatus.

There has been different opinions as to what shall be reckoned as belonging to the masticating apparatus. WILD includes the upper and lower jaw, the temporomandibular joint, the teeth, the muscles of mastication, the muscles of the tongue, lips, cheeks and hyoid bone, besides the glands, blood vessels, nerves and lymphatics of the oral cavity. I do not use the expression here in this wide meaning, but reckon the masticating apparatus to comprise the teeth in both jaws and the temporomandibular joint which brings about the movements of the teeth in the lower jaw in relation to those in the upper one.

The expression "suitability" in biological respect is an appraisal of the coordination between a biological form and the conditions surrounding it. The suitability may thus be changed both by an alteration of the biological form and of the external conditions.

In judging the suitability of the human masticating apparatus we may reckon the biological form, *i. e.* the morphology of the teeth

and temporomandibular joint, as a constant factor, the change which occurs in the course of the phylogenetic development proceeding so slowly that we can put it out of consideration. On the other hand the external conditions or the function of the teeth may alter in such a degree that a formerly suitable set of teeth becomes less suitable.

We shall first examine the masticating apparatuses of a number of other vertebrates in relation to their function.

The temporomandibular joint in mammals is a new formation, os articulare and os quadratum which form the articulation between upper and lower jaw in lower vertebrates being transformed into the auditory ossicles malleus and incus (hammer and anvil) in mammals, while os temporale and os mandibulare form the joint in the latter. The function is the same, however, in both cases, and can of course be compared.

The quadrate-articular joint in non-mammalian vertebrates consists of two joint surfaces, which are so adapted that the one jaw can hinge on to the other (Fig. 1). The two surfaces do not glide over each other in any significant degree while in function, but it looks as if it is always the same points of the two joint surfaces which meet one another. The joint surfaces have often a very complicated form. In conjunction with strong ligaments a joint is created which can only perform opening and shutting movements.

Most of the lower vertebrates get their sustenance from live prey which is swallowed whole without any mastication. To catch such prey pointed prehensile teeth, such as are often found in lower vertebrates, are the most suitable, and only opening and closing movements are needed for this operation. To hold the prey until it can be swallowed, while it is squirming and trying to escape, it is an advantage that the lower jaw can only perform hinging movements. If the structure of the joint admitted of lateral movements, the animal would have to use muscular power to prevent the lower jaw from slipping sideways during the struggles of the prey to get free. With the structure the joint has this is unnecessary.

Also fish which live on mussels and other crustaceans are well served with the quadrate-articular hinge joint. They have usually flat crushing teeth, which are very suitable for breaking the shell of the prey, and the prey is ready to be swallowed immediately after the shell is crushed.

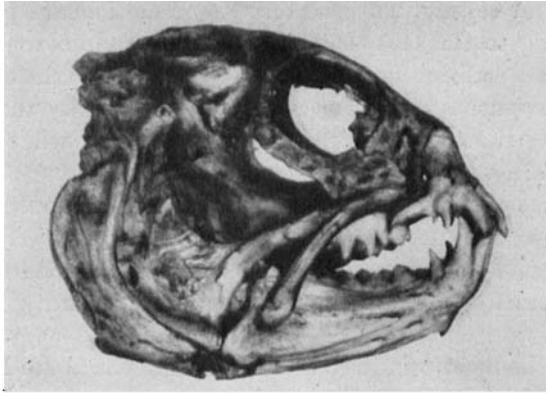


Fig. 1 a.

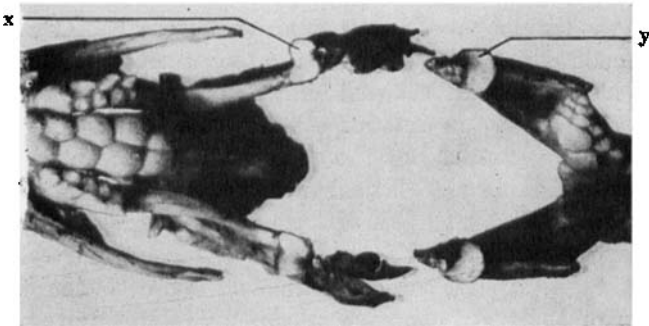


Fig. 1. *Anarrhichas lupus* L. Cranium. a. Seen in profile. b. Seen toward the masticating surfaces in both jaws. x. Cranial part of quadrate-articular joint. y. Mandibular part of the joint.

The chief difference between the quadrate-articular joint in non-mammalian vertebrates and the temporomandibular joint in mammals is that the latter have developed a so-called discus articularis. This is a disk of fibrocartilage with smooth surfaces, over which each of the two joint surfaces can glide. The function of such an articular disk is generally to cancel out small divergencies in the shape of the two joint surfaces. In the temporomandibular joint of mammals discus articularis has also the function to provide the joint with greater mobility. Thus FICK characterizes discus articularis as a sliding cavity for the joint head.

This form of the temporomandibular joint allows the lower jaw to perform lateral and anteroposterior movements, besides

opening and closing. The possibilities of motion are particularly great owing to the fact that the temporomandibular joint of the one side can perform movements independently of the other. Thus lateral movements of the lower jaw are effected by the one joint head being slid frontally in the joint cavity, while the other remains fairly still.

The extensive mobility of the lower jaw has no doubt had great significance for the development of mammals. Without this mobility such a general utilization of vegetable food as we find in large existing groups of mammals would hardly have been possible.

One of the most primitive orders of mammals is the Insectivora which have retained many original features and which are thought to be most closely related to the first mammals. In the hedgehog (Fig. 2) the cranial part of the temporomandibular joint is formed by a small cartilage-covered area on os temporale. The joint surface has no natural external limit, for example in the form of bony projections, so in that respect the conditions are favourable for lateral movements. But the occlusion of the teeth constitutes a complete hindrance to lateral movements.

Thus in Insectivora there is functionally a disagreement between the temporomandibular joint and the shape of the teeth. The rows of teeth are locked so completely by occlusion that no abrasion of the teeth can give release for lateral movements of the lower jaw. And owing to the extra muscular effort which is needed to keep the two surfaces of the joint together during the struggles of prey to break free the mobility of the lower jaw prevents full utilization of the sharp teeth as an instrument for catching larger prey. The insectivores live therefore on such little resistant prey that the jaws manage without any greater protection against luxation than is afforded by ligaments and muscles of mastication.

Temporomandibular joint and teeth approximately such as we find in Insectivora may well have formed the starting point for the development of the main groups of masticating apparatus in some of the most specialized groups of mammals — the Carnivora, Ungulata and Rodentia. For the development to the typical carnivores which have specialized in living on other mammals, and particularly the herbivorous, the alteration of the teeth form was not very great. The development of the temporomandibular joint, on the other hand, was of fundamental character.



Fig. 2 a.

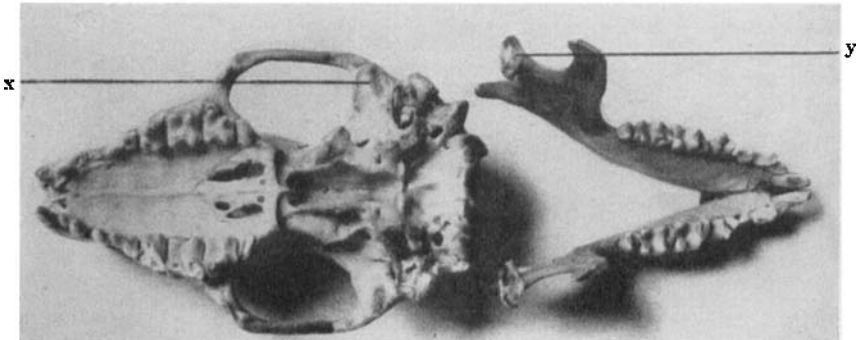


Fig. 2. *Erinaceus europaeus* L. Cranium. a. Seen in profile. b. Seen toward the masticating surfaces in both jaws. x. Cranial part of temporomandibular joint. y. Mandibular part of the joint.

When the carnivores had to revert to a hinge joint in order that the temporomandibular joint might be functionally suitable, the discus articularis did not disappear so that the joint obtained the same shape as in the non-mammalian vertebrates. But the joint surfaces were so refashioned that their shape prevented lateral movements of the lower jaw, such as these proceed in most other mammals (Fig. 3). This was obtained by the mandibular parts of the joint being developed into cylinders which went in a medio-lateral direction, while the cranial parts became furrows which fitted round the cylinders. In some species the furrows cover the cylinders to such an extent that it is difficult to separate the parts from each other even in skeletal material.

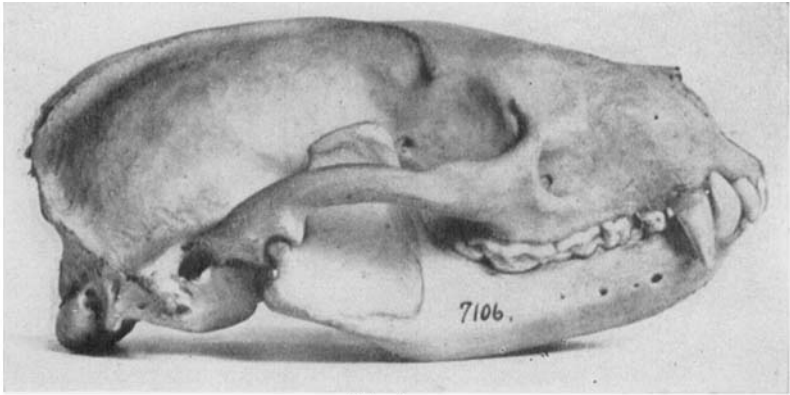


Fig. 3 a.

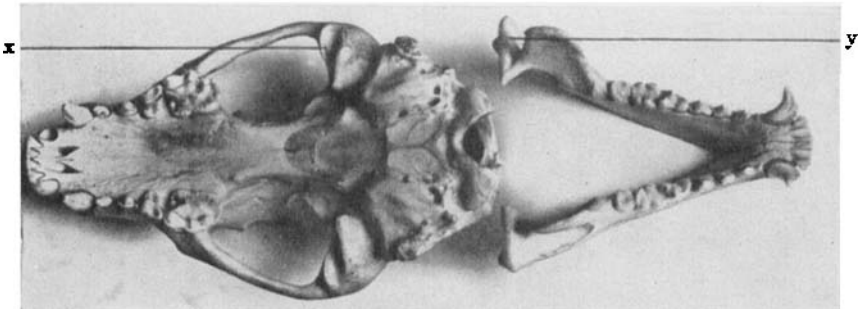


Fig. 3. *Meles meles* L. Cranium. a. Seen in profile. b. Seen toward the masticating surfaces in both jaws. x. Cranial part of temporomandibular joint. y. Mandibular part of the joint.

For the utilization of animal food there is needed a partitioning of the prey, if this is so large that it cannot be swallowed whole. The high, pointed cusps of the premolars and molars are used for this purpose, these fitting together in the upper and lower jaws like a pair of scissors. In such a cutting action it would have been an advantage if the lower jaw could have performed a lateral movement, in order that the premolars and molars in both jaws might glide past each other when these were closed and more easily partition the prey. This might proceed by the mandibular cylinders of the temporomandibular joint gliding along the cranial furrows until full contact was obtained between the premolars and molars in both jaws on the one side of the mouth. In certain, very exceptional, cases an abrasion of the carnivorous

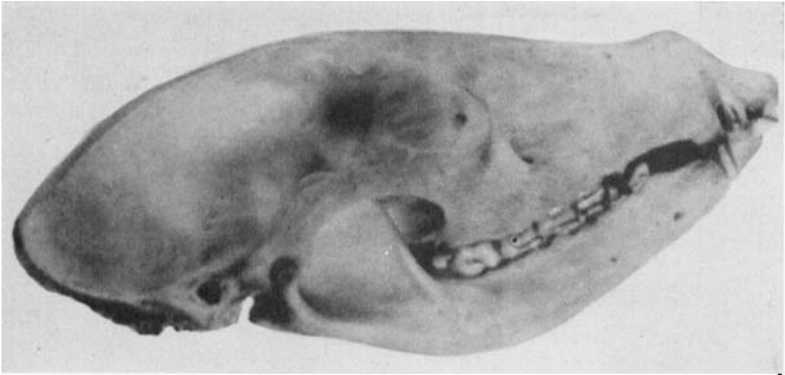


Fig. 4 a.

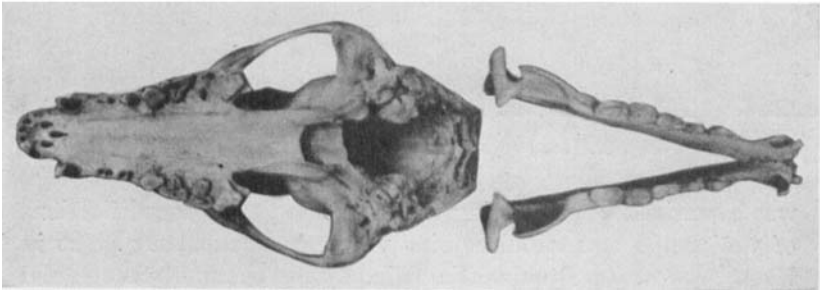


Fig. 4. *Nasua rufa* DESM. Cranium. a. Seen in profile. b. Seen toward the strongly abraded masticating surfaces in both jaws.

teeth is found which indicates such movement of the lower jaw (Fig. 4). The premolars and molars in the lower jaw are seen to be worn quite flat in a horizontal plane. In the upper jaw the teeth are worn obliquely, with the result that the lateral edges are considerably deeper than the medial.

When we look at the cranium from below (Fig. 5) we see that the lower jaw is considerably narrower than the upper one. The parts of the premolars and molars of the latter which projects over the teeth of the lower jaw is worn away in the same manner as the other part of the teeth. For such abrasion to have occurred the lower jaw must have been pushed to the side when the jaws were closed.

In the development from the insectivore-like forms to the typical herbivorous Ungulata and Rodentia the temporomandibular joint had already the property of lateral movement which

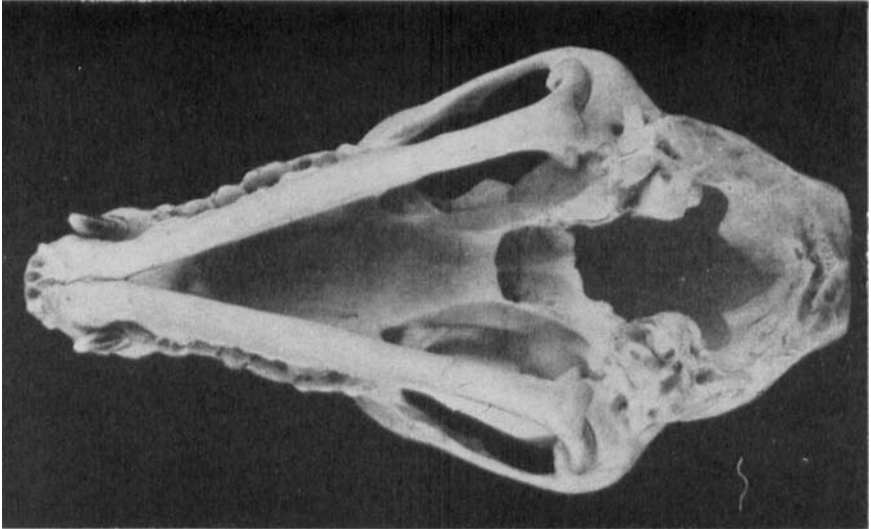


Fig. 5. *Nasua rufa* DESM. Cranium seen from below.

was essential for masticating vegetables, so that the modifications of the temporomandibular joint were not particularly great in these groups. In Ruminantia (Fig. 6) for example the cranial part of the temporomandibular joint consists of a vaulted surface without any natural limit except in caudal direction. The mandibular part is slightly concave and fits against the cranial part.

In rodents (Fig. 7) the cranial part of the temporomandibular joint is a rounded groove running in a cranio-caudal direction. The mandibular part is a roller-shaped elevation going in the same direction and fitting into the groove.

In herbivorous mammals it was especially the tooth shape which had to be modified in order that the masticating apparatus might be adapted to its new function. No teeth must project in such a way that the movements of the lower jaw in a horizontal plane are hindered. In the region of the front teeth this is attained either by the absence of teeth in the one jaw, as in ruminants, or by the teeth having such a form, as for instance in the horse, that they do not prevent jaw movements.

It is likewise necessary for the cusps of premolars and molars to present no obstacle to lateral movements of the lower jaw. The intact premolar and molar in ruminants has fairly pointed

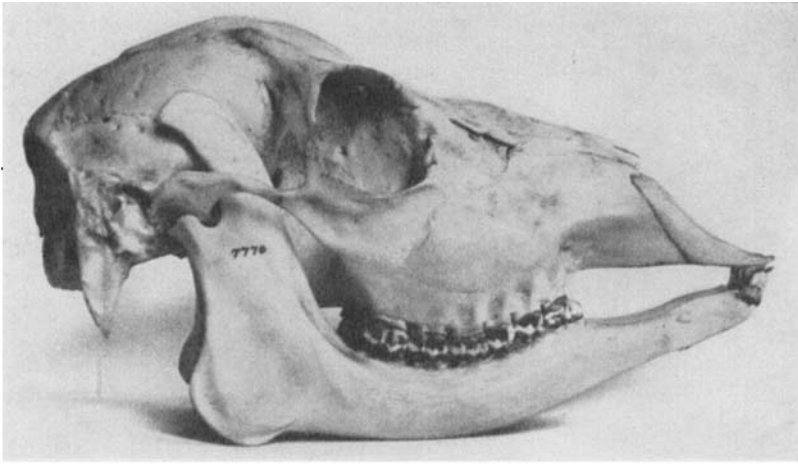


Fig. 6 a.

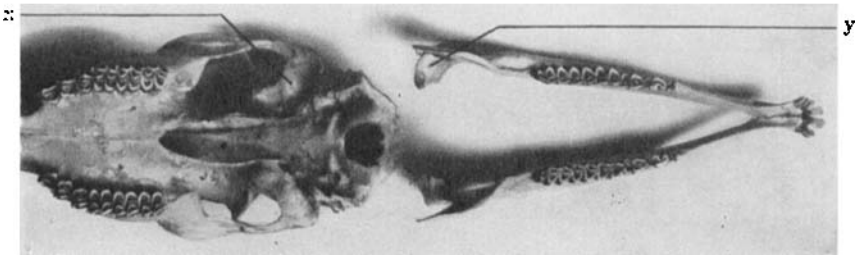


Fig. 6. *Capreolus capreolus* L. Cranium. a. Seen in profile. b. Seen toward the masticating surfaces in both jaws. x. Cranial part of temporomandibular joint. y. Mandibular part of the joint.

cusps (Fig. 8 x). If all the teeth entered into occlusion simultaneously in this form, it is conceivable that the cusps of each jaw would fit into another in such a way that the lower jaw could not perform lateral movements. From the series of reindeer premolars and molars at various stages of age which I show in fig. 8, from the point where the milk teeth have just erupted (Fig. 8 a) until all the permanent teeth have entered into function (Fig. 8 b) we see that the cusps on the latest erupted teeth are always worn down before the next teeth enter into function. The milk teeth get the cusps planed down before the first molar enters into occlusion. The first molar is worn down before the second erupts, and so on. Despite the pointed cusps there is thus

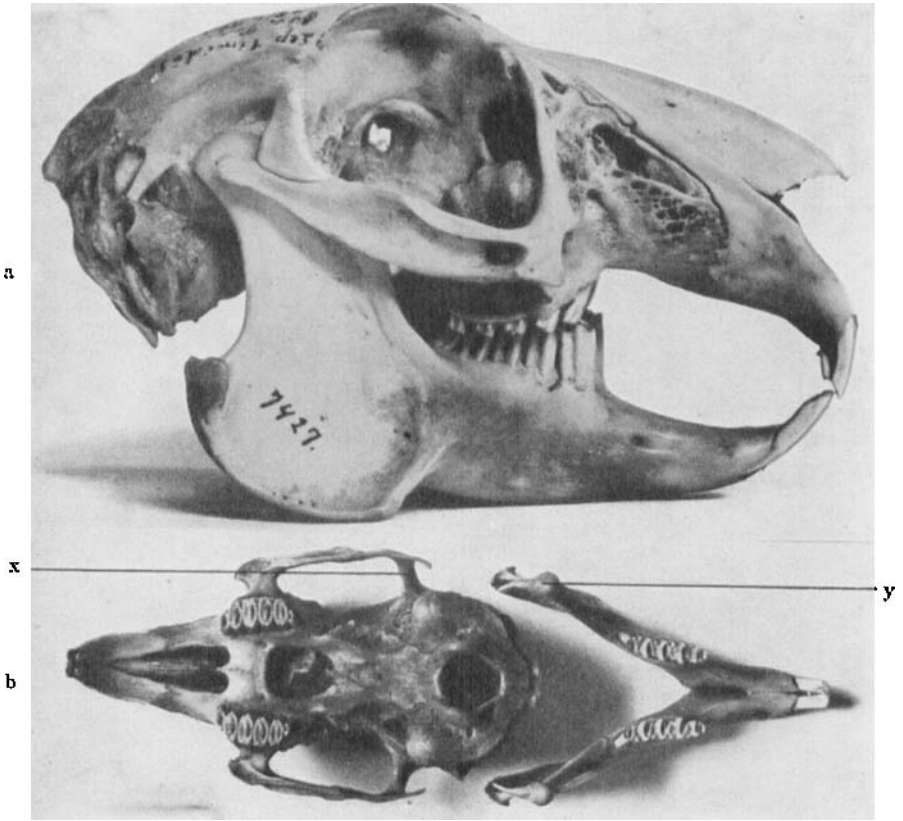


Fig. 7. *Lepus timidus* L. Cranium, a. Seen in profile, b. Seen toward the masticating surfaces in both jaws. x. Cranial part of temporomandibular joint. y. Mandibular part of the joint.

at all stages an occlusion plane which forms no hindrance to the lateral movements of the lower jaw.

The premolars and molars in herbivorous vertebrates are developed into large grinding teeth. Their efficiency in this direction is increased by the fact that the various hard tissues of which the teeth are composed are stratified in such a way that even if the teeth are worn down they will always present a surface of alternately hard and less hard tissue, whereby the grinding effect will the whole time be at its maximum.

A longitudinal ground section of a ruminant molar which has just entered into bite (Fig. 9) shows that in principle it is built

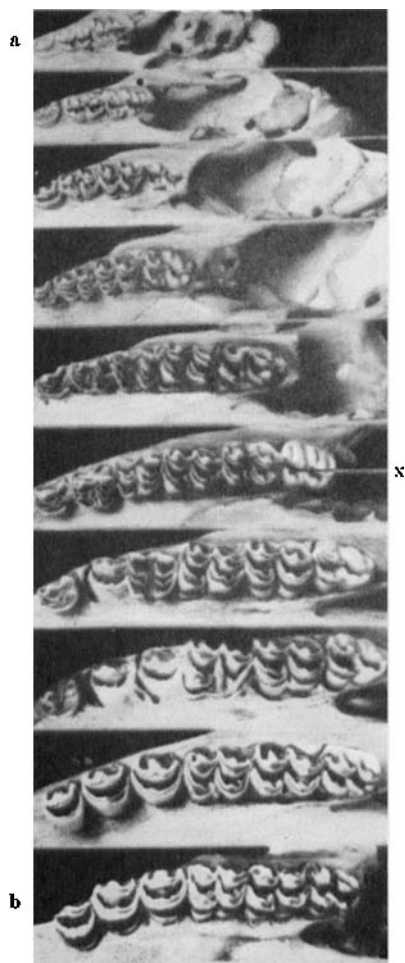


Fig. 8. *Rangifer tarandus* L. Cheek teeth in various stages of age from the milk teeth have erupted (a) until all the permanent teeth have entered into function (b). x. Intact molar.

like a human molar. The difference lies in the fact that the crown is very long relatively to the roots, and that the central groove stretches through almost the entire length of the crown and is in some species filled with cement. Accordingly when the pulp cavity is gradually filled with dentin the masticating surface from the one side to the other will consist of the following tissues during the whole wearing down of the crown: Cement, enamel.

dentin, enamel, cement, enamel, dentin, enamel, cement. The length of the crown gives it, in spite of the high degree of wear, a long term of function. At first the greater part of the crown is concealed in the jawbone, but it gradually emerges as abrasion makes this necessary.

In the grinding teeth of rodents (Fig. 7) enamel, dentin and cement alternate especially along the rows of teeth, so that the

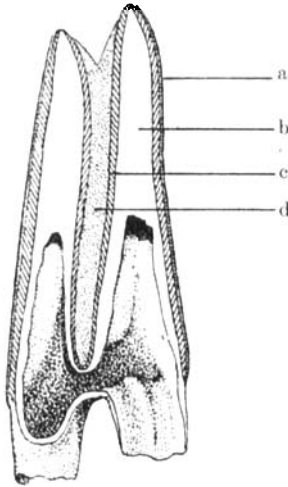


Fig. 9. Longitudinal ground section of intact ruminant molar. a. Coronal cement  
b. Dentin. c. Enamel. d. Coronal cement in central groove.

teeth resemble lamellae running crosswise to the row. As the tooth substance is worn away it is replaced in rodents either by constant new formation of the hard dental tissues or, as in ruminants, by the fact that the tooth is very long and grows up according as abrasion makes it necessary.

Since Gysi's investigations it has been usual to assume that most mammals perform very specialized movements of the mandible. Carnivores can only perform opening and closing movements, ruminants for the most part make lateral movements, and rodents anteroposterior movements. Human beings on the other hand are distinguished by being able to combine all these movements. According to my investigations the structure of the temporomandibular joint in all mammals, as we found to a certain extent in carnivores also, gives the possibility for movements of the

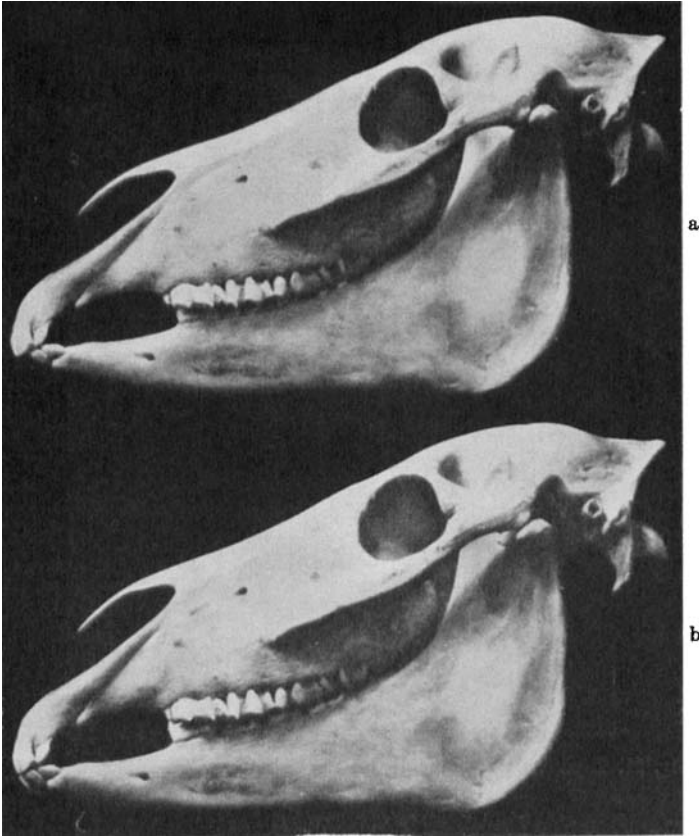


Fig. 10. *Equus caballus*. Cranium seen in profile. a. Lower jaw in rest position. b. Lower jaw in protrusive bite.

lower jaw in all directions, and it is possible that they make use of this facility to a greater extent than we have realized hitherto.

The ungulates move the lower jaw in a medio-lateral direction during the mastication of food. In the case of ruminants which have horny plates in the upper jaw instead of front teeth it is not so easy to deduce from cranial studies anything about the movements of the mandible during mastication. In ungulates, which have front teeth in both jaws, the conditions are easier to observe. In a horse cranium seen in profile (Fig. 10 a) the upper incisors bite in front of the lower ones when the joint heads of the temporomandibular joint on both sides rest firmly in their joint cavities. From the high degree of wear, however, we must

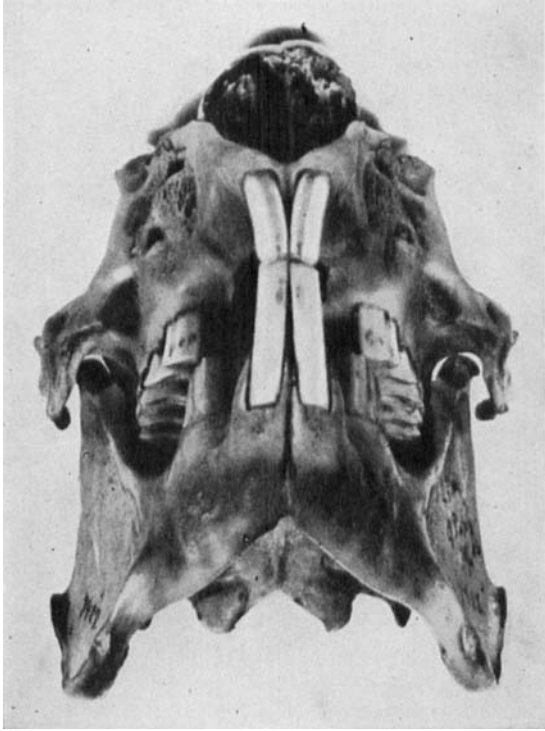


Fig. 11. *Lepus timidus* L. Cranium seen obliquely from below, upwards.

assume that the front teeth in both jaws glide against each other during function, and the shape of the temporomandibular joint permits also a frontal movement of the lower jaw, so that the front teeth in both jaws come into contact (Fig. 10 b).

The usual view of the masticating process of the rodents is that they move the lower jaw in a cranio-caudal direction. Only in respect of a few species has it been stated that they probably make movements also in a medio-lateral direction.

If we look at a rodent cranium obliquely from below, upwards (Fig. 11), we can see the occlusion of the molar series on both sides. The lower jaw is considerably narrower in the molar region than the upper, on account of which the lateral part of the masticating surfaces of the lower molars barely bites on to the medial part of the masticating surfaces of the upper molars. I have found this relation between the width of the lower and the upper jaw in all the rodent craniums I have examined.

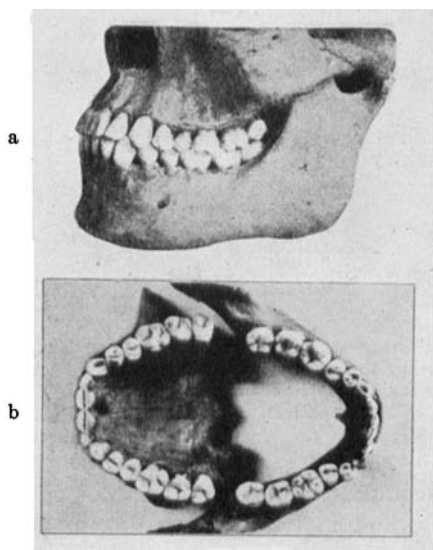


Fig. 12. *Homo*. a. Cranium with the teeth in occlusion. b. Masticating surfaces of the teeth in both jaws. (From HOUSE, M.: *Dent. Cosmos*, 70: 913 (1928).)

If the movements of the mandible during mastication in such an animal proceeded exclusively in a cranio-caudal direction, the abrasion of the masticating surfaces of the lower molars would take place only laterally and that of the upper molars only medially. In all rodents, however, the abrasion proceeds uniformly over the whole masticating surface on all molars. From this it may be inferred that the lower jaw also moves out to the side. Judging from the wear on the surfaces it seems most probable that the mandible in rodents performs an approximately circular movement during mastication. Such a movement of the lower jaw is in good conformity with the structure of the temporomandibular joint. As mentioned earlier it is not necessary for the movement to be uniform on both sides of the jaw. The mandibular part of the joint may well be quiescent on the one side of the jaw while the other side moves backwards or forwards, or both sides may move in opposite directions.

One of the characteristics of the primates, and therefore also of human beings, is the fact that they have preserved so many primitive features. This applies also to the masticating apparatus (Fig. 12). Comparing it with the masticating apparatus of the insectivores we find in both cases that the temporomandibular

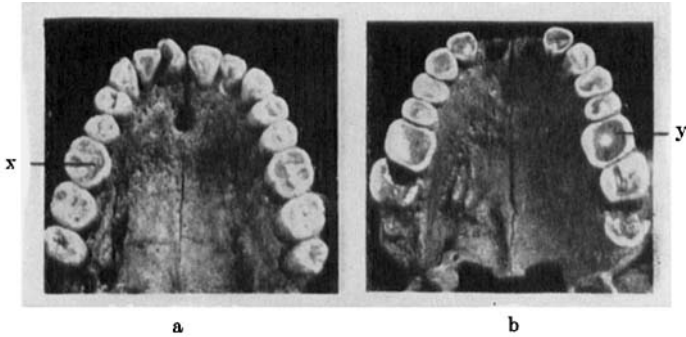


Fig. 13. *Homo*. Masticating surfaces of the teeth in upper jaw. a. Incipient abrasion. x. Enamel and dentin alternate on masticating surface. b. Advanced abrasion. y. Masticating surface consisting of dentin with enamel round the periphery. (From LEIGH R.: *Dent. Cosmos*, 71: 756 (1929).)

joint permits quite a high degree of horizontal movement of the lower jaw, both medio-laterally and cranio-caudally.

The premolars and molars in human beings form together a larger masticating surface than in insectivores, and have got more rounded and somewhat lower cusps. The height of the crown and the attachment to the jaw have not altered in essential respects. The front teeth have become broader and more even in size.

In occlusion there is also in man a fairly large protrusion of the upper front teeth over their antagonists in the lower jaw, and the cusps of the molar series of the one jaw fit into the grooves of the antagonists. There are, however, no teeth which overlap the antagonists to a large extent, as is the case in so many other mammals. There is nevertheless a certain locking of the bite against movements of the lower jaw in a horizontal plane, both medio-laterally and cranio-caudally, but the locking is not so absolute as in insectivores.

In human beings too there is an opposition between the movement possibilities of the temporomandibular joint and the shape of the teeth. As the disagreement is less pronounced in human beings than in insectivores there is opportunity for a functional correction of the parts of the teeth which are opposed to lateral movements. By the use of sufficiently hard food and powerful mastication an abrasion of the grinding surfaces of the premolars and molars and cutting edges of the front teeth occurs, whereby the original obstacles to lateral movements disappear, and the occlusal surfaces in the upper and lower jaw are levelled

to such a degree that they are able to glide smoothly over each other.

The advantage of the primitive form of the masticating apparatus in man is that it makes them independent of a particular kind of food. On the other hand a very specialized masticating apparatus makes an animal dependent on a definite diet, and if this disappears from the animal's vicinity it may be catastrophic for its existence. Human being's independence of a particular kind of sustenance is no doubt one of the reasons why they have been able to spread all over the globe and have thereby become the group of mammals with the largest geographical dispersion. In some places human beings live exclusively on meat; in others they use only vegetable food; and between these extremes we find every form of mixed diet.

Common to all human beings living in a natural state is that the use they make of the teeth has the effect of heavy wear on the masticating surfaces. However, such rapid abrasion as is found in ruminants, where the cusps of the latest formed molars are worn flat before the next teeth enter into occlusion, is rare. As a rule all the teeth have got into position before any considerable abrasion can be observed on their masticating surfaces.

Although a certain wear is necessary before there will be harmony between the temporomandibular joint and the masticating surfaces of the teeth, the teeth of human beings are not designed for a heavy and too prolonged abrasion.

Thus the premolars of human beings have no mechanism for replacing the dental substances which are lost in the course of the abrasion, either by the crowns being specially long or by continuous new formation of the teeth. Nor are the various hard substances so bedded that the grinding action of the crowns against each other is at a maximum at each stage of abrasion, a condition which also makes the teeth more resistant to the functional stress during mastication.

As long as the abrasion has not got past the enamel at the bottom of the central groove (Fig. 13 a, x) there is an alternation of enamel and dentin in the masticating surfaces of the premolars and molars. Then the grinding effect is still good and the surfaces bear well the stress of the powerful masticating action. As the central groove in human teeth is very shallow in comparison with those of the ruminants, the abrasion reaches the stage relatively quickly when the masticating surfaces consist of perfectly even

dentin surfaces, which have an edge of enamel only round the periphery (Fig. 13 b y). Then the masticating effect becomes poorer, because there is left only a large, even surface, consisting of relatively soft substance, and the abrasion also proceeds more quickly, as the masticating surface is less resistant than before.

Abrasion may in certain cases proceed so quickly that the formation of secondary dentin does not keep pace with it, the result being that the pulp is laid bare. It is difficult to explain in any other way the signs of apical periodontitis which are sometimes found in craniums with excessively worn, but cariesfree teeth. The rapid wear is particularly dangerous, because the human teeth are so short that the crown may finally be worn away. Among peoples living in a natural state the abrasion may extend right up to the gingival margin, so that even the residue of enamel round the periphery of the teeth is worn away.

In such a set of abraded teeth caries is seldom found, except approximately in very worn premolars and molars, where the last residue of enamel is broken off. It is also very seldom that in such a set of teeth such extensive pathological changes occur in the periodontium that the attachment of the teeth is endangered.

The most conspicuous difference between primitive and civilized peoples, as regards the function of the teeth, is that the food of the latter requires so little mastication that abrasion of the teeth does not occur. Parallel with this we find an increased caries intensity and more extensive destruction of the supporting tissues surrounding the teeth, owing to periodontitis.

The question may be raised whether the change in the consistency of the food which results in the absence of abrasion is the chief cause of the increase in caries intensity, or whether the change in the chemical composition of the food is the decisive factor.

In the discussion on caries etiology it is generally assumed that the chemical composition of the diet is the only factor which has significance, no regard being paid to its consistence and the resultant difference in the functional stress on the teeth, except perhaps the cleansing effect which hard and coarse food has on the teeth.

According to the usual view, caries initiates by the process that fermentable carbohydrates, which pass over to lactic acid, form a coating on the teeth and decalcify the calcium salts of the enamel. For this reason caries often begins in the central groove of the molars, where fragments of food easily lodge.

It is, however, not the case that retained particles of food always cause caries. In those ruminants, which have no coronal cement the very deep central grooves of the grinding teeth are invariably filled with compact remnants of the food they eat. In the reindeer, for example, we find moss pressed down into all the central grooves. When the teeth are worn down it looks as if this layer of moss acts like a soft dental substance between the enamel layer surrounding, in the same way as the coronal cement in those species which have such tissue.

Why do not these retained fragments of food produce caries? According to Miller's theory it would be said that such fragments are not able to form acid. Therefore there is no caries.

It is possible, however, that the extreme functional stress which leads to abrasion also has a caries-hindering effect. When the diet requires strong mastication it must be presumed that the blood circulation in both periodontium and dental pulp is more lively than when such food is eaten as does not require any particular mastication. It is possible that the stagnation of the blood circulation in the tooth and its environment is one of the chief reasons why the intensity of caries increases so greatly among civilized peoples. The changes in the quantity and composition of the saliva which occur concomitantly with strong mastication must also be taken into consideration.

Among persons who are somewhat advanced in years the teeth often loosen on account of periodontoclasia, in spite of the fact that they have a full set of teeth and no abrasion. In this case too it may be reckoned that the weakness of function makes the blood circulation more sluggish in the periodontium and reduces the resisting powers of the tissue. Moreover, the masticating pressure is less favourable for the periodontium when the teeth are intact than when they are abraded.

The incongruity between the temporomandibular joint and the shape of the teeth in human beings, already mentioned, has the effect that the teeth are constantly exposed to a horizontally directed pressure. In spite of the fact that the shape of the teeth is best suited for opening and closing movements there will always be in addition a certain horizontal stress on the teeth during mastication, as the temporomandibular joint permits of lateral movements of the lower jaw.

The usual view is that the structure of the periodontium more easily bears pressure in the longitudinal direction of the teeth

than in a more or less oblique direction. The periodontium in young persons can no doubt better bear the deleterious effect of the horizontal component of the masticating pressure. As the years pass, however, the power of resistance in the periodontium grows weaker, and pathological processes may then be let loose which lead to its destruction. Moreover in older persons there will normally occur a physiological diminution of the marginal periodontium which still further reduces its resistance to the pressure component which has the harmful effect.

It may seem to be a contradiction that the teeth in people who live in a state of nature endure the powerful stress which leads to excessive wear of the teeth, without harm to the periodontium, while the periodontium in more civilized people are often destroyed by such small stress that it causes no abrasion of the teeth. This may be explained by the fact that the abrasion which reduces the horizontal component of the masticating pressure begins at such an early stage of life that the periodontium still endure a powerful functional stress without harm. The pathological destruction of the periodontium occurs, on the other hand, usually later in life, when the powers of resistance are smaller.

The complex of causes which produce periodontoclasia and caries is no doubt extremely complicated, and I have simplified it deliberately in order to stress the factors which may bring the function into relation with the pathogenesis of these diseases.

The criterion whether a masticating apparatus is suitable for its purpose is surely that it should be able to function through the whole of the life of the individual. We may say then that the human masticating apparatus is suitable for its purpose among people living in a state of nature, although it would have been better if the power of resistance to wear had been greater at the later stages of abrasion. Among civilized peoples the position and shape of the teeth do not bear the lateral movements of the lower jaw for which the temporomandibular joint is designed, as the stress on the supporting tissue of the teeth is too great when the diet is of such a kind that the teeth are not worn down. At the same time by the use of such diet the teeth are more easily destroyed by caries. The masticating apparatus of human beings is therefore unsuitable for the kind of diet on which civilized people live.

The cranium illustrated in figs. 4 and 5 belongs to Dr. R. Selmer-Olsen, Oslo. The craniums depicted in figs. 2, 3, 6, 7, 8, 10 and 11 have been kindly lent by the University Zoological Museum, Oslo. Fig. 9 has been drawn by Miss Ingeborg Gjøen, Oslo.

### Summary.

An analysis is made of the masticating apparatus and its function in the non-mammalian vertebrates, the Insectivora, Carnivora, Ungulata and Rodentia.

By a comparison between these and the human masticating apparatus it is deduced that the latter is suitable for its purpose among peoples living in a state of nature, who use their teeth in such a way that an abrasion of their masticating surfaces takes place, although it would have been better if the power of resistance to wear had been greater at the later stages of the abrasion.

The extensive destruction of the teeth of civilized peoples by caries and periodontoclasia is brought into connection with the lack of functional stress, which expresses itself in the absence of abrasion, and which leads to stagnation of the blood circulation in the periodontium and dental pulp.

### Zusammenfassung.

Verfasser giebt eine Analyse von Kiefergelenk, Zähne und Kaufunktion bei non-mammaligen Vertebraten, und Insectivora, Carnivora, Ungulata und Rodentia.

Durch Vergleichung zwischen diese und das Kauapparat des Menschen wird es hervorgehoben dass die Verhältnisse zweckmässig ist bei Naturvölker die ihre Zähne so benutzen dass eine Abrasion der Kaufläche im Stande kommt. Es wäre doch günstig wenn die Widerstandskraft gegen Abnutzung auf den späteren Stufen der Abrasion grösser wäre.

Die verbreitete Zerstörung der Zähne civilisierter Menschen, durch Karies und Parodontose, wird in Verbindung mit der fehlende funktionelle Belastung gesetzt, diese bewirkt eine Ausbleibung der Abnutzung und führt zur Stagnation der Blutcirculation in Parodontium und Zahnpulpa.

### Résumé.

L'auteur analyse l'appareil masticateur et ses fonctions chez les vertébrés non-mammifères, chez les insectivores, chez les carnivores et chez les herbivores.

Lors d'une comparaison entre ceux-ci et l'appareil masticateur humain il est déduit que ce dernier est adapté à son emploi chez les peuples vivant à l'état de nature, qui se servent de leurs dents de telle façon qu'il y a une abrasion des surfaces mastiquantes, même s'il eût été préférable que la résistance à l'usure soit plus prononcée dans les dernières phases de l'abrasion.

La destruction massive des dents chez les peuples civilisés, par la carie et la périodontoclasie, est mise en relation avec le manque de fonction qui se reflète par l'absence d'abrasion et qui mène à la stagnation de la circulation sanguine dans la pulpe dentaire et dans les tissus péri-dentaires.

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