Anatomy. — *"The Chin Problem"*. By Prof. L. BOLK.

(Communicated at the meeting of February 23, 1924).

At the meeting of this Academy of February 1921, during which I made a statement concerning the coming into being of specific human characteristics, I supported the hypothesis that all these characteristics bear a common badge, i.e., that they are persistent foetal conditions. As compared with those of the other Primates, man is subject to a checked, partly incomplete course of development. The specifically physical characteristics of man are, therefore, as a rule of a negative nature for, a characteristic that becomes highly developed in the case of other Primates is either entirely absent in man or displays reduced development. I should, however, here point out that this checked development, this foetalisation, — as I have indicated the phenomenon — is not a specifically human characteristic of formation; the influence of this development-governing principle can also be illustrated in other Primates. In man, however, it has become predominantly significant.

In the above-mentioned statement I already pointed out that man possesses two specific physical features which can scarcely be regarded as a symptom of foetalisation, i.e., the projecting chin and the raised bridge of the nose. Neither of these two characteristics can be considered as persisting foetal conditions; they are not of a negative but of a positive nature. During the systematic elaboration of the development of the human form, with the principle of foetalisation as basis, I was faced by the difficulty of explaining these two characteristics in their incipience. And, particularly as far as the chin is concerned, none of the theories anent the creation of this characteristic was capable of solving this difficulty.

This circumstance compelled me to endeavour to arrive at my own conception, based upon my own investigations, in respect of the cause or causes of the existence of these two characteristics. While I am still uncertain as to the nose, the research as far as the chin is concerned has been brought to a conclusion and has led to very surprising results. Of these a short review will be made in this paper, while a detailed account of this research will appear in the course of this year in the transactions of the Academy.

A comparison between the distal end of the lower jaws of an adult man with that of any other Primate teaches us to recognise a difference in the course and direction of the profile of the jaw. In man this is concave, whereas the lower or basal part projects in front of the upper or alveolar part. In the case of the other Primates, the profile is convex and the upper or alveolar part of the jaw projects in front of the lower or basal part.

The question as to the cause of a projecting chin in Man has already occupied many research-workers and the fact that they have arrived at very divergent conclusions proves that the solution of the problem is not so very simple. I shall not enter into the various theories and the very extensive literature on this subject; let it suffice to mention the names: TOLDT, WALKHOFF, WEIDENREICH, SCHWALBE, KLAATSCH, E. FISCHER, KEITH, VAN DEN BROEK, H. VIRCHOW, as some of so many authors who each have supported a more or less individual conception of the genesis of the chin. In this short review I can the more justifiably exclude the theories of these workers from consideration as the results of my own research have no immediate connection with any of these theories. The reason for this is to be found in the circumstance that the morphological basis upon which these theories depend is too limited and, therefore, the manner in which the problem was formulated does not, in my opinion, answer to all the anatomical facts.

From now onwards, a jaw with a profile, as generally exists in the lower Primates, will be indicated as "*Ageneiotic*", whereas the adult human jaw will, in contradistinction to this, be termed "*Eugeneiotic*". Now the formulation of the chin problem by all the authors above-mentioned was simply this: "To what cause must be attributed the development of the eugeneiotic jaw from the ageneiotic, more primitive form?" This simple formulation was the result of a methodologic mistake, viz., the choice of full-grown forms as objects of comparison; the jaw of the full-grown lower Primate was opposed to that of the adult human being. In a treatment on the orbital region of the Primate skull [1]), which appeared a few years ago in the works of this Academy, I already pointed out how necessary it is, instead of making a comparison between full-grown forms — that is, final conditions — to compare the courses of development of those final conditions, as these offer us a broader morphological basis and a more documented manual for the solution of the question as to what causes lie at the bottom of the genesis

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[1]) Verh. Kon. Akad. v. Wet. Deel XX. Amsterdam. 1919.

of the one form from the other. For surely only the growing form is plastic and susceptible to formative causes. Through following this principle during my research into the formation of the chin, I arrived at my conclusion, which differs from that of the above-mentioned writers.

The individual development of the lower jaw of the lower Primates is very simple. The anlage of the jaw is an ageneiotical one, and this form is maintained during further growth. This may appear from Figure 1, in which the reconstruction of an early

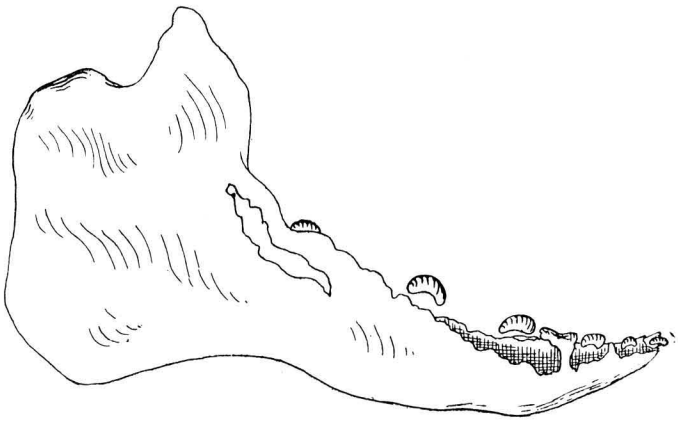

Fig. 1.

stage of development of the jaw of a Mycetes is presented. I shall silently pass over the fact that the profile of the jaw may be unequally inclined backwards in the case of various genera of Primates; the alveolar part projects more in one species than in the other.

With Anthropomorphi a different course of development occurs. As appears from Fig. 2, in which five post-natal stages of development of the lower jaw of Chimpanzee are sketched, the type of the jaw changes during growth. Foetal material for investigation of this group was not at my disposal. The very young Anthropoid possesses a lower jaw whose profile runs straight downwards, a circumstance which may have induced SELENKA's remark that a chin sometimes occurs in the young Gorilla. A projecting chin, as in the case of the adult human being, does not, however, occur. The lower jaw of the young Anthropoid shows more resemblance to that of diluvian man (Spy, la Naulette). This jaw-form cannot be called ageneiotic; it is a type I shall refer to as "*Mesogeneiotic*". Now, it is a very remarkable fact that, in the Anthropoids, this mesogeneiotic type is gradually transformed into the ageneiotic, which

is proper to the lower Primates from the beginning. As I am restricting myself to the main lines in this paper, I shall not expatiate upon the details of this transformation.

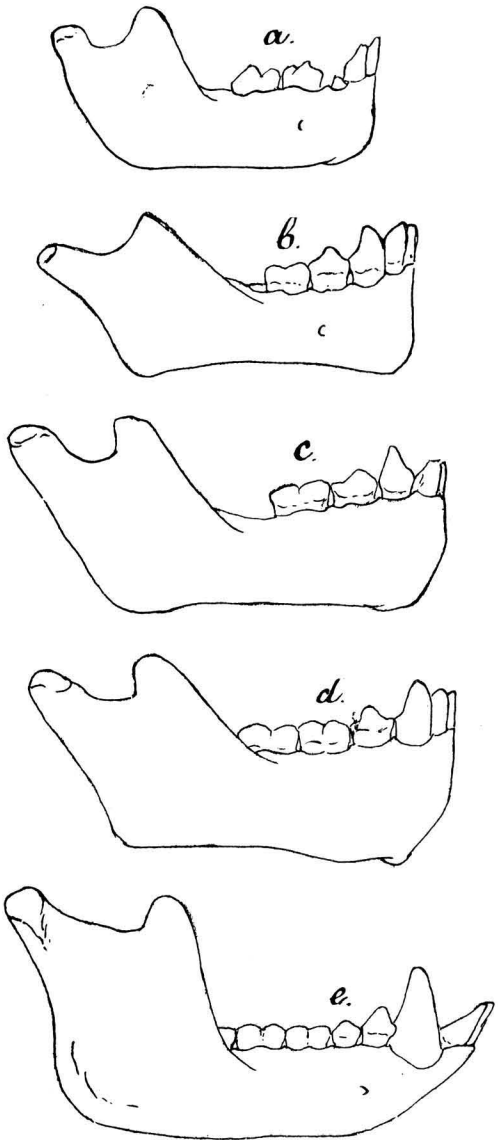

Fig. 2.

The mesogeneiotic type is not always, however, lost. In the Siamanga, for instance, one finds adult individuals in whom this type persists, as can be seen from Fig. 3. The appearance of this form of jaw in the full-grown Siamang is in itself already sufficient to prove that the causes so far suggested of the development of the human form of jaw from the primitive form cannot be correct. For all these causes (reduction of teeth, speech, ossicula mentalia, action of muscles) have this in common that, their formative influence has been at work in the primitive man. And among the Siamangs there are individuals with a lower jaw which, in its profile is even more human than, for instance, the jaw of Heidelberg.

Certainly, the mesogeneiotic jaw with its vertical profile is, as far as its outward appearance is concerned, an intermediate stage between the primitive form of jaw of the lower Primates and the jaw, with its projecting chin, of adult, recent man; aethiologically, however, it is not an intermediate type, for this form came into existence owing to a special cause, entirely different from those which originated the prominent chin.

I established the process of development of the human chin on the basis of reconstructed foetal jaws during the first phases of

development and from the numerous jaws of children which are to be found in the anatomical Museum of Amsterdam. The conclusions to which I came differ, not inconsiderably, from the theses so far generally entertained in this regard. Both TOLDT and WEIDENREICH maintain that, in the human embryo the human jaw originally has the shape of that of the lower Primates, the profile tends backwards and downwards and the alveolar part projects, therefore, forwards. In the terminology adopted by me, therefore, the human jaw would have had, in its earliest stage an ageneiotic form. Now, gradually the basal portion would seem to protrude more prominently and finally begins to project in front of the alveolar so that, as TOLDT asserts, for instance, the jaw has acquired its typically human aspect in about the second year.

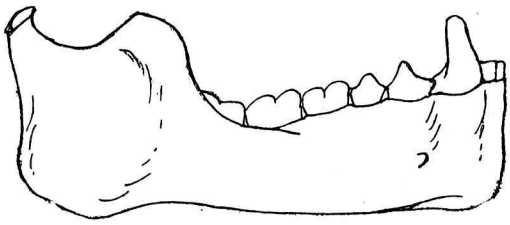

Fig. 3.

Now this conception is not correct. In the process of development and transformation of the mental region of the human jaw, one must distinguish between the origin of two relief-phenomena, viz., of what KLAATSCH has called the "Lateral chin" and of the definite chin. In my opinion KLAATSCH very justifiably made this distinction. I cannot, however, concur in the explanation given by this writer of the origin of the lateral chin. The lateral chin is formed by both the Tubercula mentalia and the Fossae mentales found above these. These tubercula and fossae come into existence in the earliest stage of the development of the bony jaw and the cause of this will be mentioned briefly later on. In Fig. 4 the lateral surface of the model of a lower jaw of a human foetus of 30 mM. length (vertex to coccyx) is depicted. The Fossa mentalis stretches from the Foramen mentale over the whole distal part of the jaw and the Tuberculum mentale protrudes distinctly from under the Fossa.

Furthermore, this figure proves that TOLDT's description of the foetal human jaw is not correct for, if one compares fig. 4 with fig. 1, the difference between the young foetal human jaw and that of the Mycetes' embryo strikes one immediately. The latter is typically ageneiotic but that of the human embryo is mesogeneiotic; its profile slopes, with a slight convex undulation, straight downwards. On comparing the two jaws an impression is obtained as if, in the human being, the entire distal part, from the Foramen mentale upwards, is bent, which would also follow from the different position of the germs of incisivi and caninus in man and Mycetes.

The course of the profile in Fig. 4 is strongly reminiscent of that of the Heidelberg jaw.

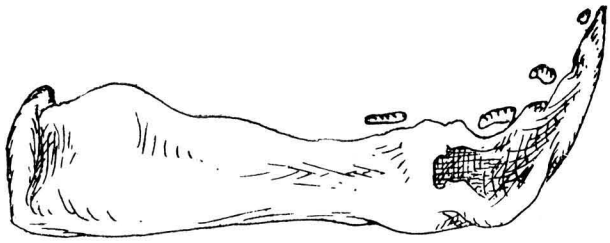

Fig. 4.

So the human jaw is, in its origin, mesogeneiotic. The transition of the frontal border into the lower border of the Dentale is, as appears from Fig. 4, originally rounded off but, through the subsequent development of the Tuberculum mentale, the bend becomes more rectangular. In the human jaw's development, therefore, the primitive form-phase, the ageneiotic jaw of the lower Primates, is missing.

The jaw of the new-born human being is mesogeneiotic but at the same time characterised by the presence of more or less developed Tubercula mentalia, which form the lateral chin. Now, it is certainly a remarkable fact that, in recent man, the mesogeneiotic form of jaw persists until the commencement of tooth-changing, whereas, in diluvian man, this type continued during the entire length of his life.

In Fig. 5 the outlines of the foremost part of some jaws of children of five and six years are sketched. They all have the simple, stretched slope of the mental profile of the jaw. At the ages mentioned a really prominent chin, making the profile of the jaw concave, does not yet exist.

In man, now, the prominent chin develops fairly rapidly and the eugeneiotic type substitutes the mesogeneiotic. This process takes place between the sixth to thirteenth year, as appears from fig. 6 in which the chin is sketched of the jaws of children of eleven and twelve years old. The human jaw, therefore, certainly undergoes a process of transformation during development but not to the extent Toldt and other writers assert. Moreover, the transformation comes to pass at a later age than that indicated by the writers mentioned. The primitive form is not ageneiotic, to assume the definite eugeneiotic form already in the second year but an mesogeneiotic one, and the transformation into the eugeneiotic type takes place only after the sixth year, that is, therefore, during the change of teeth. Generally both the Tubercula mentalia and the Fossae mentales show a

reduction between the second and sixth year — the lateral chin becomes flatter.

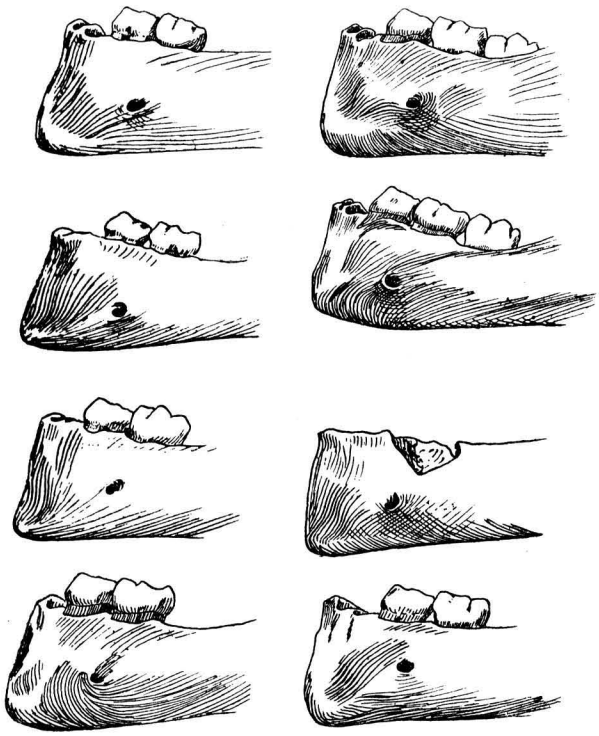

Fig. 5.

From this very succinct summary of the processes of development of the lower jaw in the lower Primates, Anthropoids and man, it will appear that the chin problem is far more complicated than

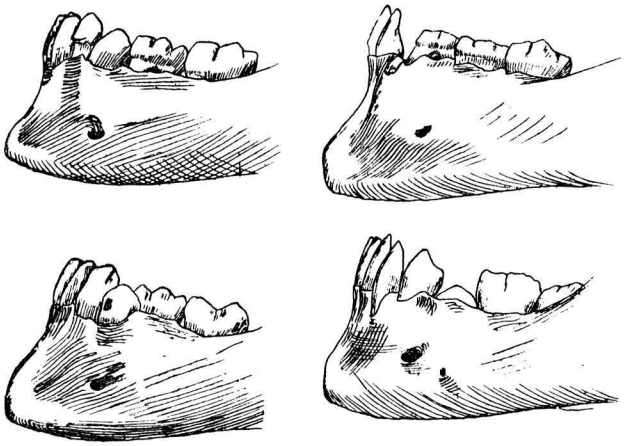

Fig. 6.

has so far been supposed and cannot be epitomised in one single question and answer.

By comparing two final forms — as has been the practice so far — and by the alluding only to the projecting and receding chin, only the following question arose: To what cause should be attributed the development of the former from the latter form? But if, instead of taking final conditions with the greatest differences, one compares processes of development, the number of questions increases owing to the greater quantity of variations of forms and manners of transformation in the different Primates. The nature of these can best be indicated by means of the short summary of the facts in the table given below.

	Embryological form	*Adult form*
Lower Primates	Ageneiotic	Ageneiotic
Anthropoids	Mesogeneiotic	Ageneiotic
Diluvian man	Mesogeneiotic	Mesogeneiotic
Recent man	Mesogeneiotic	Eugeneiotic.

In this table two groups of transformations are expressed, viz., the phylogenetic and the ontogenetic. The former is recognised in the series of adult forms, the latter by comparison of the embryological form with the adult form. The ageneiotic jaw of the adult Anthropomorph is, therefore, a secondary form, the result of operative causes during growth. The nature of these causes will be indicated later on. So there is a remarkable divergence between the processes of development of the lower jaw in man and anthropoids. The infantile type is the same but, whereas the jaw of anthropoids reassumes the more primitive type — so, to put it thus: becomes "more ape-like" —, in man the jaw develops to the highest type and becomes, therefore, "more human".

In the young Anthropoid child, the "lateral" chin is but slightly developed; I suspect that this becomes lost for the most part already during foetal development. This surmise is based upon the manner in which this projection originates, which will be described briefly further on.

The plan set out above represents the starting point of a number of questions; in this short summary I shall restrict myself to answering two of the most important. In the first place, owing to what cause did the mesogeneiotic jaw develop from the ageneiotic and, secondly, what, in man, caused the eugeneiotic form, so typical to adult recent man, to shape itself from the mesogeneiotic? While answering the first question I shall at the same time have an

opportunity of throwing some light upon the origin of the lateral chin. All other questions which arise, as well as the many details which came to light during my research, will be discussed at large in my elaborate treatise.

The ageneiotic jaw is characteristic to the lower Primates and must be regarded as the primitive form, for here the embryological form is also of this type. And since, in the human embryo, the jaw is mesogeneiotic, a comparison of the first stages of development must be made between the lower Primates and man to arrive at a conclusion anent the probable reason of the difference in form.

The lower jaw proceeds from both the Dentalia, which develop in the tissue overlying the Meckelian cartilages. Now, if one compares the cartilaginous mandibular arch of the embryo of a monkey — say Mycetes — with that of a human embryo, a considerable difference is immediately noticeable in the relation of the ventral parts of the Meckelian cartilages with respect to each other. In Mycetes the two halves of the arch approach each other under a very sharp hook (Compare Fig. 7), merge into each other and form a fairly long, joint, beak-shaped foremost projection. In the space between the germs of the Caninus and first molar, the arch bends slightly upwards (see Fig. 8).

In man one is faced by a totally different state of affairs. In the first place, the two Meckelian cartilages do not grow together; both halves of the arch remain independent. (Fig. 9). But not altogether.

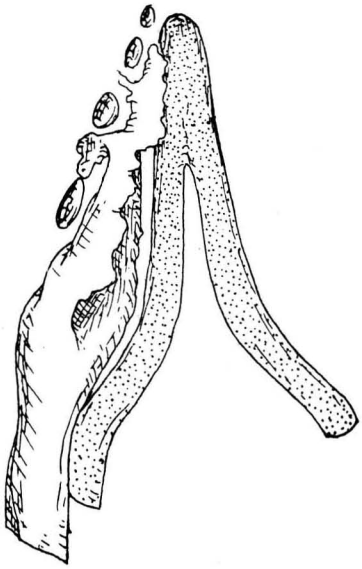

Fig. 7.

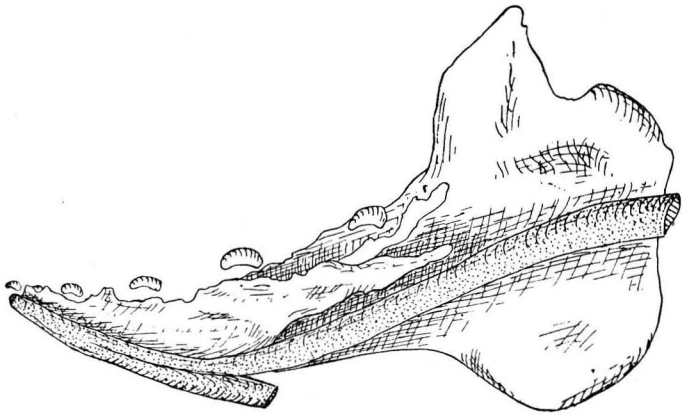

Fig. 8.

For, for a short distance, the medial edges of the distal extremities rest against each other and here a connection does exist between both cartilages.

A second difference is not less obvious. In the space between the germ of the Caninus and the first milk-molar, the Meckelian cartilages bend upwards with a sharp bend, forming a hookshaped curve (see Fig. 10). This peculiarity, which is well known in literature, has never, strangely enough, been connected with the chin problem and yet, as we shall see, it is of the greatest significance in the solution of this problem.

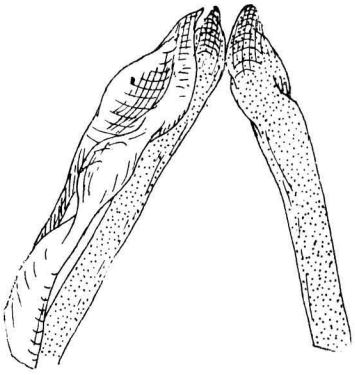

Fig. 9.

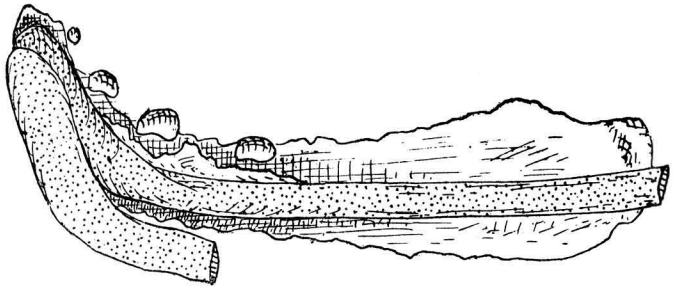

Fig. 10.

In the different shape of the mandibular arch in Mycetes and man, the type of the foetal jaw is, in both forms, as it were preformed. The forward-tapering extremity, with its beak-shaped projection of the but slightly bent arch in Mycetes, answers to the ageneiotic jaw of this monkey, whereas in the hookshaped, upward tending extremities of the cartilages in man, the vertical course of the profile of his foetal and infantile chin is already expressed.

Now does this different structure really exercise any influence upon the form of the osseous jaw? A comparison of fig. 1 with fig. 4 will show that this question must be answered in the affirmative. In complete accordance with the structure of the arch, the osseous jaw of Mycetes is already typically ageneiotic in this early stage of development. In man, it is as if the whole distal end of the Dentale is bent upwards. Not only the Meckelian cartilages but also the Dentalia form a hook-shaped bend. This becomes very apparent if one compares the situation of the dental germs in figures 8 and 10; with Mycetes they are laid in a horizontal plane while in man, on the other hand, they lie more underneath each other. The twisted end of Meckel's cartilages, therefore, causes an analogous curve of the distal extremity of the Dentalia. And this bend of the osseous halves

of the jaw in a very early stage of development is the cause of the mesogeneiotic type of the foetal human jaw.

Through this upward bend of the distal ends of the Dentalia, the distal part of the basal border of these pieces of bone in the ageneiotic type becomes the frontal border of the jaw in the mesogeneiotic type. And this can be easily ascertained in the infantile human jaw: the border-edges of the so-called chin-triangle in the infantile human jaw are the upward-tending distal ends of the original basal borders of the Dentalia.

Now the question arises as to why the bend of Meckel's cartilages also forces the Dentalia into such a hook-shaped bend? The cause becomes clear through the topographic and histogenetic relation which in man exist between the cartilaginous mandibular arch and the Dentalia. These conditions are, however, in man quite different from those in Mycetes, as will appear from a comparison between figures 11 and 12. The first-named figure shows the relation of the

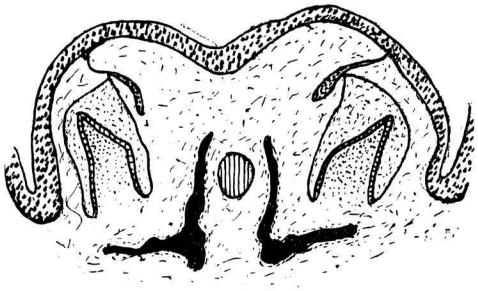

Fig. 11.

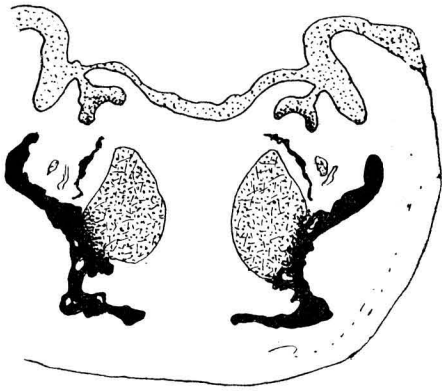

Fig. 12.

foremost part of the Dentalia in respect to the beak-shaped projection of the cartilaginous mandibular arch in Mycetes in the level of the second Incisivus. There is no connection between the Dentalia and the cartilaginous arch; the beak-shaped projection lies between both Dentalia. In man an entirely different relationship exists between Dentalia and MECKEL's cartilages for, as follows from fig. 12, here the Dentalia are connected with the lateral surface of the cartilages. This firm union between bone and cartilage extends to the point where Meckel's cartilages bend upwards, i.e., between the germs of the canine and first milk molar or the Foramen mentale. Behind the latter the Dentale develops quite independently and laterally from the cartilage. This intimate relationship between Dentale and

cartilage is not secondary; if one examines still earlier stages of development in man, one discovers that the lateral surface of the hook-shaped, twisted part of the cartilage is the starting point of the ossification of the Dentale. Through the upward bend of the distal end of Meckel's cartilages, the same end of the Dentalia is, therefore, also bent in a vertical direction.

Figure 12 may also serve the purpose of demonstrating the origin of the Fossae mentales and of the Tubercula mentalia, which form the lateral chin of man. It appears from this figure that the Fossa mentalis indicates the place where the Dentale is united with Meckel's cartilage, while the Tubercula dentalia form the lowest border of this deeper part, which stretches as far as the Dentale is joined to the cartilage, i.e., to the Foramen mentale.

Thus we have learned the cause of the genesis of the mesogeneitic jaw; this type is already preformed in the cartilaginous mandibular arch. While I shall now silently pass over a number of details, there is one point I should like to mention briefly. The mesogeneiotic jaw of the human child is characterised not only by the straight line of the profile but also by the broad arch of the foremost part. Also this feature of the human mandibel is explained by the behaviour of Meckel's cartilage. If one examines somewhat more developed human embryos, one discovers that the bent, hook-shaped ends of Meckel's cartilages flatten and broaden markedly, so that they become broad cartilage plates, laid in a frontal plane. The Dentalia now grow round the cartilage plates so that the latter are taken up into the jaw, as it were, and take an active part in the formation of the mental region of the jaw, in any case determine its form. The part of Meckel's cartilages behind the Foramen mentale remains a round bar laid medially from the Dentale.

We have now learned a few of the principal points in the morphogenesis of the mesogeneiotic jaw. The question naturally arises: What was the cause of the hook-shaped bending of the distal ends of Meckel's cartilages in man? This question will be briefly dealt with at the end of this paper; we shall now answer the question: Owing to what cause has the highest type of development, namely, the eugeneiotic, in recent man, arised from the mesogeneiotic jaw?

A general indication as to the direction in which the solution of this part of the chin problem must be sought is afforded by the fact that the mentum prominens in recent man does not begin to form itself until after the sixth year, while in the thirteenth a well-developed chin is already in evidence. This fact naturally induces the question as to whether perhaps the origin of the projecting chin

may have some connection with the tooth-changing process, which takes place for the most part between the ages mentioned. And indeed, it transpires that this is the case. But not only does a causal connection exist between the transformation of the mesogeneiotic into the eugeneiotic jaw and the tooth-changing process in man, but this same process also explains the transformation, in Anthropoids, of the infantile mesogeneiotic jaw into the ageneiotic of the adult.

In the post-natal development of the set of teeth, two phenomena must be carefully distinguished from one another, viz., the tooth-changing, i. e., substitution of the milk teeth, and the lengthening of the row of teeth by the addition of new elements behind those already present. Moreover, the size of the milk teeth as compared with that of the substituting teeth of the permanent set is of great influence.

Now if, with respect to these points, one compares man with the Gorilla, for instance, the following very important differences are observed: With Gorilla the change of teeth and lengthening take place simultaneously; in man no lengthening of the row of teeth takes place during the changing process. And secondly: the total length of the teeth substituting the milkset is greater than that of the milk-teeth in Gorilla, whereas in man, the length of the milk-set and that of the substituting teeth is the same; indeed, the row of the milk teeth is on the average even a little longer. These differences are of profound significance for the growth of the jaw during the changing process, as will now be demonstrated, in the first place in man.

In literature, the fact that the length of the set of milk teeth in man is equivalent to that of the substituting teeth, is but very little known, though it has been noticed already by Hunter. The significance of this must in the first place be sought in the fact that, after complete eruption of the milk teeth the alveolar arch of the human lower jaw does not grow any more. I was able to confirm the accuracy of this fact, to which Tomes[1]) had already drawn attention, as will appear from the following table. In this table the average of the three following measurements of 75 jaws of children from two to three years old, and of 50 jaws of adults have been stated.

1. The transversal diameter of the dental arch measured from the middle of the hind surfaces of both the second milk-molars, respectively of the front surfaces of both the first permanent molars.

2. The cord of the aveolar arch, measured from one of the points just mentioned to the Incision.

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[1]) Dental anatomy, p. 232 7th edition.

3. The circumference of the alveolar arch, measured from one of two points mentioned on the one side to that on the other.

The results of these measurements are as follows:

	Transversal.	*Cord.*	*Circumference.*
Infants (75)	38.6 m.M.	29.5 m.M.	69.5 m.M.
Adults (50)	39.5 „	28.6 „	66.4 „

From this table it is apparent that the cord and circumference of the adult jaw are even somewhat smaller than those of the infantile jaw. I shall not here enter into the cause of this.

The alveolar arch of the human jaw, therefore, does not grow after the second year. Between the second and sixth year, however, the upper border lengthens somewhat, as room has to be made for the first, permanent molar then being formed. This signifies, therefore, that, between the second and sixth year, the upper border as well as the inferior border of the Corpus mandibulae takes part in the growth in length. Now, however, the phase of tooth-changing follows, which extends from the sixth to the fourteenth year. During this period the alveolar arch of the jaw need not re-form itself, for the permanent set of teeth that now takes its place does not require more room than the milkset, which is substituted by the former. But, neither does a lengthening of the alveolar border occur, for the lengthening of the set by the addition of the second molar only takes place *after* the change of teeth. So, between the sixth and thirteenth year, the growth of the pars alveolaris of the human jaw comes to a stand-still. But the jaw in its entirely *does* grow in conjunction with the increase in size of the body in general and the skull in particular. Also the pars basilaris of the jaw magnifies and lengthens during the period of life mentioned. And the inevitable result must, therefore, now be that this part starts projecting in front of the pars alveolaris and the eugeniotic jaw is formed.

The protruding chin in man is, therefore, the result of the unequal growth of pars alveolaris and pars basilaris between the sixth and fourteenth year. After this period the pars alveolaris also starts lengthening again, to make room for the second and, later third permanent molar.

In the Anthropomorphs, of whom the child also possesses a mesogeneiotic jaw, the phenomena are in every respect opposite to those in man.

In the first place, the alveolar arch expands both in length and breadth, as will appear from the table given hereunder, in which are given the averages of the measurements of six young Chimpanzee jaws with complete milk-set and of seven adult Chimpanzee jaws:

	Transversal.	*Cord.*	*Circumference.*
Infants (6)	30.1 m.M.	31.3 m.M.	75.2 m.M.
Adults (7)	„ 294 .	40.9 „	98.5 „

This enlargement is necessary because the permanent teeth in the Chimpanzee are so much bigger than the milk teeth. Now, as the process of substitution begins after the first permanent molar is cut, the greater room required for the permanent set must be found by lengthening of the alveolar part in front of this tooth, i.e., the actual alveolar arch. This fact is now supplemented by the second, viz., that the process of tooth-changing and the lengthening of the tooth-row take place simultaneously. This appears from the following formula, in which the permanent teeth of the lower jaw are arranged in the rotatory order of their cutting: M_1 I_1 I_2 M_2 P_2 P_1 C. M_3.

Owen and Broca state that M_3 is cut even earlier than C. Thus, while in man M_3 is cut six or seven years after I_2, after tooth-changing is finished, this tooth appears immediately after I_2 with Gorilla. This type of tooth-changing, in which change and increase take place simultaneously, I was able to observe in Macacus and Semnopithecus.

Now, what is the influence of the development of the set of teeth with the Anthropomorphi upon the processus alveolaris? As has already been said, precisely the contrary from that in man. The pars alveolaris must lengthen here considerable in a comparatively short space of time in order to afford sufficient room to the so much larger substituting teeth and the simultaneous increase of the amount of teeth. In man, therefore, there is a stagnation in growth of the upper border during a number of years, whereas with the Anthropoids, on the other hand, there is a greatly accelerated growth, which is closed by the cutting of M_3 and, not uncommonly, by the often simultaneous change of C, when the individual can be regarded as adult. This is reason why, with the Anthropomorphs, the pars alveolaris must lengthen more considerably during growth than the pars basalis. The upper border of the corpus mandibulae begins to protrude in front of the inferior border and the mesogeneiotic jaw of the child is transformed into the ageneiotic jaw of the adult individual.

With this the chief points in the solution of the chin problem are indicated, a solution which was only possible after drawing a sharp border-line to the morphological foundation of the problem. While I now refer to my full treatise on this subject for the details, I shall add one more remark of a more general nature.

Stress has been laid above upon the differences in the post-natal development of the tooth-set in man and the Anthropomorphs. Now it is of the greatest importance for my conception of the development of the human form, mentioned above that the biological character of these differences consists in a retardation of the process of development in man. This retardation had as a consequence that the actual process of tooth.changing and the lengthening of the tooth-set no longer took place simultaneously but occurred successively. And in the previous statement, to which I referred at the beginning of this paper, I laid stress on the fact that the biological basis of the foetalisation principle consists of a checking of human development in its entirety, while this checking in the case of certain characteristics leads to a general suppression. And, as a result of this, the specific features of man are of a negative character. Now it appears that also the form of the human jaw is a result of this process of retardation and that its mentum prominens is but apparently a characteristic with a positive character.

Now, in connection with the shape of his jaw, this fact naturally opens a perspective upon the rate of development of Diluvian man. For his jaw remains mesogeneiotic, that is to say, therefore, that the post-natal development of his set of teeth must have taken place more quickly than that of recent man. On account of this, the necessary lengthening of the pars alveolaris kept pace with the general growth of the jaw. And in this respect it is certainly a very important fact, to which H. VIRCHOW also drew attention in his monography on the subject, that, with the EHRINGDORF child, the change of teeth and the lengthening of the set still take place simultaneously. The same was occurring in the childs of Krapina. The second molar is cut before the change of the milk molars — like in Antropomorphi, therefore. From these facts I conclude that Diluvian man must have developed at a quicker rate, and that he must have been full-grown earlier, than recent man, particularly the white races.

Finally, an answer to the question as to why, in man, the distal ends of Meckel's cartilages bend upwards, in which fact the cause lies of the transformation of the ageneiotic into the mesogeneiotic jaw. This bend is the necessary morphological complement of the subcranial position in which the nose capsule persists in the human embryo. Thus also, the transformation of the ageneiotic into the mesogeneiotic jaw is an expression of the general principle of development which endowed man with his specific characteristics. For further details of this, I refer to my extensive paper on this subject.
