ON THE GROWTH OF THE JAWS. By Professor HUMPHRY, M.D., F.R.S.[1]

ANALOGY leads us to suppose that the enlargement of the jaw-bones is effected, and their proper shape given and preserved, mainly or entirely, by addition at some parts and subtraction at others, there being little or no interstitial growth; and the disposition of the teeth and the changes which take place during second dentition, as well as the position of the additional teeth of the second series, and a comparison of the arch of the lower jaw at different periods of life, are confirmatory of that view.

In the lower jaw the five anterior permanent teeth, on either side, are formed below and behind the five deciduous teeth—the two permanent incisors beneath the two deciduous incisors, the permanent canines beneath the deciduous canines, and the bicuspids beneath the deciduous molars. As they ascend they advance a little forwards into the places of the deciduous teeth. The permanent incisors and canines, being larger than their predecessors, occupy rather more space, and extend a little beyond the range of the deciduous canines, so that the permanent canines encroach somewhat upon the territory of the deciduous molars. This is, however, compensated for, and room is afforded by the size of the bicuspids not quite equalling that of the deciduous molars. The third molars of the child, which are also the anterior molars of the permanent series, and which are formed immediately behind the hinder deciduous molars, retain their position throughout life; and the alveolar arch between them, in which the ten deciduous teeth and their ten successors are placed, undergoes very little alteration in size or shape after birth. Even while the two halves of the jaw remain separate, there is very little growth at the symphysis; and after they are ankylosed, which takes place between the sixth and ninth month after birth, the growth at this part seems to be entirely arrested.

True, there is some apparent difference of opinion on this point. Bell,[2] comparing the jaw at seven years with the same jaw at twelve or fourteen, finds that the "ten anterior permanent teeth occupy a somewhat larger arch than the temporary ones which precede them do;" and Dr Hermann Welcker[3] represents the transverse distance between the two first permanent molars to be rather greater, and the width of the alveolar arch to be also rather greater in the adult than in the child.

[1] As there has been recently much discussion, more particularly in Germany, as to the mode of growth of bones, whether it is by expansion or by addition and absorption, or both, I think it worth while to reprint this paper, which was read at a meeting of the Cambridge Philosophical Society on November 9, 1863, and published in vol. xi. of the *Transactions* of that Society.—G. M. H.

[2] *On the Teeth*, p. 83.

[3] *Untersuchungen über Wachsthum und Bau des Menschlichen Schadels*, p. 11, and Taf. iii. fig. 6.

Whereas Hunter[1] finds that "the jaw does not increase in length between the symphysis and the sixth tooth after the bodies of the six teeth are pretty well formed; and from this time, too, the alveolar process, which makes the anterior part of the arches of both jaws, never becomes a section of a larger circle, whence the lower part of a child's face is flatter and not so projecting forwards as in the adult." The fact is, the part of the arch of the jaw which is first formed, viz., the part intermediate between the alveolar and the lower edges, retains its original curve, undergoing no alteration of form; but as the bone increases upwards and downwards the new part is, in each direction, and more especially below, thrown a little outwards, that is, into a wider curve. Slight additional space is thus afforded for the teeth, and a convex vertical outline is given to the hinder surface of the jaw. In the European jaw the projection of the alveolar part is very slight, that part of the teeth being nearly vertical, whereas the lower or mental edge is thrown out considerably, giving a marked prominence to the chin. In the Negro the mental projection is less, and the alveolar projection is greater; and in the monkey and other inferior animals the alveoli become thrown out into an arch extending far beyond the range of the jaw at birth, but the chin remains suppressed to its original curve, or nearly so.

In the upper jaw the relations of the several primary teeth and their successors to one another is the same as in the lower jaw; but the enlargement of the alveolar arch by extension outwards, during its downward growth, is somewhat more marked. Hence the alveoli and the teeth acquire a more oblique direction; and hence the incisors and canines project in front of their opponents in the lower jaw, so as to admit the cutting edges of the lower incisors to be drawn up, scissor-like, behind the edges of the upper incisors, when the jaws are approximated.

The additional teeth of the second dentition (the two hinder molars on each side) are placed behind those of the first dentition, in a line which is a continuation of the alveolar line of the infant. This is shown by placing an infantile jaw upon an adult jaw, so that the alveoli of the two correspond; for the permanent molars of the adult are then seen to be in the same line with the temporary molars of the infant.

Hunter observes that "the jaws lengthen only at their posterior ends, so that the sixth tooth which was under the coronoid process in the lower jaw, and in the tubercles of the upper jaw of the fœtus is at last, viz., in the eighth or ninth year, placed before these parts; and then the seventh tooth appears in the place which the sixth occupied with respect to the coronoid process and the tubercle; and about the twelfth or fourteenth year the eighth tooth is situated where the seventh was placed. At the age of eighteen or twenty the eighth tooth is formed before the coronoid process in the lower jaw, and under or somewhat before the tubercle in the upper jaw."

The only mode in which we can conceive the lower jaw to be thus

[1] *Works by Palmer*, ii. 45.

elongated is by a gradual absorption of the fore part of the coronoid and condyloid processes, and a gradual addition to the hinder part of those processes, as well as at the angle and along the hinder edge of the jaw. In this way the coronoid process, which is at first situated over the rudiments of the permanent molars, may become shifted to a plane behind them. That this is the change which actually takes place has been inferred by some physiologists,[1] and is proved by the following experiments which I made during last summer:—

In a pig, ten weeks old, a hole was bored through the ramus of the lower jaw, midway between the fore and hinder edges; and two wires were passed through it and secured, one encircling the anterior or coronoid portion and edge, and the other the posterior or condyloid part. After a month the pig was killed. The loop of the anterior wire was found projecting a quarter of an inch beyond the coronoid edge, showing that the bone had receded in that situation; whereas the loop of the posterior wire was buried more than a quarter of an inch deep in a notch in the condyloid part, showing that the bone had advanced in this direction, and to a greater extent than it had receded from the front. (See fig. 1.)

In a pig, thirteen weeks old, a wire was placed round the left ramus of the lower jaw, encircling it entirely, and, of course, including the anterior and the posterior edges. Two weeks later a wire was passed through a hole bored near the anterior or coronoid edge of the right ramus, and secured round that edge; and a second wire was passed through a hole bored near the hinder or condyloid edge, and was secured round it. After three months the pig was killed.

On the left side the loop of the wire projected half an inch, or more, beyond the coronoid edge; whereas, behind, it was buried in a deep notch in the condyloid edge, so deep that the head and angle of the bone reached (had grown) to a plane more than an inch behind the wire. (See fig. 2.)

On the right side the anterior ring of wire was found in the tissue in front of the ramus, and fell from it, having been disengaged by the absorption of the bone in this situation. Slight thickening and unevenness of the edge of the coronoid process mark where it laid. The hinder ring was still held in place by the portion of bone which it encircled. It was nearly an inch from the hinder edge of the jaw. (See fig. 3.)

I have already remarked that the additional molars of the permanent series grow up, on either side, in a continuation of the line formed by the primary teeth. Hence, though the bones of the alveolar arch are extended backwards and the arch is rendered more elliptical, it is not widened. The widening of the jaw, in correspondence with the in-

[1] Mr Tomes, whose excellent account of the development, disposition, and cutting of the teeth was unknown to me when this paper was read, describes the growth of the jaw as taking place in this way, and states (*System of Dental Surgery*, p. 117): "If a transverse section be taken from the base of the ramus of a growing jaw, it will be found that indications of absorption are presented at its anterior edge; and at the point corresponding to the posterior edge of the jaw evidences of osseous development are present."

creasing width of the base of the skull, takes place almost entirely behind the alveolar arch in the ramus, and must be effected by a progressive absorption on the inner surface, and an addition at the outer surface, similar to the absorption and addition that are taking place, respectively, at the coronoid and condyloid edges. Accordingly, we find that in infancy the rami of the jaw are in a line with the alveoli; whereas, subsequently, they diverge considerably, and a well-marked obtuse angle in a horizontal plane is formed, on either side, between the alveolar arch and the hinder portion of the jaw.

The gradual diminution of the angle between the horizontal portion of the jaw and of the ramus, from an almost straight line to a right angle, which is partly for the purpose of affording vertical space for the molar teeth is effected by absorption at the base of the coronoid process in front and addition at the "angle" behind. These changes are most marked in the European members of the human family; and it is probably a consequence of these changes, and of the smallness of the angle in which the hinder molar or wisdom tooth is developed that it is liable, in its growth, to intrude upon the mucous membrane in front of the coronoid process, causing irritation of it, and so imposing some penalty for the peculiarity of our configuration.

In a paper in the *Medico-Chirurgical Transactions*, vol. xliv., I pointed out that the amount of growth in the shafts of certain of the long bones differs a good deal at the two ends. Thus in the case of the thigh-bone, the elongation of the shaft is effected chiefly at the lower epiphysial line, whereas in the humerus it is chiefly at the upper end. I further showed that the relations of the muscular and other soft structures to the bone, during this inequality of growth at its two ends, are maintained by an interstitial growth in these structures, combined with a continual shifting of them upon the surface of the bone towards the part at which the growth is proceeding most quickly.

In the jaw it is evident that a change of the same kind must go on. If the elongation of the jaw takes place, exclusively or chiefly, by addition to the hinder edge, the newly added portion would, unless there be some compensating adaptation of the soft parts, be left uncovered by muscular fibres; and the masseter and internal pterygoid muscles, instead of retaining their position on either side of the "angle," would, in course of time, be found at the middle of the body of the jaw, or even nearer to the chin. The compensating adaptation is effected through the provision that, although the bone grows only, or chiefly, at the back part, the periosteum and the adjacent soft parts grow interstitially in their whole length; and as they grow they slide, or are shifted, backwards, along the surface of the bone, so as to retain their proper relations to it. During this shifting of the periosteum a slight traction is exerted upon the vessels and nerves passing to and from the bone, which causes an alteration in the position and direction of the foramina transmitting them into the bone. This affects, to a slight extent, even the mental foramen, which at birth slants, from within, forwards, and which,

during the first dentition, is placed beneath the anterior molar, whereas after birth it slants rather backwards, having a rounded hinder edge and an overhanging anterior margin; and in the second dentition it is found in a line between the two bicuspids or beneath the hinder one.

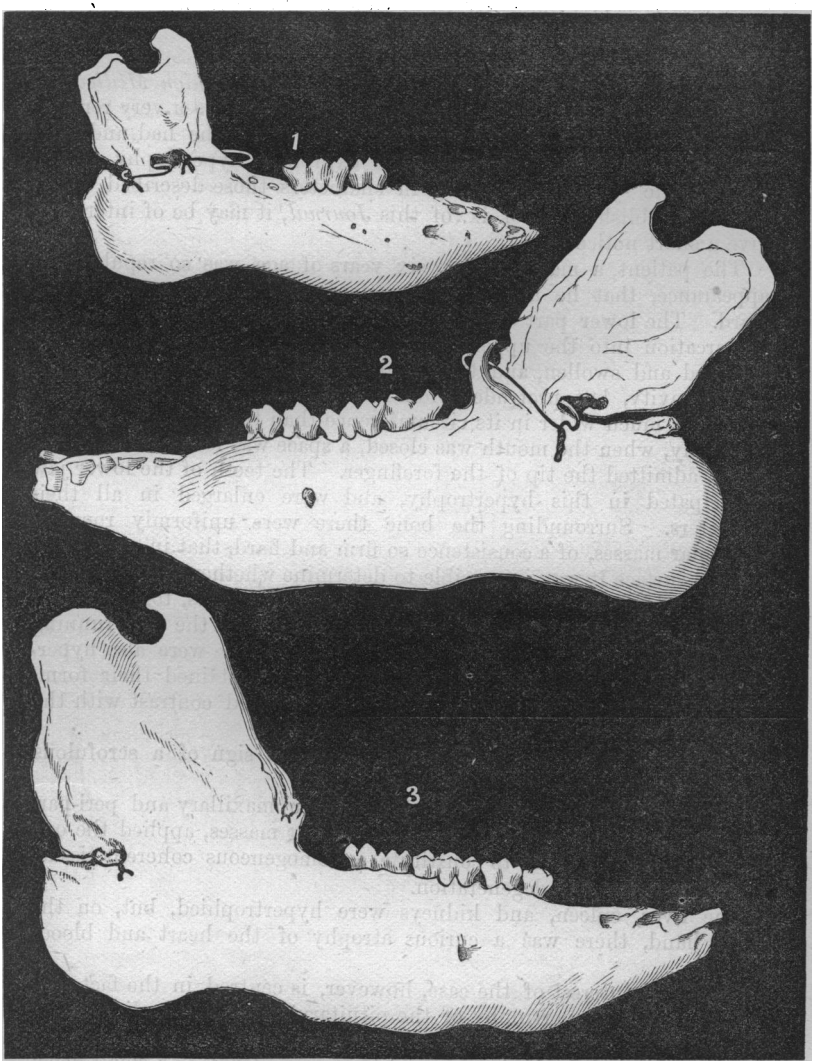
In the upper jaw the changes are very similar to those in the lower. The permanent molars, developed behind and above one another in the "tubercle," descend and move backwards; and the space for them is formed by addition to the hinder part of the tubercle. During this period the contiguous pterygoid processes of the sphenoid bone undergo alterations similar to those in the coronoid processes of the lower jaw, that is, they receive addition behind, and are absorbed in front, and are so rendered more vertical. The malar eminence of the maxillary bone, and with it the zygoma, are, in like manner, thrown backwards; and as the bone is deepened by addition to the alveoli from beneath, and as the teeth grow down into the alveoli and become distanced from the orbit, the interval between them and the orbit is occupied by the antrum.

REFERENCES TO WOODCUT ON OPPOSITE PAGE.

Fig. 1. Lower jaw of a young pig killed one month after two wires had been passed through a hole in the middle of the ramus and secured, one round the coronoid and the other round the condyloid edge. The anterior wire projects some distance in front of the bone; whereas the posterior wire is buried deeply in the hinder edge.

Fig. 2. Left side of the lower jaw of a young pig. Eleven weeks before it was killed a wire was passed round the ramus. The wire projects in front of the coronoid process, though this is somewhat masked by a horn of new bone having been thrown up on its anterior and outer side. It is, moreover, buried deeply in the hinder part of the ramus. Indeed the ramus looks as if it had been cut more than half through by it, and had thus yielded a little to the pressure upon it, so acquiring a preternatural slant backwards.

Fig. 3. Right side of the lower jaw of the same pig. Two months before it was killed a wire was passed through a hole near the anterior edge of the ramus and secured round that edge; and a second wire was passed through a hole near the hinder edge and secured round it. The front wire has disappeared; the position which it occupied is marked by a slight thickening at the root of the coronoid process. The hinder wire, still encircling the bone round which it was passed, is at a considerable distance from the hinder edge of the jaw.


1
2
3