could be seen in other regions of neighboring odontoblasts. As the cells migrate toward the pulp away from the forming dentin, they appear to remain attached at these junctional sites.

We have not observed these regions of attachment between fibroblasts in healing wounds or between chondroblasts. In the former the cells are actively motile until wound repair is complete, and in the latter the cells appear to be isolated by the cartilaginous matrix.

The terminology of cell contacts is not yet standardized, and it is possible that the terms used for the specialized regions of the junctional complexes of epithelia may require modification when they are applied to other tissues. The sites of contact between the connective tissue cells noted above are focal, and, like epithelial desmosomes, appear to function as structural intercellular attachments. However, they do not share the morphologic characteristics of epithelial desmosomes, such as intercellular lines, and the characteristic dense layer and looping filaments found subjacent to the plasmalemma (*1*). Rather, they are more similar in appearance to the intermediate junction (*zonula adherens*) described for epithelial cells, although they are not continuously circumferential in the connective tissue cells, with the possible exception of being so in the odontoblast.

One report of tight junctions (*zonula occludens*) between fibroblasts grown in culture has appeared (*5*). We have not observed such regions in any of the cells we studied.

The sites of attachment between connective tissue cells probably play a role in the maintenance of tissue architecture and of intercellular relationships.

Our observations of these regions may be important in understanding subtle differences in the functions of these cells in forming many of the specialized connective tissue structures.

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Intracranial Mobility in the Coelacanth

Abstract. *Analysis of the jaw mechanism of the coelacanth* Latimeria *shows that the action of the intracranial articulation and the associated subcephalic muscles (a system unique to the Crossopterygii) is important in increasing the angle of the gape and the power of the bite. Maximum rotation at the intracranial joint is approximately 15 degrees.*

Discovery of the living coelacanth *Latimeria chalumnae* Smith in 1939 had special significance for students of the problem of the origin of tetrapod vertebrates, because of the close relation of the Coelacanthini to the extinct Rhipidistia—the group of fishes from which the first terrestrial vertebrates arose (*1*).

Among the most interesting features of the cranial anatomy of *Latimeria* is the presence of a joint dividing the braincase into two distinct portions (ethmosphenoid and otico-occipital). A similar intracranial joint is present in all fossil members of the Crossopterygii. A complex system of muscles and ligaments, including special subcephalic muscles innervated by the tenth cranial nerve, is associated with the intracranial articulation in *Latimeria* (*2*), and the tip of the large persistent notochord inserts upon the postero-ventral margin of the ethmosphenoid division of the braincase (another unique feature of crossopterygian fishes).

The function of the intracranial articulation in Crossopterygii has long intrigued paleontologists. Some have suggested that the joint was incapable of movement, even in Devonian Rhipidistia; but most have believed that such a prominent and persistent structure must have had well-defined adaptive and functional significance (*3*). Hitherto the function of the intracranial joint could not be explained by study of the available material of *Latimeria* since all specimens had been fixed in preservative, with immobilization of all muscles and ligaments. Recently, however, I obtained a specimen that had been frozen immediately after capture (*4*).

This specimen measures 107 cm in standard length and weighed 15.87 kg when fresh; its scales indicate an age of about 8 years. Motion and still pictures were made of the range of possible movements of the various skull components immediately after the specimen had thawed; I report the following results:

1) The ethmosphenoid division of the skull can be rotated through a maximum angle of approximately 15 deg relative to the otico-occipital division.

2) The "normal" position of the skull as the gape is closed is such that the ethmosphenoid division of the braincase is in its most ventral position (Fig. 1*A*). At this point the line of the gape from the jaw articulation to the tip of the snout is approximately 27 deg from the horizontal.

3) As the lower jaws are depressed and the gape is opened by simulation of the action of the coraco-mandibular muscles, movement is also produced at the intracranial joint. When the gape is opened to what seems at first to be its maximum extent (approximately 22 deg), the ethmosphenoid has rotated dorsally through approximately 8 deg (*5*); thus the lower jaw has been depressed through some 14 deg (Fig. 1*B*).

4) With the gape open in this position, the cheek can be expanded and contracted in a manner typical of all bony fishes.

5) If further pressure is applied to the lower jaws, the ethmosphenoid is caused to rotate further dorsally. Simultaneously, the quadrate region is moved forward and slightly downward, since the palatoquadrate arch moves as a unit with the ethmosphenoid division of the skull; thus the lower jaws are extended forward. As a result of this new mechanism the gape is increased to approximately 40 deg, 7 deg of the increase resulting from the dorsal rotation of the ethmosphenoid (Figure 1*C*).

6) In order to return the skull to the first position with the gape closed, one must both adduct the lower jaws and retract the ethmosphenoid; that is to say, it is necessary to simulate the action of both the adductor mandibulae and the subcephalic musculature.

7) It was notable that no move-

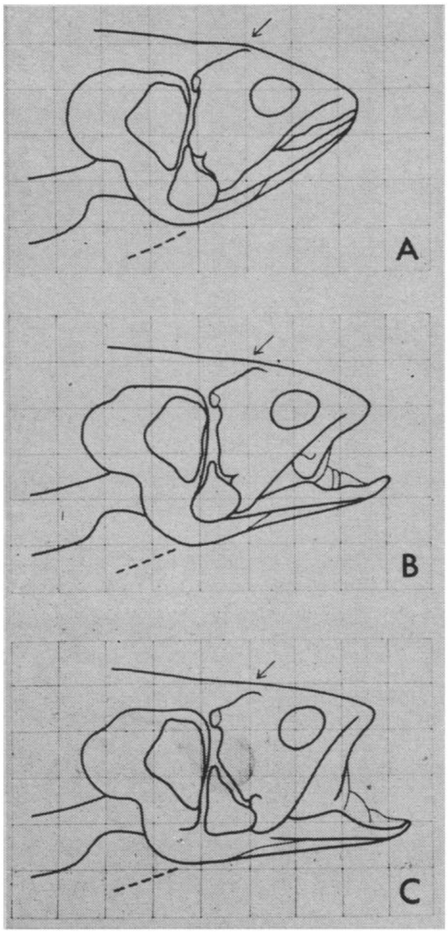

Fig. 1. Head of *Latimeria chalumnae* with mouth closed (*A*), with mouth open in intermediate position (*B*), and with mouth fully open (*C*). Arrows indicate the position of the intracranial joint: the the grid is scaled to 4 cm.

ment of the otico-occipital division of the skull relative to the trunk was observed during operation of the intracranial articulation. In fact the range of potential dorso-ventral movement of the head upon the trunk is narrow, although there is considerable possibility of lateral movement.

It is interesting that the posterior angle of the gape is filled by a complicated whorled fold of skin which presumably prevents food from escaping from the corners of the mouth when the gape is fully opened. One may surmise that a similar fold of tissue must have existed in the fossil Rhipidistia, in which the length of the jaws and extent of the gape were even greater than in coelacanths.

One may distinguish two separate modes of operation of the jaws in *Latimeria*. Firstly, the gape may be opened and closed through an angle of approximately 22 deg and the cheeks expanded and contracted, with a small displacement of the ethmosphenoid (through approximately 8 deg) dorsally from the "resting" position. Arrangement of the ethmosphenoid and palate is such that this amount of displacement of the ethmosphenoid does not produce appreciable forward movement of the quadrate and lower jaws. Further, in this situation simple adduction of the lower jaws by the adductor mandibulae musculature seems to be sufficient to return the ethmosphenoid to the resting position. In this sequence the mechanism of the skull in the feeding and breathing movements is little different from that of other bony fishes.

The second mode of jaw operation is more complicated. The complex arrangement of the intracranial joints, the subcephalic musculature, and the complicated interconnection of the palate, jaws, and hyoid arch (*6*) allow further increase of the gape from the first position. In the process the lower jaws themselves are depressed only through a further 11 deg, but the action of the coraco-mandibular muscles is transferred to the quadrate region, the ethmosphenoid is rotated upward through a further 7 deg, and the whole lower-jaw complex is extended forward.

Operation of the adductor mandibulae muscles alone is apparently not enough to close the mouth when the skull is in this position; closure can be accomplished only by simultaneous action of the mandibular adductors and the subcephalic muscles. Clearly, therefore, the antagonist of the subcephalic muscle system is the coraco-mandibular system that depresses the lower jaws. This second mechanism seems to add little to capability of expansion of the branchial chamber and is probably primarily a feeding mechanism. The action of the subcephalic muscles in retracting the ethmosphenoid must very greatly increase the power of the bite.

The functional significance of intracranial articulation in *Latimeria*, and doubtless in all fossil crossopterygian fishes, is that it can greatly increase the angle of the gape and the general mobility of the jaws; and it greatly increases the power of the mandibular adductor system.

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References and Notes

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3. A review by K. S. Thomson of the evidence concerning intracranial articulation in fossil crossopterygian fishes is in press (*Proc. Linnean Soc. London*). Many authors have ascribed a shock-absorbing function to the intracranial articulation, but at least with respect to the Rhipidistia, in which the lower jaw is firmly connected to the otico-occipital through the hyomandibular, this theory is untenable.
4. Caught off Iconi, Grand-Comore, on 14 March 1966, the specimen was conveyed to Peabody Museum, Yale Univ., where it was numbered 1482 in the Fish Collection.
5. The angle of gape was measured from the tip of the snout, to the jaw articulation, to the tip of the mandible.
6. J. Millot and J. Anthony, *Anatomie de Latimeria chalumnae* (Centre National de la Recherche Scientifique, Paris, 1958), vol. 1, fig. 20.
7. I thank Barbara Moss and Algis Taruski for technical assistance, John Howard for photographic assistance, and D. V. Anderson, U.S. Consul-General in Marseilles, for overseeing transportation of the specimen.

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Bipiperidyl Mustard, A New Obesifying Agent in the Mouse

Abstract. *Bipiperidyl mustard, after conversion to its bis-cyclic immonium ion form, has been found to cause rapid and extensive lipid deposition in mice given single doses of the drug. The obesity appears to result from an alkylation reaction; the responses of the treated animals to food restriction and realimentation resemble those observed in gold thioglucose–treated mice; also in analogy to gold thioglucose, the bipiperidyl mustard effects can be counteracted by sulfhydryl compounds. These observations are suggestive of a similarity of mode of action between the alkylating agent and gold thioglucose, a conclusion which is supported by preliminary findings of ventromedial lesions in the hypothalamus of the bipiperidyl mustard–treated mice.*

N,N'-bis-(β-chloroethyl)-4,4′-bipiperidine (BPM) was incubated at pH 9 (borate, $0.1N$) at 37°C for 1 hour, and injected intraperitoneally into 20-g female $C_3H \times DBA/2$ mice. Initially the mice went through a period of intoxication and weight loss lasting 3 to 6 days. This was followed by a period of very rapid lipid accumulation lasting for 2 to 3 weeks and producing weight gains up to 20 g (Fig. 1). The next phase was characterized by continued slow weight gain until a plateau was reached 3 to 4 months after injection. The final maximum body weights were 60 to 70 g (three to four times control weight).

Dosage was 5 to 50 mg/kg. The LD_{50} for female C3D2 hybrid mice is approximately 30 to 35 mg/kg. The initial intoxication, subsequent rates of weight