EVOLUTION OF CRANIAL KINESIS
IN LOWER TETRAPODS

by

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ABSTRACT

The earliest tetrapods had pleurokinetic skulls (with movable palatoquadrates and
associated dermal bones of palate and cheeks). Pleurokinesis developed from the
splanchnokinesis of the crossopterygian skull; the crossopterygian neurokinesis was
lost in the primitive tetrapods. Recent amphibians also have pleurokinetic skulls. The
stegocrotaphic Gymnophiona retain the primitive pattern of pleurokinesis; in other
extant amphibians this is modified and combined with the rhynchokinesis (Anura) or
prokinesis (Urodela). Primitive reptiles attained a pleurometakinetic condition of the
skull. Cranial kinesis was most advanced in the diapsid reptiles. The improvement of
kinesis in the amphikinetik skull of lizards included either development of
hyperstreptostyly from simple streptostyly, or a flexible palate from a firm palate.
Snakes show both of these trends. Cranial kinesis involves multiple adaptive functions
of the entire skull, with the improvement and changes of its adaptive roles in tetrapod
phylogeny discussed here. The most important evolutionary mechanisms for
increased cranial kinesis include morpho-functional and ontogenetic protoadapta-
tions. Evolution of these occurred by means of ontogenetic heterochrony (especially
fetalization), and were controlled by stabilizing selection, which is genetic reflection
of modifications, arising due to the influence of altered mechanical tasks.

KEY WORDS: Cranial kinesis, evolution, adaptive role, feeding, jaw muscles, lower
tetrapods.

INTRODUCTION

A kinetic skull was defined by Versluys (1910, 1912) as one that
allowed any intracranial movements (besides those of the lower jaw).
In simplest terms, cranial kinesis (or kinetism) occurs whenever the
upper jaw and palate, or the maxillary segment can be moved in relation
to the braincase, or axial segment. Cranial kinesis is a very ancient feature of vertebrate skulls; it arose from the primordial
mobility of visceral arches in relation to the braincase, which HOFER
(1945) referred to as branchiokinesis and splanchnokinesis. Apparently, the movements of the cranial roofs are of subordinate
significance relative to those of the palato-maxillary arches. The main
point of cranial kinesis, directly connected with its adaptive role, is
that the elements of the upper jaw and palate are mobile.
Cranial kinesis is a special mechanical property of the whole skull, conditioned by the mobility of certain intracranial articulations. Therefore the cranial kinesis represents a function, in the sense of Boek & Von Wahlert (1965); these authors defined functions as those properties of a morphological feature, that may be completely reduced to physical and chemical ones.

The crossopterygian fishes developed neurokinesis, a mode of intracranial mobility, in which the ethmosphenoidal section of the braincase can move relative to its otico-occipital section. The ethmosphenoid moves as a link of the maxillary segment, which also includes the palato-maxillary arches, most of the dermaticranium and the hyomandibulars (see Thomson, 1967). Possibly neurokinesis arose as a result of fetalization, by retention in the adult stage of embryonic independence of the trabecular and parachordal sections of the braincase. As the cranial trabeculae originate from a pair of premandibular visceral arches (De Beer, 1931), it is possible that neurokinesis represents a modified primordial branchiokinesis (as mobility of trabecular visceral arches).

ORIGIN AND MODES OF CRANIAL KINESIS IN EARLY TETRAPODS

The ethmosphenoidal and otico-occipital parts of the braincase had fused and neurokinesis become lost in the earliest tetrapods. This has been interpreted (Edgeworth, 1935; Hofer, 1945; Robinson, 1967, and others) as evidence of complete loss of cranial kinesis. The kinetic skulls of many recent tetrapods are claimed to represent the secondary acquisition of kinetism in various phyletic stems of amphibians and reptiles.

However, neurokinesis is neither the sole, nor the basic component of cranial kinesis. Crossopterygians possess not only neurokinesis, but also splanchnokinesis. The latter persisted as pleurokinesis in ancient tetrapods (a number of Carboniferous stegocephalians, Pfannenstiel, 1932); the condition is retained in Recent amphibians. Pleurokinesis represents the mobility of a pair of the maxillo-buccal segments, including the palato-maxillary arches and dermal bones of cheeks and suborbital region. The maxillo-buccal segments can be abducted outward and adducted inward relative to the axial segment of the skull. The pleurokinetic movements have some possible adaptive role as they tend to increase the transverse diameter of the gape (between jaw joints) and thus facilitate swallowing of large prey; it also improves the manipulative abilities of the jaws (some adjustment of jaws to a prey). Moreover, in primitive tetrapods with stegal skulls, the pleurokinesis enlarges the volume of the temporal fossae and provides additional