yond the phenomenon. Goethe believed the form of the animal, including man, would reveal its purpose by its totality of form and demonstrated a three-foldness. He believed that there was an underlying unity of plan, as did Thomas Huxley, in all mammal forms. Wolfgang Schad later demonstrated this in the 1970's. To understand this completeness of all forms it was necessary to change the intention from the commonly used Cartesian-Newtonian mathematical style to that of an organic style. Seeing in motion rather than seeing in an abstractness. All present scientific investigation (methodology) is theory-laden by an intention of abstractions. Change the methodological intention from reductionist-abstraction style to an organic-motion style and the form tells you why, rather than just how it is there. Goethe was a scientist who is only just being recognized for his work. He was mistaken for a Romantic. He is quoted as saying Romanticism is a sickness.

The Structure and Origin of the Second Collarbone in Birds

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The bird's shoulder consists of shoulder blade, coracoid, and collarbone. During the dissection of a *Pavo cristatus* L. 1758 corpse we found an unusual structure in the shoulder. This structure is a bone (the second collarbone), which is placed in parallel with the collarbone. One end of the second collarbone is close to the proximal end of the coracoid, and the second end is directed to the thorax ending near the inner aponeurose of the thoracal muscle. There were two such bones present on the right and left sides symmetrically. Both ends of the second collarbone, proximal and distal, are sinews. We also found the similar shoulder structure in *Asio flammeus* Pontoppidan 1763. On the basis of our findings we guess that the formation of the second collarbone was originated from the connective tissue junction, which differentiated in this area from the corresponding muscles. Following this theory we can make two statements that will depend on the function of muscle: either 1) the entire bone can be formed instead of the connective tissue junction; or 2) additional appendixes of the connective tissue can be formed from the junction in different places that will depend on bending and stretching stress during physical exercise.

Pattern and Process in Evolution of the Vertebrate Dentition

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Recognition of fundamental differences between dermal and pharyngeal denticles suggested that the latter offer a prepattern for tooth sets in gnathostome dentitions. It is argued that a transition occurred from branchial arch denticle sets, present in agnathan and gnathostome fossil taxa, to tooth sets on the jaw margins. The most plausible sequence of change in process is co-option of this endoderm-based branchial patterning mechanism for the jaw margins, forming an opposable dentition with sequential, lingual, appositional sets of teeth, subsequently restricted to this site. There is strong evidence that teleosts with opposing sets of teeth only on the fifth ceratobranchial pattern these replacement teeth in the same way. Comparison of fossil and extant chondrichthyans provides a model for evolution of dental patterning processes. This suggests change from fused tooth whorls, to unfused teeth in closed sets of the statodont type, in well spaced tooth files, exemplified by both fossil and extant sharks. A model is proposed for a segmental pattern from which alternation of tooth replacement evolved, and autonomous regulation of generative tooth sets, controlling shape, size and sequence of replacement. Dental systems in basal gnathostomes are interpreted from developmental controls, which constrain and restrict phenotypic plasticity. Those of acanthodians, placoderms and dipnoans are statodont and non-replaceable, but may have a common pattern in the arrangement of periodic, appositional, sets of new teeth.

Evolutionary Transformations of Placentation and Reproductive Strategies in Rodentia

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The radiation of the viviparous eutherian mammals is one of the most striking features of vertebrate life within the Cenozoic. The Rodentia are a very successful group that contain more than half of the recent eutherian species. Much of their success seems to be based on the evolutionary and/or ecological dynamics of their reproductive systems. Based on the character distribution of placentation within Eutheria, it is confirmed that Rodentia have a highly invasive chorioallantoic placenta (haemochorial placenta) in their stem species pattern. Recent studies reveal that the internal structure of the placenta differs fundamentally within Rodentia: in contrast to sciurognath rodents, the placental structure in hystricognath rodents is distinctly more lobulated and the maternal blood supply is concentrated internally. According to phylogenetic analysis, the latter can be regarded as an apomorphic character of hystricognath rodents. It seems to be correlated with another derived condition of rodents, i.e., precociality. It will be discussed how Hystricognathi are able to reproduce with a low energy demand, i.e. the use of high-fiber, low-energy nutritional resources. A scenario will be presented as to how this may explain their radiation during the Eocene-Oligocene transition (global cooling, expansion of grass-dominated ecosystems).

Evolutionary Transformations of Fetal Membranes and Reproductive Strategies

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The goal of the symposium is to reconstruct major evolutionary modifications of vertebrate fetal membranes in the context of viviparity and other reproductive strategies. Fetal (extraembryonic) membranes serve crucial respiratory and nutritional functions in all vertebrates, but how these functions are accomplished varies markedly between lineages. Our symposium uses the methodological framework of phylogenetic systematics to establish ancestral and derived morphotypes, and to reconstruct evolutionary transformations. Contributed papers span the range of vertebrate diversity, concentrating in particular on teleosts, sauropsids, and mammals. One main focus of the symposium is on evolutionary modifications in fetal membranes that are associated with important reproductive strategies, i.e., viviparity in fishes, squamates, and mammals, and precociality in mammals. The phylogeny of fetal membranes is reconstructed in the broad framework of the evolution and diversity of the vertebrate radiation during the last 500 million years of our planet's history.

Evolution of Pectoral Fin Development: Branching Processes, Cartilage Repatterning, and a Neopterygian Innovation

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The common view of the posterior branched portion of actinopterygian fins (the metapterygium) as homologous to branching sarcopterygian limbs is poorly founded, owing to the paucity of information about early limb development in basal actinopt and sarcopt taxa and reliance upon adult skeletal morphologies. Developmental observations of early pectoral fins in sturgeon, paddlefish, gar, and zebrafish suggest alternative hypotheses for the patterning of different fin forms in basal actinopts, basal neopts, and teleosts. The basal actinopt pectoral fin cartilages appear to develop by an outgrowth and branching process similar to that described by Shubin and Alberch (1986, Evol. Biol. 20:319–87), possibly producing the propterygium, basal radials, and metapterygial elements all out of one outgrowing mass of prechondrogenic mesenchyme. The later appearance of the cartilage models and bony elements is thus misleading if the patterning occurs before the onset of chondrogenesis. The radials of the adult gar fin appear to be patterned by modulated resorption of established cartilage matrix in the larval fin, as in teleosts. The formation of the larval pectoral cartilage plate is a derived feature of the neopterygians, and its repatterning into exactly four radials is derived for the teleosts.

Strain Patterns in the Lower Jaw of the Caiman (*Caiman crocodilus*): Implications for the Function and Evolution of the Intramandibular Joint in Archosaurs

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Potential mobility at the intramandibular joint between the dentary and the post-dentary bones in the mandible has implications for the evolution of archosaur feeding. Numerous claims for the presence of mobility at this joint

have been made for both extinct and extant taxa. The intramandibular joint is described as allowing either mediolateral or dorsoventral movement in the middle of the mandible. We examined strain patterns across the dentary-angular intramandibular joint in crocodilians, which are thought to be akinetic, as a first step to investigating the function of this joint in archosaurs. Strain gauges were placed on the dentary and the angular bones of a caiman. During feeding, strain magnitudes in the dentary were higher than in the angular bone. Additionally, maximum principal strain orientation changed significantly across the joint, being laterally directed in the dentary and obliquely oriented in the angular. The strain orientations suggest that the dentary is bent in a parasagittal plane during the power stroke, different than in the angular. While these results do not directly address whether movement occurs across the dentary-angular joint, they indicate that the crocodilian intramandibular joint re-orients and absorbs some of the forces passing through it. Investigation of joint histology may help address these issues further.

Limb Proportions and Fossorial Habits of Armadillos

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Armadillos are a very diverse group ranging from the nonfossorial *Tolypeutini*, through the powerful diggers like the giant armadillo (*Priodontes*) to the totally subterranean *Chlamyphorini*. A previous study demonstrated a close relationship between the relative length of the olecranon of the ulna (index of fossorial ability) and the fossorial ability of armadillos and other mammals. This study examines a range of other limb proportions in living armadillo species and explores biomechanical correlates with fossorial ability. The study demonstrates that the indices of the forelimb (brachial index, shoulder moment index and index of fossorial ability) do correlate well with digging habits, but also show some interesting exceptions. On the other hand the hindlimb indices (crural index, hip moment index, leg robusticity index and intermembral index) do not appear to relate to digging habits, but seem more related to body size. An attempt is made to relate the patterns of limb proportions with the behavior and ancestry of armadillos in general and more specifically with the peculiarities of different armadillo species.

Interspecific Variation in *Macropus* Crania: Form, Function and Phylogeny

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This study examines morphological variation in the adult crania of 7 species of kangaroos and wallabies (*Macropus*) in relation to function and phylogeny. Thirty six, 3-dimensional landmarks were acquired on each of 65 adult *Macropus* specimens from Western Australia. The different species occupy a wide range of habitats and latitudes and there are well known differences in diet among the species. Size and shape variability was examined using the methods of geometric morphometrics in which the principal components of shape variation were extracted from Procrustes registered landmark coordinates. Aspects of interspecific variation explained by principal components were visualized and examined for correlations with size, latitude, and diet. The first principal component correlates strongly with the latitude, and primarily reflects an increase in the length of the snout anterior to the molar teeth in species which live in cooler climates. The second principal component correlates strongly with cranial size, and reflects increased cranial flexion in smaller specimens. Principal components three and four seem to relate to dietary specializations of red kangaroos and agile wallabies and reflect changes in the masticatory apparatus. The procrustes distances between the species means were used to create a phenogram that supports the taxonomic grouping of the red kangaroo with the wallaroo group, but also shows differences that are related to function.

Structure of Endothelial Villi of Blood Vessels of an Air Breathing Mud Eel, *Monopterus cuchia*

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In our earlier work (Mishra et al., 1978) using light microscopy, many septa-like structures were found in the luminal surface of dorsal and ventral aortae of *Monopterus cuchia*. In the present study using scanning electron microscopy fixation was done by vascular perfusion of oxygenated physiological saline containing 2000 I.U. Heparin / liter. Perfusion was subsequently continued by 2.5% glutaraldehyde in 0.03 mol l^{-1} phosphate buffer pH 7.4. Scanning electron microscopy revealed multicellular microvilli originating from the intima of ventral and dorsal aortae. The endothelial microvilli are composed of several large ovoidal cells with homogenous cytoplasm with excentric condensed nuclei having flower-like arrangements. These villi have narrow stalks bearing many groups of cells arranged in concentric fashion. The veins have a smooth luminal surface lacking these characteristic endothelial villi. Endothelial microvilli bear several sensory buds that may be some sort of chemoreceptors. Arterial chemoreceptors that constitute the body's sensory mechanism for detecting a fall in oxygen in the arterial blood are found in the large blood sinusoids of mammals. In mammals it was found that receptors help in high blood flow, oxygen consumption rate and haemoglobin content. On the basis of our observation and other works on fish, we may conclude that the microvilli play a major role in maintaining blood pressure, blood flow and oxygen level in *Monopterus cuchia*.

Cranial Neural Crest Migration in Discoglossid Frogs

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The development of the migratory cranial neural crest streams in anurans seems to be highly conserved despite differences in their initial configuration. Even in a direct developing leptodactylid species, *Eleutherodactylus coqui*, which shows notable differences in the developmental anatomy of neural crest derivatives if compared to anurans with biphasic development, the migratory routes of the cranial neural crest streams are conserved (Olsson and Hanken, 1996, J Morphol. 229: 105–120). Although several species have been studied, these studies were seldom put in a phylogenetic context. To establish a hypothesis about the condition of the anuran ground pattern, it is necessary to determine the ground patterns of the most basal branchings of the anuran ingroup. In the study cited above the formation and migration of the cranial neural crest in the discoglossid anuran *Bombina orientalis* was described. In the present study we investigate and compare the formation and migration of cranial neural crest streams in *Bombina orientalis*, *Bombina variegata*, and *Discoglossus galganoi* using SEM, serial sectioning and microdissection. Our preliminary results indicate that the results in *B. orientalis* correspond closely to the discoglossid ground pattern. Minor differences between the species studied require further examination and interpretation. In order to establish the anuran ground pattern similar information is needed at least from *Ascaphus* and leiopelmatids.

Elastin and/or Elastin-like Proteins in the Skeletons of Cartilaginous and Teleost Fishes

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Elastin (EL) is found in the intercellular spaces of connective tissues (arteries, tendons, and ligaments), perichondria of cartilages, and cartilaginous joints (temporo-mandibular joint articular disc). Chondroblasts from fetal bovines were recently also reported to express EL in vitro. We performed histochemical and immunohistochemical analyses for EL in two species of cartilaginous fishes and four teleost species including zebrafish. The analyses reveal that EL and/or EL-like proteins are expressed in various tissues at different stages of early zebrafish development and in bony and/or cartilaginous matrices of all six species. As in skates (Miyake et al., 1999), dentin and enameloid in the four teleost species strongly express EL proteins. Our analyses suggest that EL and EL-like proteins may be co-expressed or singly expressed in skeletal matrices and that some of the expressions may be related to mineralization. Supported by NSERC, AMNH, SICB, Sigma Xi, and Sci. Tech. Coop. Germ./Can.