Vertebrates and Evolution

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Dedicated to
*Late Shri Mangal Singh Rajp*ut

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Preface

Vertebrates and Evolution is written bearing in mind that the modern trends of studies on the chordates have changed drastically from classical study of one or two commonly available representative types to rather detailed comparative account of organs and organ systems present in all available extant forms.

Cephalochordata are small, segmented marine animals that possess elongated bodies with a notochord that extends the length of the body, extending from head to tail, persisting throughout the animal's life. Cephalochordates are represented in modern oceans by the Amphioxiformes (lancelets, also known as amphioxus). They are filter-feeders that consume microorganisms.

Digestive system includes alimentary canal and the associated glands. Alimentary canal or gut shows four distinct regions, namely, ingressive zone that includes mouth, lips and jaws for capturing and handling food; progressive zone includes oral cavity, pharynx and oesophagus through which food passes with little digestion; degressive zone contains stomach and small intestine in which digestive process is accomplished and the egressive zone includes colon and rectum where undigested food stays before expulsion and excess water from it is absorbed.

The brain of craniates develops from the anterior section of a single dorsal nerve cord, which later becomes the spinal cord. In craniates, the brain is protected by the bones of the skull. In vertebrates, increasing complexity in the cerebral cortex correlates with height on the phylogenetic and evolutionary tree. Primitive vertebrates such as fish, reptiles, and amphibians have fewer than six layers of neurons in the outer layer of their brains. This cortical configuration is called the allocortex (or heterotypic cortex).

Eyes are structures that detect the light reflected by objects, transduce it into electrical information that, after a local processing, is sent to other parts of the encephalon for combining with other neuronal information that altogether eventually change the animal behavior. Eyes are rounded and polarized structures. From the

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anterior to the posterior part, they are made up of cornea, anterior chamber, iris, ciliary muscles, crystalline, vitreous body, retina, choroid, sclerotic or sclera and optic nerve. These components are distributed in three concentric layers or tunics (excepting the crystalline): fibrous tunic, vascular tunic, and internal nervous tunic.

Mammals normally have a pair of eyes. Although mammalian vision is not so excellent as bird vision, it is at least dichromatic for most of mammalian species, with certain families (such as Hominidae) possessing a trichromatic color perception.

In all viviparous animals the embryonic development takes place inside the uterus of the mother, because the eggs are microlecithal and the amount of stored yolk is not sufficient to cope up the needs of the developing embryo. Such embryos get attached to the uterine wall to draw essential substances from the maternal circulation through the placenta.

Evolutionary developmental biology (evolution of development or informally, evo-devo) is a field of biology that compares the developmental processes of different organisms to determine the ancestral relationship between them, and to discover how developmental processes evolved. It addresses the origin and evolution of embryonic development; how modifications of development and developmental processes lead to the production of novel features, such as the evolution of feathers; the role of developmental plasticity in evolution; how ecology impacts development and evolutionary change; and the developmental basis ofhomoplasy and homology.

The book provides an introduction to structure-function concept at the level of organs and organ systems, which is fundamental to the understanding of synthesis of comparative anatomy.

—Dr. Ashwani Kumar Dubey

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1

Introduction

ORIGIN OF CHORDATES, CLASSIFICATION OF PHYLUM CHORDATA UP TO ORDERS ACCORDING TO PARKER AND HASWELL

ORIGIN OF CHORDATES

Chordate Origins: Members of Phylum CHORDATA have four primary characters, they are-

a) A primitive endoskeleton structure called the NOTOCHORD present during the early embryonic life. This rod-like structure composed of a special type of connective tissue which is located along the mid dorsal line where it forms the axis of support for the body.

   In some animals, it persists as such throughout the life, while in most chordates it develops into vertebral column.

b) A hollow, dorsal NERVE CORD sometimes during the life. The CNS made up of brain and spinal cord is located dorsally and above the notochord.

   The CNS is a hollow canal from one end of the body to the other end.

c) GILL SLITS connecting to the pharynx are present at some stage of the life.

   Most aquatic chordates respire by gills made up of vascular filament present along the gill slits.

   However in terrestrial chordates, which don't breathe by gills the gill slits are found only in embryonic life but no vascular filaments are associative with gill slits.

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d) Chordates have POST-ANAL TAIL in some stage of life that represents a posterior elongation of the body extending beyond the anal aperture. The tail is basically a chordate locomotory structure containing the muscle and notochord.

e) Apart from the above four features the chordates also have certain characters common to some other phylum, they are:

They are bilaterally symmetrical.

Partial metamerism present.

They have a true body cavity on coelom lined with mesoderm.

They show cephalization i.e. concentration of nerves tissue and presence of special sense organs

The blood is flowing anteriorly from the ventrally located heart and pushed to the dorsal side.

Chordates From Annelids And Arthopods

The main lines of invertebrate animals show the closest affinity with chordate. Many of the supposed linking similarities between chordates and annelids or arthropods result from ANALOGY rather than HOMOLOGY. Some scientists believe that Annelids and arthropods have the closest similarity because of following reasons:

Metamerism Or Metameric Segmentaion: Both group's shows metamerism but this similarity is superficial.

REASON: The segmentation of this annulates is almost complete division of entire body into rings and units, all organ systems are affected by segmentation. However in Chordates, only dorsal myotomal region is segmented whereas even the ventral part of mesoderm is not segmented.

Orientation Of The Chordates: The two group's namely Chordates and annulates shows difference in this. The NERVE CORD is dorsal to the duct whereas in annulates it is below the gut and the brain above. Similarly the blood circulation in different directions in two groups and the limbs are also based on different plans. Since scientists like Patten and Gaskell have tried to show relationship with Eurypterids. It is thought that the Eurypterids show some superficial resemblance to the Agnatha of Devonian making the scientists believe that, the type of an annulate could be the possible ancestors of chordates.

Cleavage Pattern: Development of modern annulates is completely different from chordates. In annulates, the cleavage by which the fertilized eggs gets divided into blastomeres follows a SPIRAL PATTERN in which each blastomere arises a regular way and the future fate of each is exactly defined. In contrast the cleavage in chordates is RADIAL AND IRREGULAR.

Gastrulation: The next stage of development i.e. gastrulation is also different in two groups. In chordates, it occurs by invagination of one side of the ball of cells to form an archenteric cavity communicating with exterior. However in

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annulates, the cells forming guts migrate inward all around the sphere and later get arranged into a tube that opens to the outside.

Fate Of Blastofore: It is another point of comparison so that in chordates, protochordates and in Echinoderm blastopore becomes the anus while the mouth is a new opening hence these animals come under group DEUTEROSTOMIA. Distinct from non-chordata that belongs to PROTOSTOMIA in which blastopore becomes the mouth.

The method of mesoderm and coelom formation are also important i.e. DEUTEROSTOMIA this 3rd layer is produced by separation of endoderm so that coelom is at first continuous with the archenteron and it is said t be an ENTEROCOEL. However in the annulates, the cells separate in various ways to form a mesoderm and a coelom than arises within this solid mass as a SCHOZOCOEL.

Thus in all the above points the chordates differ from all the annulates but resembles Echinoderms and their allies.

Further features also support this relationship. For e.g.: Both have a larva with longitudinal ciliated bands and very different from the TROCHOPHORE LARVA OF ANNULATES which has transverse cilia.

Similarly NERVOUS SYSTEM of annulates consists of a set of ganglionated cords whereas in Echinoderm-like animals it is a diffused sheet of fibres and cells below the epidermis. The nerve chord of the chordate can be easily derived from Echinoderm nervous system and not from the annulates type of nervous system.

A MESODERMAL SKELETON is found in both chordates and echinoderms but absent in annulates.

The mechanism for providing energy liberation also shows systematic differences. For e.g. regeneration of ATP is brought about by Phosphoarginine and its Kinase in the arthropods and molluscs, while Phosphocreatinine and its Kinase bring about the same reaction in Amphioxus and chordate while both this systems operate in echinoderms and urochordates.

This may have the advantage; a rich energy source like Creatinine which could be easily synthesized from glycine which could be kept aside for locomotion whereas the rare Arginine could be utilized only for the important histone formation. Early on during evolution it was found creatinine was characteristic of early larva life where arginine of adult life but in neoteny, creatinine became the only substrate for ATP generation.

THEORIES ABOUT ORIGIN OF CHORDATES

It is believed that Chordates have originated from invertebrates. It is difficult to determine from which invertebrate group the chordates were developed. Chordate ancestors were soft bodied animals. Hence they were not preserved as Fossils.