I M.Sc., ZOOLOGY

SUBJECT CODE: P16Z011

ANIMAL TAXONOMY, PHYLOGENY AND BIODIVERSITY

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General Topics

1. Principles of Classification and Binomial Nomenclature

In a Library or a Store all the articles are orderly arranged. This order helps in finding the right thing in right place. It quickens the work and avoids confusion. Such orderly arrangement is called **classification.** Its purpose is to create an order in disorder.

The assembling of animals into groups based on their similarity is called **classification.** The science of classification is called **taxonomy.** LINNAEUS is referred to as the **father of taxonomy.**

Types of Classification

There are three types of classification. They are as follows:

1. Natural Classification
2. Artificial Classification and
3. Practical Classification

1. Natural Classification

Natural classification is based on two factors namely 1. Morphological similarities of many characters and 2. Common ancestry. This system of classification is followed in the field of Zoology.

2. Artificial Classification

This classification is based on the following factors: 1. Animals are classified based on their habit, habitat etc. For example, animals are classified into **oviparous** and **viviparous:** They are classified into **carnivores, herbivores** and **omnivores** on the basis of their food habits.

2. Animals are classified based on the places where they live. For example, animals are classified into **aquatic, terrestrial** and **aerial.**

3. Practical Classification

This classification is based on the utility of animals to man. Eg. Animals are classified into **harmful** animals and **useful** animals. Similarly they are classified into **edible animals** and **inedible animals.**

Units of Classification

All animals are placed in a very large group called **animal kingdom** or **animalia.** The animal kingdom is split into large groups called **phyla.** The phyla are divided into small groups called **classes.** The classes are divided into still smaller groups called **orders.** The orders are divided into **genera.** Finally each genus is divided into smallest groups called species.

Animal Kingdom

Phylum

Class

Order

Genus

Species.

These are the main units of classification. Sometimes these main units are subdivided into subunits by pre-fixing **sub** or **super**. For example, **Sub-phylum, Sub-Class, Super-Class, Sub-order, Super-order**, etc.

Species

Species is the smallest unit of classification. Species is defined as a group **of genetically similar individuals which interbreed among themselves.** So there is free **gene flow** between the members of a species.

Binomial Nomenclature

The binomial nomenclature was proposed by ***Linnaeus*** (1737). It is a system of naming animals. According to this system, **each animal** is named by **two words.** The first word is called **generic name** and the second word is called **species name.** The generic name starts with a capital letter and the species name starts with a small letter. Eg. **Periplaneta americana. Periplaneta** is the generic name and **americana** is the is the species name.

Working of the systems of Classification and Nomenclature

The method of classifying and naming animals can be easily understood by studying tape-worm and frog.

Unit		Tape-worm	Frog
Kingdom	-	Aniamalia	Animalia
Phylum	-	Platyhelminthes	Chordata
Class	-	Cestoda	Amphibia
Order	-	Taenioidea	Anura
Genus	-	**Taenia**	**Rana**
Species	-	**solium**	**hexadactyla**

Characters used in Classification

In classifying animals, the following characters are considered:

1. Levels of organization
2. Symmetry
3. Coelom
4. Number of germ layers
5. Metamerism
6. Unique features like nematocysts in Platyhelminthes pedicellariae in Echinoderms, etc.

Trinomial Nomenclature

Trinomial momenclature is a method of naming the animals. Here each animal is named by three words. The first word represents the **genera,** the second word represents the **species** and the third word represents the **sub-species.** This system is followed when there are two or more varieties (sub species) within a species. Eg. The house crow contains many varieties and they are named as follows:

Corvus splendens splendes — House crow of India and Pakistan

Corvus splendens insolens — House crow of Burma

Crovus splendens protegatus — House crow of Ceylon

Rules of Nomenclature

The International Commission on Zoological Nomenclature framed certain rules in 1901 for naming the animals. They are the following:

1. All the animals must be named by two words (binomial). The subspecies can be named by three words (trinomial).

2. In case several names have been given to a single animal by different scientists, the earliest name is to be considered valid. The duplicate names are called **synonyms.**

3. Scientific names should be derived from Latin.

4. The genus name is a single word. It must begin with a capital letter.

5. The species name may be a single or compound word. It must begin with a lower letter.

6. The scientific name should be printed in **italics.** If it is handwritten or typed, it must be **underlined** to indicate italics.

7. The name of the author, who first publishes the name, should follow the species name. Eg. **Rana tigrina** Daud.

8. When the name is changed, the original author's name is given in parentheses.

9. The name of the family is derived by adding **idae** to the name of the genus. Eg. **Trypanosomatidae.** The name of the sub-family is derived by adding **inae.** Eg. **Euglenoidinae.**

Advantages of Nomenclature

The scientific nomenclature has the following advantages:

1. Each and every animal has been provided with a scientific name.

2. One name always refers to only one animal.

3. The scientific names are international. That is, one name for one animal is used universally. An Indian student knows what exactly **Amoeba** proteus stands for and so does a German or a Russian.

4. The scientific names are self descriptive and they indicate important features of animals.

5. The scientific names indicate relationship of animals with one another. The dog, wolf and jackal have the same scientific name **Canis**. This means that all these animals are inter related.

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2. Levels of Organization

Animals have certain basic characteristics which establish relationship among them. These characteristics are as follows:

1. Grades of organisation
2. Symmetry and
3. Body cavity.

1. Grades of Organisation

This shows how cells are arranged in animals. There are **five** types of grades of organisation in animals. They are as follows:

1. Acellular grade of organisation
2. Cellular grade of organisation
3. Tissue grade of organisation
4. Organ grade of organisation and
5. Organ-system grade of organisation.

1. Acellular or protoplasmic grade: This grade of organization is found in **Protozoa**. Eg. **Amoeba**. Here all the activities are carried out by the protoplasm present within a single cell. The body is not differentiated into cells.

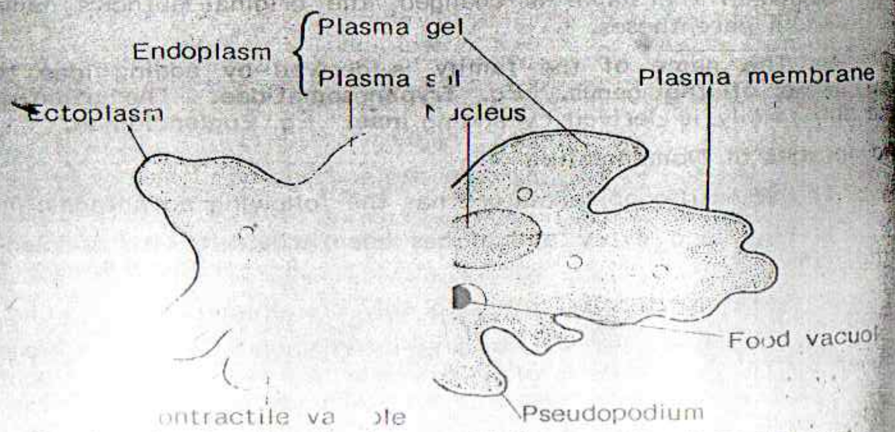

Fig.( ): Amoeba sho ing acellular grade of organizatio

2. Cellular grade: This grade of organization is exhibited by **Porifera** and **Mesozoa**. In cellular grade of organization the body is made up of many cells. But the cells are loose and independent. Here the cells exhibit division of labour doing different functions.

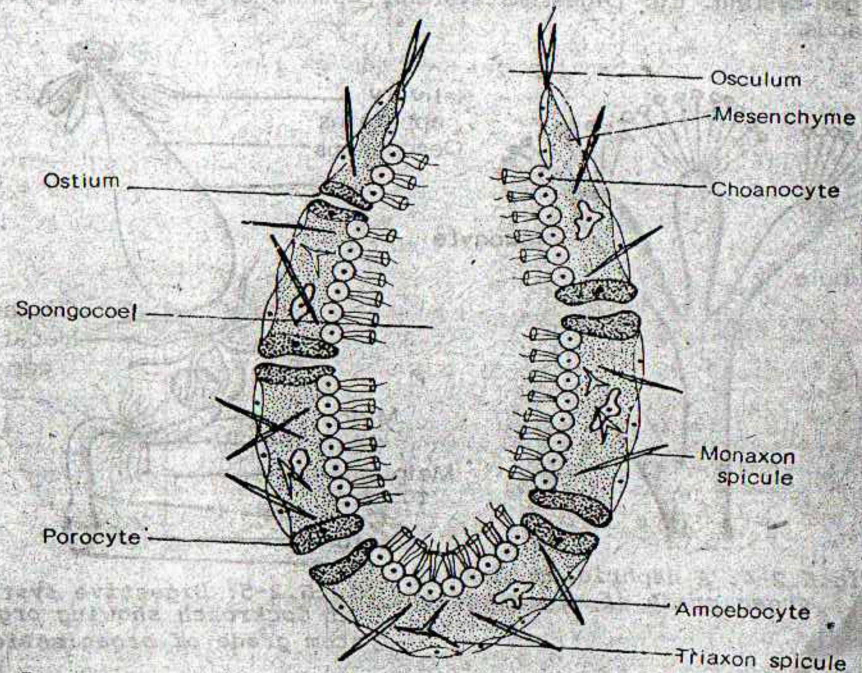

Fig.G.2-2: L.S. of a sponge showing cellular grade of organization.

3. Tissue grade: This grade of organization is seen in **Coelenterata** and **Ctenophora**. Here the cells aggregate together to form **tissues**. Eg. Nerve cells aggregate together to form **nerve-nets**.

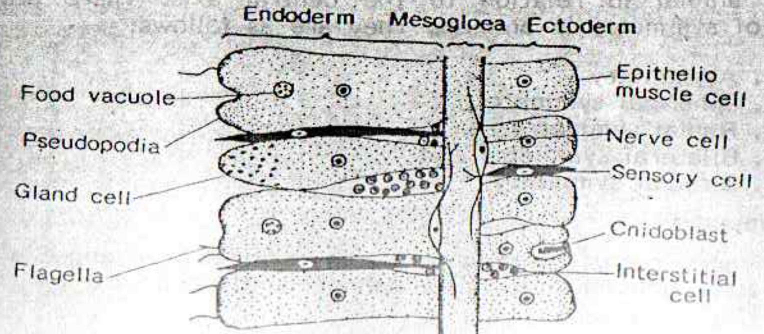

*Fig.G.2-3: Body wall of **Hydra** showing tissue grade of organization.*

Introduction to Taxonomy

Taxonomy is the classification of organisms in an ordered system that indicates natural relationships. It is a subdiscipline of Systematics which is the study of those relationships. The word taxonomy is also used in non-biological contexts in to describe any system of classification. Nomenclature is the study of names of organisms (not the organisms themselves) and is a subdiscipline of taxonomy. Often you'll see a reference to "taxonomy and nomenclature" or "systematics and taxonomy".

The nomenclature of biological taxonomy is based on Latin, though since the beginning, errors and inconsistencies have crept in, so it is not completely compliant with the grammar or usage of Latin.

Carl Linne (1707-1778), who wrote as Carolus Linnaeus, was a Swedish botanist that developed the taxonomic system, called binomial nomenclature, that is used throughout Biology. His original system was first published in 1735 under the title Systema Naturae. The system has evolved over time, but remains essentially the same.

At the top, the Linnaean system designates six Kingdoms: Plantae (plants), Animalia (animals), Fungi (mushrooms and other fungi), Chromista (brown algae and others), and Bacteria (prokaryotes). The arrangement, naming and scope of each of those Kingdoms (or any grouping within them) can vary depending on the person studying and reviewing the taxonomy, especially with regards to ongoing research in the many fields of study. However, those groups are generally recognized even by those in disagreement with them.

Stages in taxonomy

It is now well-known that taxonomy of a given group passes through several stages. These stages are referred to as alpha (analytical phase), beta (synthetic phase), and gamma (biological phase) taxonomy. Alpha taxonomy is the level at which the species are characterised and named; beta taxonomy refers to the arrangement of the species into a natural system of lower and higher categories; and gamma taxonomy is the analysis of intraspecific variations and evolutionary studies, i.e., study of speciation. But in actual practice it is rather difficult to dissociate them because these overlap and intergrade. These are only a few groups of animals (some vertebrates, especially the birds, and a few insect orders like Lepidoptera) where the taxonomy has reached up to gamma level otherwise in almost majority of the groups the works are still at alpha and beta levels.

Definitions:

- Kingdom The highest formal taxonomic classification into which organisms are grouped.

- Phylum A primary division of the kingdom ranking above a class. Botanists use the term Division.

- Class A primary taxonomic category of organisms ranking below a phylum and ranking above an order.

- Order A primary taxonomic category of organisms ranking below a class and above a family.

- Family A primary taxonomic category of organisms ranking below an order and above a genus.

- Genus A primary taxonomic category of organisms ranking below an order and above a genus. It is comprised of species displaying similar characteristics. In taxonomic nomenclature, the genus is used, either alone or followed by a Latin adjective or epithet, to form the species name.

- Specific epithet The term for the uncapitalized second word used in binomial nomenclature to designate a species. In the species name Anolis carolinensis the specific epithet is the word carolinensis.

- Species A primary taxonomic category of organisms, ranking below a genus and comprised of related organisms capable of interbreeding. In writing, organisms in this category are represented in binomial nomenclature by an uncapitalized Latin adjective or noun following a capitalized genus name, as seen in Anolis carolinensis. The genus is often shorthanded, as found in A. carolinensis.

- Trinomial nomenclature A three-part taxonomic designation indicating genus, species, and subspecies, such as Anolis sagrei sagrei.

o Taxon (pl. Taxa) any grouping within the taxonomic system. Plantae is a taxon, and Anolis and Homo sapiens taken together are taxa.

Within each rank (kingdom, genus, etc.) other ranks may be recognized. The primary lesser ranks used include groups using prefixes such as "sub", "super" and "infra", such as suborder and superfamily. These are useful in grouping taxa below or above a certain major rank without changing their more formal (and usually more familiar) taxonomy. In addition to those prefixes, Tribe is another commonly used grouping above the genus level. Usually understanding the meaning of a taxonomic grouping is apparent from its use.

The importance of taxonomy are:-

1. It helps to ascertain the number of living beings on Earth. More than one million of species of plants and animals have been discovered and classified so far.

2. It aims to classify the living organisms. Millions of organisms are classified scientifically in categories, which helps to have a better understanding.

3. It helps us to get an idea of the traits present in plants and animals.

4. It gives an idea of the order of the physical development.

5. It gives an idea of local fauna and flora, thus helping us to distinguish the endemic species.

Global biodiversity is being lost at an unprecedented rate as a result of human activities, and decisions must be taken now to combat this trend. But how do decision-makers decide where to establish protected areas if they don't know what is being protected? How can regulators identify and combat harmful invasive species if they cannot distinguish them from native species? How do developing countries ensure that they reap the benefits of the use of their biological diversity, if they don't know the biological diversity that is being used? Taxonomy provides basic understanding about the components of biodiversity which is necessary for effective decision-making about conservation and sustainable use. For more information on the benefits of taxonomy,

Aims and tasks of a Taxonomist

The primary aim of a taxonomist must be the construction of classes of living things about which scientifically useful inductive generalisations can be made. Many workers have enumerated various aims and tasks of a taxonomists. For the sake of convenience to readers, there are summarised below.

1. To catalogue the diversity of life on earth and to preserve large samples, both of extant and extinct organisms, drawn from the diversity in various sorts of collection.

2. To differentiate the various kinds of organisms and to point out their characteristics (both qualitatively and quantitatively) through descriptions, keys, illustrations, etc.

3. To provide names for each kind of organisms, so that all concerned can know what they are talking about and so that information can be recorded, stored and retrieved when needed.

4. To develop a set of principles in regard to the choice and relative importance of characters with the ultimate aim of arranging species in hierarchy of higher categories.

5. To estimate genetic and phylogenetic relationships among organisms.

6. To contribute towards the understanding of evolutionary process.

7. To integrate the data from all fields of biology, like behaviour, genetics, physiology etc., and to detect and then summarise significant patterns possibly with the help of modern electronic computers.

8. To document and preserve specimens to provide a useful reservoir of data.

9. To help in clarifying the place of systematics or taxonomy in general biology by revising their aims and priorities, realistically restructuring the efforts in applied taxonomy and reaffirming faith in taxonomy.

Identification using taxonomic keys

A taxonomic key is a simple tool used to identify a specific object. A taxonomic key is one of the most useful tools available to scientists trying to identify an unknown organism. Systematists rely on keys to help identify known organisms and determine whether they have discovered a new organism entirely. Taxonomic keys are useful tools guiding researchers towards the known name of an organism. However, all taxonomic keys are not created equally. They are often created on a regional level or for a particular group of organisms (i.e., Plants of the Great Lakes Region, Argentinean Monocots etc.). So it is important to pick a key that represents the diversity of the region or group of organisms you are interested in examining.

DICHOTOMOUS KEYS allow the user to determine the identity of items using a sequence of alternative choices. Dichotomous comes from the Greek root dich-, meaning "two" and temnein, meaning "to cut." Dichotomous keys always give two, mutually exclusive choices in parallel statements. The pair of statements is referred to as a couplet and each 1/2 of a couplet is a lead. At each couplet of a dichotomous key the user is presented with two choices about a specific character present in the group of organisms, a specific character state is described for each lead. Sometimes the characters are quantitative (i.e., measurements) and sometimes the characters are qualitative (e.g., texture). As the user makes a choice about a particular characteristic of an organism s/he is led to a new branch or couplet of the key. Each couplet provides characteristics that become progressively more specific until the final step is reached and identification is made. Followed correctly, keys will lead you to the correct name of an unknown organism or object. Dichotomous keys can be developed to identify anything in any sort of classification.

POLYCLAVE KEYS are tools used to help identify unknown objects or species. The keys are generated using interactive computer programs. Polyclave keys use a process of elimination. The user is presented with a series of choices that describe features of the species they wish to identify. The user then checks off a list of character states present in the organism they wish to study. The program looks to match those character states with all the species they can possibly match. If a species does not have that character state it is eliminated from the list. The more character states listed the more species that are eliminated. This allows the rapid elimination of large numbers of species that the specimen cannot be. The process continues until only one species (or a short list of species) remains. This allows the user to eliminate lots of potential species and identify the species or at least a short list of possible species. This continues until only one species is left. If all went well, and the key fits your group of organisms, that is the name of the species you have located! Even the best keys have their limitations, so make sure you verify your identification using multiple tools (image verification, herbarium specimens, expert identification, etc.).

Phyletic lineage

The sequence of arrangement of species from ancestors to the descendant through evolution is called phyletic lineage.

1. provides a connecting link between the present day organisms and their remote past ancestors.

2:-It shows the unbroken series of species arrangement.

3:-It also throw light on the evolution of organisms.

Linnaean Hierarchy:

Hierarchy (used in many classifications other than that of organisms) was developed mainly in the seventeenth and eighteenth centuries and reached nearly definitive form (for zoologists) in the tenth edition (1758) of Systema Naturae of Linnaeus. Linnaeus recog¬nised within the animal kingdom only five categories — classis, order, genus, species and varieties.

As the number of known ani¬mals grew, making finer divisions necessary, two additional categories were soon added — family (between genus and order) and phylum (between class and kingdom). The varieties used by Linnaeus was subsequently either discarded or replaced by the sub¬species.

The above-discussed categories form the basic taxonomic hierarchy of animals. Thus any given species belong to these seven obli¬gatory categories

Typological

typological species concept The concept of a species as a group whose members share certain characteristics that distinguish them from other species. This Aristotelian concept was applied to the natural world by the early taxonomists, but by the late 19th century was being supplanted by other concepts, notably the biological species concept. These could better account for the many cases in which species appear to be virtually indistinguishable (see sibling species) or where intermediate phenotypes occur due to hybridization. However, taxonomists must use a typological approach when attempting to classify exclusively asexual organisms (see agamospecies). See also phylogenetic species concept.

Nominalistic

The nominalistic species concept is the concept of Occam and his followers, of the belief that nature only produces individuals. Species are the creation of man. In nature, they lack definite existence. During the 18th century in France, this concept was in demand and even now is used by some botanists.

The Biological Species Concept defines a species taxon as a group of organisms that can successfully interbreed and produce fertile offspring. According to that concept, a species' integrity is maintained by interbreeding within a species as well as by reproductive barriers between organisms in different species.

Evolutionary species concept: An evolutionary species “is a single lineage of ancestor-descendant populations of organisms which maintains its identity from other such lineages [in space and time] and which has its own evolutionary tendencies and historical fate”

Polytypic species are composed of allopatric or allochronic populations that differ from one another. However, all populations of sexually reproducing organisms differ slightly, and certain standards must be met before subspecies can be recognized. A second difficulty is that closely related species with similar ecological requirements occasionally replace each other geographically and it is difficult to decide whether they are full species or subspecies. Finally, many isolated populations are in the middle in the process of evolving into new species and are on the borderline between subspecies and species status.

A **subspecies** is a particular group within a species that has branched off usually due to geographic isolation. Subspecies can develop unique characteristics but are still genetically similar enough that they could interbreed with the rest of the species.

Super species: A group of closely related, geographically separated species whose members have evolved from different allopatric populations of the same parent species and can interbreed and produce fertile offspring when brought into contact.

II.1

Rules of nomenclature

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The International Code of Zoological Nomenclature (ICZN)

It is important that scientists working in different parts of the world and speaking different languages must nevertheless be able to share results of their research without confusion as to what organisms they are talking about. In other words each species must have a name that is the same throughout the world. There are many cases where multiple names have been proposed for the same species. To resolve such matters, it is necessary to have a set of rules that is accepted by taxonomists everywhere. What we have is the International Code of Zoological Nomenclature. This complex set of rules was developed by the ICZN and adopted by the International Union of Biological Sciences. In addition to rules for determining which name should be used for a species, there are rules for determining whether a new name has been published in an acceptable way and whether the name is eligible to be used. There are also rules defining circumstances under which an established name will continue in useage even though a different name would be used if we strictly followed priority to use the oldest eligible name. This is necessary to avoid confusing persons who use the names. The explanation given here is greatly simplified. For full details see International Code of Zoological Nomenclature, Fourth Edition, published in 1999 by The International Trust for Zoological Nomenclature, c/o The Natural History Museum, Cromwell Road, London SW7 5BD, UK.

The type system

A central concept of the International Code is use of types as "name bearers." When scientists describe new species of Support, they designate one individual for each species as the holotype or name bearer for that species. This solves two problems:

1. The published description of a new species is often insufficient to distinguish it from other species that exist in nature but may be unknown to the scientist. A person studying the matter at a later time can examine the holotype and observe details not mentioned in the original published description.

2. It often happens that the scientist who describes a new species was looking at several specimens thought to belong to a single species. Subsequently, more extensive study reveals that the specimens actually belong to multiple species. The identity of the holotype determines which species keeps the name.

Just as specimens are designated as holotypes for species, species are designated as type species for genera and subgenera. At one time the type species was often called the genotype, but when genotype became widely used in genetics the taxonomists abandoned "genotype" and now use "type species." The type system also applies at higher levels. Taxa at ranks above genus up to the rank of superfamily have a type genus. There is a standard naming convention for these family-group names. The first step is to determine the "stem" of the type genus (see Article 29 in the ICZN).

- To name a superfamily, add "oidea" to the stem of the type genus name.
- To name a family, add "idae" to the stem of the type genus name.
- To name a subfamily, add "inae" to the stem of the type genus name.
- To name a tribe, add "ini" to the stem of the type genus name.
- To name a subtribe, add "ina" to the stem of the type genus name.

These standard endings are required for superfamilies, families and subfamilies. Adoption at the levels of tribe and subtribe has been slower, and names formed in different ways are also used.

Kinds of types

Various names are used to identify types of different kinds:

- Type genus, the "name bearer" for family-group taxa (taxa with a rank higher than genus up to superfamily).
- Type species, the "name bearer" for genus-group taxa (genus or subgenus).
- Type specimen
  - Primary types, the "name bearers" for species names
    - Holotype, the single specimen designated as holotype when the species was first described.
    - Syntypes (also known as cotypes), multiple specimens identified by the author when the species was first described without designating a specific holotype.
    - Lectotype, the specimen designated by a subsequent author and selected from the syntypes.
    - Neotype, a specimen designated by a subsequent author as the namebearer when the original primary type(s) have been lost or destroyed.
  - Secondary types, not recognized as "name bearers" for species names

- Allotype, a specimen of the opposite sex from the holotype and designated as allotype when the species was first described.
- Paratype, additional specimens examined when the species was first described, but not designated as holotype or allotype.
- Paralectotype, a specimen that was once a syntype, but is not the specimen later designated as lectotype.

Status of names

Names used for taxa can have different status. In some cases, the names for the status are formally defined by the International Code of Zoological Nomenclature (ICZN). In actual practice, phasmidists and orthopterists do not always follow a strict interpretation of the rules. This website has recently implemented the taxonomic status conventions used by the Integrated Taxonomic Information System (ITIS) database, an active contributor to the Catalogue of Life project. The website attempts to follow the classification found in the most recent scientific publications covering the topic. An exception is made for names at higher ranks (usually subfamily and higher). At higher ranks, different taxonomists sometimes maintain conflicting opinions over many years. In such cases, this website stays with the traditional interpretation until there seems to be a consensus developing for a newer interpretation.

Species Files recognize five basic categories of name status:

- Valid. A name that is accepted as correct for the taxon. In some cases it is a required emendation (deliberate change in spelling) because the International Code specifies certain changes to fit the required format (no digits, no hyphen, no diacritical marks, gender of a species name in conformity with the gender of the genus name).
- Temporary. A name that is used until a valid name is provided.
- Nomen nudum. A name that was not properly associated with actual specimens.
- Nomen dubium. A name used without sufficient information so that later authors are unable to determine what taxon was meant.
- Synonym. An additional name used for a taxon that has a valid name.

Each name status may have one or more attributes (status details) that fall into four types:

- Junior homonym. A taxon name that is spelled the same as a previously named taxon (differences in species gender endings notwithstanding) and not accorded precedence. The rules are different based on the taxon rank. A junior homonym is compatible with a name status of temporary or synonym.
  - Preoccupied. Names of genera and subgenera must be unique throughout the animal kingdom. If a name was previously used for a different genus or subgenus, the name is

preoccupied. Homonyms are less common at ranks higher than genus, but they do occur and are subject to more complex rules.

  - Primary. A name for a species or subspecies that at the time of its original description was already in use for a species or subspecies in the same genus. A primary homonym is never eligible to become valid even if the taxa are separated to different genera.
  - Secondary. A name for a species or subspecies that at the time of its original description was not already in use for a species or subspecies in the same genus. However, at a later date a species or subspecies was moved to a different genus causing the two usages of the same name to be in the same genus. A secondary homonym can become valid if the taxa are later separated in different genera.
- Emendation. An available name whose spelling has been intentionally changed.
  - Justified. The mandatory correction of an incorrect original spelling; e.g., original spelling contained diacritical marks, hyphens, etc. A justified emendation is compatible with a name status of valid, temporary, or synonym.
  - Unjustified. An intentional change in the original spelling of a name that is not mandated. An unjustified emendation is compatible only with a name status of synonym.
- Unavailable. A name that is excluded from any recognition under the rules of nomenclature.
  - Misspelling. An accidentally misspelled version of a previous name. A misspelling is compatible only with a name status of synonym.
  - Incorrectly formed name. A name that does not conform to the ICZN standard according to its taxonomic rank. An incorrectly formed name is compatible with a name status of temporary, nomen nudum, nomen dubium, or synonym.
  - Unnecessary replacement. A name used as a nomen novum for a valid taxon name. An unnecessary replacement is compatible only with a name status of synonym.
  - Suppressed by ruling. A name that has been specifically ruled by the ICZN to be unavailable. Depending on the ruling, the name may be partially, totally, or conditionally suppressed. A name suppressed by ruling is compatible only with a name status of synonym.
  - Unavailable for other reason. The reason should be stated in the Comment text area. An unavailable name for other reason is compatible with a name status of temporary or synonym.
- Other.
  - Junior synonym. A name created that describes an identical taxon previously described with the same or different name. A junior synonym is compatible only with a name status of synonym.
  - Misapplied. A name used erroneously because the specimens studied did not actually belong in the taxon the author thought they were in. A misapplied name is compatible with a name status of temporary or synonym.

- Nomen oblitum. A name that has priority for a taxon, but is nevertheless not used in order to continue usage of a widely used and accepted name. A nomen oblitum is compatible only with a name status of synonym.
- Nomen novum. A new name that is used to replace a valid taxon's original name in the event of homonymy. A nomen novum is compatible with a name status of valid, temporary, or synonym.
- Nomen protectum. A name given precedence over its unused senior synonym or senior homonym which has become a nomen oblitum. A nomen protectum is compatible with name status of valid or synonym.
- Unnamed. A taxon that has not yet been given a name and description in a qualified publication. Nevertheless, information available in a publication or website makes it desirable to be included in this website for the sake of completeness. An unnamed name is compatible only with a name status of temporary.

External links

- International Commission on Zoological Nomenclature

Disadvantages:

They are not useful to people with a different language or dialect

Some species have several common names

Some species share the same common name

Some species may not have a common name

Scientific names are Latin or Latinized names that are standardized by a series of rules and are applicable worldwide.

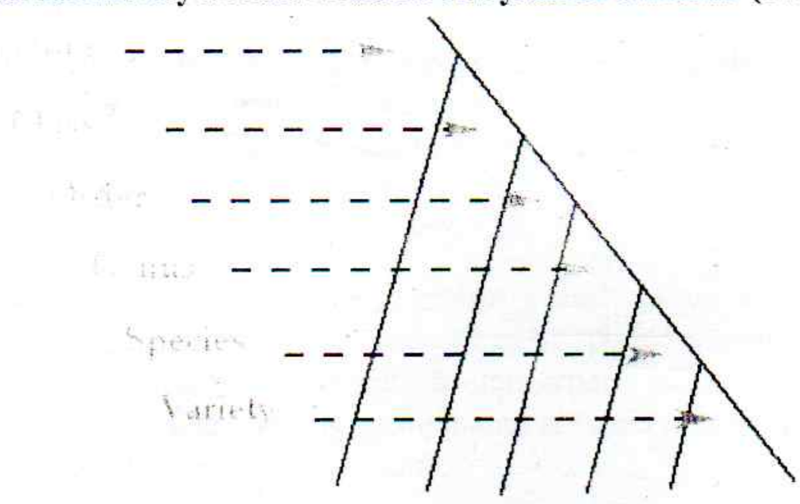
Linnaean Hierarchy!

This is a system of categories that connote taxonomic rank. The same thing could be achieved through a system of indentation (see below) or a system of numbers connoting rank in a hierarchy. However, these latter systems are generally more difficult to represent and remember by the user.

With the Linnaean system one only needs to know the general categories and know rank order in the hierarchy!

The original Linnaean system had a limited set of categories that successfully reflected a nested set of groups within groups.

Linnaean Hierarchy in 10th Edition of Systema Naturae (1758)



Later many authors began to incorporate categories above and below these original categories. Some classifications contain well in excess of 10 different categories, as can be see below.

Categories Used in More Modern Classifications

the original description. These specimens are valuable as reference materials that are deposited at multiple, dedicated museums or institutions, they have no standing in nomenclature (these series can sometimes contain misidentified specimens). Paratypes may, however, serve as useful materials to select a neotype from if needed.

Genus-group types.

These types represent species, comprised of names - not specimens. Traditionally authors did not designate types of genera; modern codes, however, require that for a generic or subgeneric name to become available a type species must be designated by the author describing the new genus or subgenus.

Types for genera published before mandates of types are most commonly fixed &endash; assigned either through monotypy or subsequent designation.

Monotypy: The genus has only one species included in it at the time that they type species is designated and is thus monotypic. If other species are added to the genus before a type is designated then the type can only be the original species that existed in the genus.

Subsequent designation: If more than one species was originally included in a new genus the type can be selected either by the original author or at a later time by another person.

Indication: An original indication of a type is one that the author of the name indicates via illustration or other means and is referred to as typus or typicus.

Tautonymy: When a new genus and species is described with the same name for the genus and species epithet it becomes the type. An example is Bison bison. This is okay in zoology but not in botany.

Family-group names.

Genera form the types in these groups. Family group names are subject to the rules of homonymy (below), in that no two can be spelled identically, even though they may be based on different, although similar, generic names. Just because a generic name on which the oldest family-group name is based is in synonymy (below), this does not invalidate the family group name.

For example:

Insect suborder Heteroptera the family Velocipedidae contains a single valid genus *Scotomedes*. The generic name on which the family name is based, *Velocipedes*, is a junior synonym of *Scotomedes*.

Angiosperm genus *Winteria* is a junior synonym of *Drimys* but the genus is in the family Winteraceae.

Homonymy

However, there are some biases practiced today.

A "good" specimen

An adult in breeding condition or with additional characters visible.

Types of Types:

There are two forms of types - (1) names or (2) specimens.

Species-group types.

These represent a single specimen to which a name is attached. This provides an objective criterion for establishment of usage of that name. Species-group types are recognized in the codes as primary types and include the following possibilities.

Type locality: All types of species and subspecies are tied to a spatial location called the *type locality.*

Holotype: Single specimen designated by the author(s) of the name at the time of publication of the original description.

Neotype: A specimen later designated to replace a holotype (or other primary type) if the latter can be documented as lost or destroyed.

Syntypes: A group of specimens thought to represent a species, as designated or indicated byt he author(s) of the original description. These specimens may sometimes be referred to as the "type series". Cotypes are sometimes used in the same way. If syntypes exist for a species only from this series can a lectotype be designated. [Many early descriptions of species were based on syntypes because the requirement for a holotype designation or indication did not exist].

Lectotype: One of the syntypes chosen by the original or subsequent author(s) to function as the name bearer.

Primary types are customarily deposited in recognized institutions dedicated to the long-term maintenance of collections.

Other types:

Isotype: a specimen (in botany) collected from the same individual plant as the holotype.

Topotypes: specimen(s) collected from the same location as the holotype (perhaps at the same time).

Paratype: Commonly designated in descriptions of new species as specimens being studied by the author in the description of the new species or subspecies and designated by that person at the time of publication of

This basic principle refers to the application of the same name to different taxa. Our codes of nomenclature state that NO two names above the species-group level may be the same in zoology or botany, although names may be duplicated between the two fields.

Homonyms are of different types:

Senior homonyms: The available name on the basis of priority.

Junior homonyms: A preoccupied name (not in use) on the basis of priority or by a ruling by a nomenclatorial body.

Primary homonyms: In a species-group (species, subspecies, etc.) these are names that are the same and were proposed in the same genus-group taxon. The junior homonym must always be replaced must always be replaced either by a new name or a junior synonym (if one exists)

Example: *Cottus pygmaeus* &endash; pygmy sculpin. This species was described and later it was discovered that this name was already preoccupied by an old description of a *Cottus* from the Old World. This then is a primary homonym. A new name for the pygmy sculpin is currently being described.

Secondary Homonyms: These are species that are placed in the same genus subsequent to their publication and they have the same specific epithets. The senior secondary homonym is the older of the two names. An alternative name will have to be provided either through description or junior synonyms for the junior homonym.

Example:

***Cyprinella garmani* (Jordan)**

gibbous shiner

Notropis garmani Jordan, 1885:813. [Substitute name for preoccupied *rubripinna* Garman, 1881]

Cyprinella rubripinna Garman, 1881:91. [Original description; Type locality: Lago del Muerto, near Parras, Coahuila, Mexico.]

Synonymy

In taxonomy the concept of synonymy relates to the application of different names to the same taxon. As in the case for homonyms, synonyms can be of several types.

Senior synonyms: The oldest of two or more names that are considered valid by nomenclatorial codes. This is usually based on priority, but may also be done on the basis of choice of names by the first revisor (zoology) or by a nomenclatorial governing body.

Junioir synonyms: The junior names are thoase that are considered invalid on the basis of priority or because of a choice of the first revisor, or by a governing body of nomenclature. These names, however, can be elevated to senior synonyms if new taxa are identified later and the type(s) of the new taxa are the name bearers of these names.

Objective synonyms: Different names that by examination of nomenclatorial literature alone are judged to refer to the same taxon. For example, any two family-group names with the same type genus or any two genera with the same type species are objective synonyms. Two species based on the same specimen are also considered objective synonyms. These synonyms are generally created only by a drug or alcohol-induced stupor that lasts for days or weeks for the author or by an inadvertent error.

Subjective synonyms: These are different names that have been applied taxon as determined by a taxonomist or systematist. An example would include two species originally described as distinct but were later determined by a professionial in the field that they are the same species. This is the most common type of synonymy and these can be the sources of confusion and great debate.

Example:

Stoneroller

***Campostoma anomalum* (Rafinesque)**

Rutilus anomalus Rafinesque, 1820.

Exoglossum spinicephalum Valenciennes, 1844

Exoglossum dubium Kirtland, 1845

Leuciscus prolixus Storer, 1845

Chondrostoma pullum Agassiz, 1854

Campostoma nasutum Girard, 1856

Campostoma formosulum Girard, 1856

Dionda plumbea Girard, 1856

Regarding Stability of Nomenclature

The strict application of the code can be suspended in some instances.

One has the right to appeal to the commission.

There is a statute of limitation for an unused senior synonym in zoology of 50 year = *nomen oblitum*

Other items on Nomenclature

First revisor principle:

This is the first person to examine a species or group of species under the modern codes. This person has the right to choose which of several equally valid names is to be used. They may also identify a lectotype and designate and restrict type localities. They may choose senior synonyms among names published in the same publication by page or line priority if they wish.

Retroactive? Yes.

Validity and Availability

Name correctly formed and validly and effectively published

Available (zoology)

Legitimate (botany)

However, the only name that can be used is a valid (zoology) or correct (botany) name.

Illegitimate names

Forgotten name = *nomen oblitum* (after 1960 if not used for 50 years) [Law of proscription]

Superfluous name = *nomen superfluum*

A name is superfluous if it includes the type of another name wich should have been used (i.e., a description error; should never have been described)

Ambiguous name = *nomen ambiguum*

A name that has been used for a long time in different contexts and is thus confused (seriously)

Dubious name = *nomen dubium*

Available name but cannot be assigned to a definite taxon due to the shortcomings in the original description/diagnosis or because of type material problems. These names are in taxonomic limbo and are never allocated until such time that a type fixation is devised. Usually in these cases no type was designated or only an illustration may exist.

Improper publication of a new name without a description

= *nomen nudum*. These are names that may be nomenclaturally published but lack any description or indication; they have no nomenclatural status (i.e., not occupied)

Supressed names = nomina conservanda.

These are names that have been suppressed by a nomenclatural governing body.

Law of type fixation

Provides for the fixation of a name application, at all levels, by designation of a single type.

What constitutes an indication?

- A bibliographic reference to a previously published description, definition, or figure.
- Inclusion of a name in an index to a work
- Substitution of new name for a previously established name
- Citation of one or more available epithets in combination with, or listed under, the new generic name
- Illustration of an included species
- Description of the "work" on an animal (tubes, tracks, feces, nests, galls, etc.)

Differential diagnosis

Minimum description is necessary

One should go beyond and compare to nearest relatives

Names of hybrids

No! They are not taxa, they are individual organisms. However, there are species of hybrid origin and these are taxa and should be named.

Date of publication

This is the mailing date, not the printed date.

Formation of names

Latin or latinized

Gender must agree

Use no long, hard to pronounce names (recommendation)

Do not use the same name as a species in a related genus (or subspecies in a related species) because it could become a homonym.

The taxonomist should provide etymology (and gender)

Patronyms

Women = -ae; Man = -i; Brothers or Mr and Mrs -orum; Sisters -arum

However, it is preferred by many that the names be descriptive.

Original Spelling

The original spelling is retained with exceptions (*lapsus calami* = inadvertant printer's error)

Authorship

No anonymous descriptions after 1950

Use of parentheses

Abbreviations for authors (L. = Linnaeus)

Suspension

Any automatic provision of the code which disturbs the objectives of nomenclature can be suspended for any given case presented by appeal to the ICZN for use of its plenary powers.

Occupation:

For a name to have status in nomenclature it must be occupied. This requires the following.

Properly published

Must be in Latin or Latinized

Must be formed properly

Cannot be based on hypothetical taxa, teratological specimens, hybrids, etc.

Must be accompanied by a description, diagnosis, and indication

(After 1930 must have an actual diagnosis or definition or reference to OR be proposed expressly as a replacement name for an existing name)

In addition:

After 1930 &endash; genus group names the type species must be unambiguously designated. Species group names - a description of the work alone is unacceptable.

After 1950 &endash; name cannot be proposed anonymously

If any of these are violated the name is nonexistent nomenclatorially.

However, species group names can be based on any stage of the life cycle or life history, either sex, or body part.

Availability

Again, those names that are occupied, identifiable, and, in addition, would be valid of they were the earliest available name of the taxon (excludes some homonyms, nomina oblita, nomina dubia, names suppressed by the nomenclatorial governing body. A name may be occupied but not available.

Generic names

Treated as Latin nouns

Latin nouns have grammatical gender, but this usually has nothing to do with the actual gender; often indicated by ending

&endash; *a* mostly are feminine

II 3

Introduction to zoological nomenclature and the ICZN

1. Natural History Museum, London, U.K. iczn@nhm.ac.uk www.iczn.org Ellinor Michel International Commission on Zoological Nomenclature(ICZN) Zoological Nomenclature

The International Commission on Zoological Nomenclature Present Role: To revise and publish the International Code of Zoological Nomenclature To consider and rule on specific cases of nomenclatural uncertainty in zoology Mandate: 'Sense & Stability in Animal Names' Support Convention on Biological Diversity, Decisions adopted by the 4th meeting of the Conference of the Parties (Bratislava, 4-15 May 1998)

Early codes: Stricklandian (1843 & 1866) Kiesenwetter (1858) Lewis & Sharp (1872-1875) Dall (1878) American Ornithologists' Union (1886) Blanchard (1889) Deutsche Zoologische Gesellschaft (1894)

A universal code for all animals: Commission established: 1895 Publication of the "R è gles": 1905 1 st International Code: 1961 2 nd : 1964; 3 rd : 1985; 4 th : 1999 5: in the works for 2012

"adopted by the International Union of Biological Sciences" (IUBS - ICSU)

Legal? Semi-legal? Who decides?

Ideally, this is a do-it-yourself manual!

When Trouble Strikes! Take a case to the Commission 28 distinguished scientists from 20 countries Sit judgment on cases

Where a problem is discovered concerning the naming of animals which can not be dealt with by direct application of the rules of the Code, applicants present an argument , a "Case" which is published in BZN Counter arguments or support ("Comments") are published subsequently The Commission votes on the application and a decision, called an "Opinion" , is then published

What the ICZN doesn't do Make taxonomic decisions Give names to organisms Enforce correct use of names Change names (we make decisions between existing alternatives)

What the ICZN doesn't do Petition To Change Human Beings' Zoological Name WHEREAS ' c o mplex' describes human beings far more comprehensively than does ' s a pient' and so the Latin complexus describes human beings and differentiates our species from others more accurately than does sapiens ; Whereas human beings act based on names and descriptors, accurate or not, at least as much as on demonstrated reality; Whereas calling themselves by the inaccurate name Homo sapiens promotes and perpetuates an attitude in human beings of their own exceptionalism & superiority; Whereas Carolus Linnaeus acted non-scientifically when he invented the name Homo sapiens – deferring to a belief in human exceptionalism & superiority based on established religion, to avoid persecution due to the lack of legal protection for free speech & thought in his time; Whereas calling themselves by the inaccurate name Homo sapiens and deeming themselves inherently superior to and more worthy of consideration than other beings is a factor in human behavior that unjustly and to humans' and all other beings' disadvantage destroys other beings and disrupts Earth's ecosystems & biosphere; Whereas, as long as the International Commission on Zoological Nomenclature and the scientific community generally sanctions use of the Homo sapiens for human beings, those who strive to teach ecology and ethics and to reverse ecologically destructive behavior and its consequences will be in the untenable position of referring to the beings perpetuating such behavior as sapient; Whereas recognizing hyper-complexity rather than sapience as their distinguishing trait, human beings will be more likely to establish a less-unjust and less-destructive relationship to other beings and the rest of nature than they have wrought to date; Whereas the International Commission on Zoological Nomenclature is accepted worldwide as the authority on species names and therefore is in a position to change human thought and behavior for the better by giving our species a more accurate name; THEREFORE, Responsible Policies for Animals, Inc., located in Glenside, Pennsylvania, USA, with members and supporters throughout the human world, urges the International

Commission on Zoological Nomenclature, c/o The Natural History Museum, Cromwell Road, London SW7 5BD, UK, to change human beings' species name to Homo complexus and to announce this change to the scientific community and to the human world generally. Respectfully submitted this 5th Day of August, 2008. THEREFORE, Responsible Policies for Animals, Inc., located in Glenside, Pennsylvania, USA, with members and supporters throughout the human world, urges the International Commission on Zoological Nomenclature, c/o The Natural History Museum, Cromwell Road, London SW7 5BD, UK, to change human beings' species name to Homo complexus and to announce this change to the scientific community and to the human world generally. Respectfully submitted this 5th Day of August, 2008.

16. The Code Criteria & Principles Online: www.iczn.org/iczn/index.jsp Code of Ethics General Recommendations

17. The Code: Criteria & Principles Criteria of Publication Criteria of Availability Principle of Priority Principle of Coordination Principle of Homonymy Principle of Typification Code of Ethics General Recommendations

18. Code of Ethics: " 4. No author should propose a name that, to his or her knowledge or reasonable belief, would be likely to give offence on any grounds. 5. Intemperate language should not be used in any discussion which involves zoological nomenclature, and all debates should be conducted in a courteous and friendly manner" General Recommendations: 5. "New names should be in latin form; they should be euphonious and easily memorable......"

19. The Code: Namewise – anything goes

20. The Code: Namewise – anything goes (almost)

21. Carolus Linnaeus 1707-1778 The founder of binominal / binomial organismal nomenclature Primarily a botanist Set a bad example for generations of biologists? Principles of orderliness & amusement?

22. Phallus impudicus Linnaeus, 1753

23. Clitoria ternatea Linnaeus, 1753

24. Johan Sigesbeck published a diatribe criticising Linnaeus. Linnaeus's chose a small-flowered weedy composite to bear the name "Sigesbeckia" Retaliation?

25. Alexandre Arsene Girault (1884-1941) Shillingsworthia shillingsworthi Mozartella beethoveni Homo perniciosus

26. Cornelius Becker Philip (1900-1987) Chrysops balzaphire Tabanus rhizonshine Trombicula fujigmo

27. Cornelius Becker Philip (1900-1987) Chrysops balzaphire Tabanus rhizonshine Trombicula f u j i g m o u a o y r c c t d k k e r s

28. James Mark Brennan (1905-1984) Trombicula doreme … .fasolla … tido

29. Orsonwelles Hormiga (a fat spider) Pinocchio Pagliano & Scaramozzino (a wasp) Lucifer Doderlein (a fish) Satan Hubbs & Bailey (a catfish)

30. Abra cadabra Eames & Wilkins (a bivalve) Agra phobia Irwin (a beetle) Ohmyia omya Thompson (a fly)

31. Pieza kake Pieza pi Pieza rhea Pieza deresistans For more curious scientific names: http://cache.ucr.edu/~heraty/yanega.html#Curious%20Scientific%20Names

32. Record Setters Longest Genus Name Gammaracanthuskytodermogammarus Dybowski (an amphipod) Longest Genus and Species Name Brachyta interrogationis interrogationis var. nigrohumeralisscutellohumeroconjuncta Plavilstshikov (a cerambycid beetle) Shortest Genus and Species Combination Ia io Thomas (a bat)

33. Offensive Names? Anophthalmus hitleri Scheibel, 1937 a blind cave-dwelling beetle named as an honorific by a Nazi taxonomist

34. Offensive Names? ' Followers of Hitler are hunting them so vigorously for mementos that the species is like to become extinct. Martin Bähr, an entomologist at the Zoological State Collection in Munich, said: "There has been a run on these creatures. Collectors are scouring their natural habitat for them. Almost all of our specimens at the museum have been stolen."' Telegraph, November 2006

35. Offensive Names? Agathidium bushi Miller & Wheeler 2005 Agathidium cheneyi Miller & Wheeler 2005 Agathidium rumsfeldi Miller & Wheeler 2005 - slime-mould beetles

36. Agathidium bushi Miller & Wheeler Agathidium cheneyi Miller & Wheeler Agathidium rumsfeldi Miller & Wheeler - slime-mould beetles

37. Criteria of Publication Criteria of Availability Principle of Priority Principle of Coordination Principle of Homonymy Principle of Typification Zoological Code: Criteria & Principles

43. Criteria of Publication Criteria of Availability Principle of Priority Principle of Coordination Principle of Homonymy Principle of Typification Zoological Code: Criteria & Principles

44. Criteria of Availability Zoological Code: Criteria & Principles

45. Criteria of Availability Zoological Code: Criteria & Principles

46. Criteria of Publication Criteria of Availability Principle of Priority Principle of Coordination Principle of Homonymy Principle of Typification Zoological Code: Criteria & Principles

47. Principle of Priority the oldest name has priority Senior synonym Junior synonym Objective synonym Subjective synonym Zoological Code: Criteria & Principles

48. Starting point of zoological nomenclature: 1758 –

49. International Code of Zoological Nomenclature 3 rd Ed. (1985) Starting point of zoological nomenclature: 1758 – except...

50. Principle of Priority Principle of the First Reviser If two or more items have the same date of publication, the first subsequent author who deals with the matter, makes a choice and publishes the decision in the required manner, the First Reviser, is to be followed. [Art. 24.2]. Zoological Code: Criteria & Principles

51. Criteria of Publication Criteria of Availability Principle of Priority Principle of Coordination Principle of Homonymy Principle of Typification Zoological Code: Criteria & Principles

52. Principle of Coordination the act of publishing a new zoological name thereby automatically and simultaneously establishes all the corresponding names in the relevant other ranks, with the same type Zoological Code: Criteria & Principles

53. Challenges in the present Code: Principle of Typification DEAD or ALIVE?

54. Principle of Typification Article 16.4.2: authors of new taxa must publish a statement of intent that extant types will be deposited in a collection Article 73.1.4 "Designation of an illustration of a single specimen as a holotype is to be treated as designation of the specimen illustrated; the fact that the specimen no longer exists or cannot be traced does not of itself invalidate the designation." Challenges in the present Code:

55. Principle of Typification The Article, as formulated, thereby permits the description of threatened animals or those for whom the collection of specimens is otherwise impractical, impossible, or unethical. Challenges in the present Code:

56. Ichnotaxa Challenges in the present Code:

57. Thalassinoides burrows produced by crustaceans, from the Middle Jurassic, Makhtesh Qatan, southern Israel. Helminthopsis ichnosp. a trace fossil from the Logan Formation (Lower Carboniferous) of Wooster, Ohio. Ichnotaxa

59. Ambiregnal organisms photosynthesizing = plant non-photosynthesizing = animal Challenges in the present Code:

62. Ambiregnal organisms (+ Principle of Typification) Challenges in the present Code:

63. Criteria of publication electronic-only publication Challenges in the present Code:

64. Other problems with the present Code: Alternative Languages

65. The Code is an evolving document New edition under construction now for publication in 2012 (ah, right, lets get busy!)

66. Homonyms & Synonyms Article 53.2. Homonyms in the genus group. In the genus group, two or more available names established with the same spelling are homonyms. Article 60.2. Junior homonyms with

synonyms. If the rejected junior homonym has one or more available and potentially valid synonyms, the oldest of these becomes the valid name of the taxon with its own authorship and date.

67. Homonyms & Synonyms Discovered (by Europeans) 1798 Described as Platypus anatinus Shaw, 1799 Platypus , is Latin derived from the Greek words π λατύς ("platys", flat, broad) and π ους ("pous", foot), meaning "flat foot", and anatinus means "duck-like" in Latin.

68. Homonyms & Synonyms A homonym was quickly discovered Platypus for the ambrosia beetle was established by Herbst, 1793 Platypus Shaw, 1799 is a junior homonym of Platypus Herbst, 1793. Which one is the Platypus ?

69. Homonyms & Synonyms Independently described as Ornithorhynchus paradoxus Blumenbach, 1800. Ornithorhynchus is derived from ορνιθόρυνχος ("ornithorhynkhos"), which literally means "bird snout" in Greek.

70. Homonyms & Synonyms Ornithorhynchus Blumenbach, 1793 is a junior synonym of Platypus Shaw, 1799, therefore the correct name for the genus is Ornithorhynchus Blumenbach, 1800. . But the correct name for the species is Ornithorhynchus anatinus (Shaw, 1799).

71. Homonyms & Synonyms Article 53.2. Homonyms in the genus group. In the genus group, two or more available names established with the same spelling are homonyms. Platypus Shaw, 1799 is a junior homonym of Platypus Herbst, 1793, so is rejected. Article 60.2. Junior homonyms with synonyms. If the rejected junior homonym has one or more available and potentially valid synonyms, the oldest of these becomes the valid name of the taxon with its own authorship and date. Ornithorhynchus Blumenbach, 1800 is a junior synonym of Platypus Shaw, 1799, so steps in to fill the gap. (and the species name from Shaw, 1799, stays alive)

72. Homonyms Article 52.1. Statement of the Principle of Homonymy: When two or more taxa are distinguished from each other they must not be denoted by the same name. Article 52.2. Operation of the Principle of Homonymy. When two or more names are homonyms, only the senior, as determined by the Principle of Priority may be used as a valid name.

73. Homonyms Fairmaire (1869) established the name Syntarsus Fairmaire for a genus of beetle (Coleoptera, Zopheridae) Type species of Syntarsus is Syntarsus asperulus Fairmaire, 1869 designated by Dajoz 1980 for a colydiine from Madagascar.

74. Homonyms One hundred years later, Raath (1969) named a genus of coelurosaurian dinosaur Syntarsus Raath, 1969 Type Species: Syntarsus rhodesiensis Raath, 1969 from the Triassic of Zimbabwe. An additional species Syntarsus kayentakatae Rowe, 1989 described from the Jurassic of Arizona

75. Homonyms ' Syntarsus' was used as the name of the in-house journal of the National Museums and Monuments of Zimbabwe. This homonymy had gone unnoticed until.... Megapnosaurus Ivie, Slipinski & Wegrzynowicz, 2001 proposed (Greek: megas (big) apnos (dead) and sauros (lizard)) as a replacement name .... in an entomological journal INSECTA MUNDI

76. Name changes can be contentious “ 'Big dead lizard' is named and shamed Entomologist Michael Ivie says that his new name for the dinosaur formerly known as Syntarsus was meant as a joke. But his choice of Megapnosaurus , which means 'big dead lizard', has not amused palaeontologists. Ivie, based at Montana State University in Bozeman, renamed Syntarsus after realizing that a beetle discovered in 1869 already had the same name. Following recognized taxonomy guidelines, Ivie issued a correction and attempted to inform the discoverer of Syntarsus , Mike Raath of the University of the Witwatersrand in Johannesburg. But palaeontologists were not impressed. Some pointed out that the name is inaccurate, as Syntarsus was not big by dinosaur standards, and others have disputed Ivie's right to rename it. The controversy highlights problems with duplicate names. Thousands of biological species are thought to share the same names, and a recent paper (J. Alroy, Proceedings of the National Academy of Sciences ;

10.1073/pnas.062691099; 2002) suggests that this and other taxonomy problems may have led to overestimates of global diversity. Nature 416, 21 March 21, 2002

77 Name changes can be contentious MEDIA COVERAGE " Entomogist's name change bugs paleontologists " - USA Today", March 11, 2002 " Beetle beats Jurassic dinosaur" – CSIRO media release, 12 May, 2002 Big dead lizard' is named and shamed – Nature 416, 21 March 21, 2002

78 Name changes can be difficult to enforce Inexplicably, the name Syntarsus is still commonly in use for the dinosaur e.g. on the website site of the Natural History Museum www.nhm.ac.uk /.../ detail.dsml?Genus = Syntarsus which says: " Taxonomy: Dinosauria, Saurischia, Theropoda, Neotherapoda, Ceratosauria, Coelophysoidea, Coelophysidae, Syntarsus Named by: Raath (1969) Type species: rhodesiensis Other names used: Megapnosaurus Ivie, Slipinsky & Wegrzynowicz (2001), Syntarsus colberti Hunt & Lucas 1991= Coelophysis bauri Other species: S. kayentakatae Rowe 1989 "

79 Challenging taxa Article 1.2. Scope Article 1.2.1. The scientific names of extant or extinct animals include names based on domesticated animals , names based on fossils that are substitutions (replacements, impressions, moulds and casts) for the actual remains of animals, names based on the fossilized work of organisms (ichnotaxa), and names established for collective groups.

80 Challenging taxa Ringed Dove Streptopelia roseogrisea/risoria - domestic and wild forms : one species with two names

81 Challenging taxa Ringed Dove Streptopelia risoria/roseogrisea - domestic and wild forms : one species with two names Columba risoria (ringed dove, ringed turtle-dove or barbary dove) was described by Linnaeus (1758) ... and later transferred to the genus Streptopelia by Bonaparte (1855). Columba roseogrisea (African collared dove) was described by Sundevall (1857)

82 Challenging taxa Ringed Dove Streptopelia risoria/roseogrisea - domestic and wild forms : one species with two names Streptopelia risoria (Linnaeus, 1758) Streptopelia roseogrisea (Sundevall, 1857)

83 Challenging taxa Ringed Dove Streptopelia risoria/roseogrisea - domestic and wild forms : one species with two names Streptopelia risoria (Linnaeus, 1758) Streptopelia roseogrisea (Sundevall, 1857) Domestic Wild morphology interbreeding

84 Challenging taxa Ringed Dove Streptopelia risoria/roseogrisea - domestic and wild forms : one species with two names Streptopelia risoria (Linnaeus, 1758) Streptopelia roseogrisea (Sundevall, 1857) Domestic Wild Senior synonym, but... ICZN requested to use its plenary power to rule that the name Columba roseogrisea Sundevall, 1857 is not invalid by virtue of being pre-dated by a name based on the domestic form Columba risoria Linnaeus 1758.

85 Challenging taxa Article 1.2. Scope Article 1.2.1. The scientific names of extant or extinct animals include names based on domesticated animals , names based on fossils that are substitutions (replacements, impressions, moulds and casts) for the actual remains of animals, names based on the fossilized work of organisms (ichnotaxa), and names established for collective groups. Columba roseogrisea Sundevall, 1857 could be made invalid by Columba risoria Linnaeus 1758 - commission intervention sought This is the situation for many domestic-wild comparisons - cats, dogs, camels, llamas, cattle, etc. Loss of information if these names are synonyomized.

86 Homonyms Article 52.1. Statement of the Principle of Homonymy: When two or more taxa are distinguished from each other they must not be denoted by the same name. Article 52.2. Operation of the Principle of Homonymy. When two or more names are homonyms, only the senior, as determined by the Principle of Priority may be used as a valid name. Syntarsus Raath, 1969, the dinosaur, must give way to Syntarsus Fairmaire, 1869, the beetle.

87 Stability: Usage vs. Priority Article 23.2. Purpose. In accordance with the objects of the Code the Principle of Priority is to be used to promote stability and it is not intended to be used to upset a long-

accepted name in its accustomed meaning by the introduction of a name that is its senior synonym or homonym.

88. Glyptodon Owen 1839 Megatherium Cuvier, 1796 Stability: Usage vs. Priority The saga of how this nearly lost its name to one of these in 2005...

89. Stability: Usage vs. Priority Megatherium Cuvier, 1796 Weiss (1830) found some fossils which he assigned to Megatherium Cuvier, 1796 Geoffroy Saint-Hilaire (1833) decided they were not Megatherium and established the name Lepitherium for the these remains D'Alton (1834) recognized that they do not belong to anything like a Megatherium

90. Stability: Usage vs. Priority meanwhile Glyptondon was getting off to a rough start.... Owen in Parish (1838) gave the name Glyptodon to a genus primarily based on an isolated indeterminable tooth. As the tooth has been lost this name is generally considered as a nomen dubium (impossible to determine whether a specimen belongs to that group or not) . (In fact, this tooth probably belonged to what is currently known as Panochthus Burmeister, 1866, so not a glyptodon at all.) ? ? ? ? ? ?

91. Stability: Usage vs. Priority Owen (1839) established the name Glyptodon clavipes for a tooth and part of the skeleton of an impressive fossil animal from Argentina. Glyptodons are now widely recognized...

92. Stability: Usage vs. Priority The name problem: The name Lepitherium Geoffroy Saint-Hilaire, 1833 is the earliest available name for what is now recognized as a glyptodont. Stability would be threatened if the priority of Lepitherium Geoffroy Saint-Hilaire, 1833 is maintained over Glyptodon Owen 1839. In order to conserve the name Glyptodon Owen, 1839 it is proposed that the names Glyptodon Owen in Parish, 1838 and Lepitherium Geoffroy Saint-Hilaire, 1833 be suppressed.

93. Stability: Usage vs. Priority Article 23.2. Purpose. In accordance with the objects of the Code the Principle of Priority is to be used to promote stability and it is not intended to be used to upset a long-accepted name in its accustomed meaning by the introduction of a name that is its senior synonym or homonym. Lepitherium Geoffroy Saint-Hilaire, 1833 is suppressed so Glyptodon Owen in Parish, 1838, can continue to be used

94. Stability: Usage vs. Priority The Giant River Prawn Macrobrachium rosenbergii (De Man, 1879) One of the most commercially important crustaceans in the world: Widely fished in South and Southeast Asia Extensively cultured in Asia, America and Africa . . The overall production is 205,033 tons with a net value of US$896,263,000. In the last decade, average M. rosenbergii production rose by some 35% in quantity and almost 20% in value .

95. Stability: Usage vs. Priority First recorded in Southeast Asia by Rumphius (1705) Before Linnaeus' Systema Naturae (1758), thus does not provide nomenclatural priority Macrobrachium rosenbergii (De Man, 1879)

96. Stability: Usage vs. Priority De Man (1879) described Palaemon carcinus var. rosenbergii from Andai, New Guinea (today Papua, Indonesia) on the basis of a single female. He believed it to be only a 'variety' (nowadays - subspecies) of P. carcinus Linnaeus, 1758 (American species). Macrobrachium rosenbergii (De Man, 1879)

97. Stability: Usage vs. Priority Sunier (1925) showed that P. carcinus is a species in America only, proposed Palaemon dacqueti Sunier, 1925, for specimens from the Indo-West Pacific with Java as a type locality. Cowles (1914) noted 2 distinct forms in Indian and Philippine material, but continued to use the name P. carcinus for both.

98. Stability: Usage vs. Priority Types for: dacqueti rosenbergii M. dacqueti M.rosenbergii

99. Stability: Usage vs. Priority THE BIG PROBLEM: The species of prawn that is predominantly fished, cultured and studied by biologists is the one to the WEST of Huxley's Line and is defined by a specimen (lectotype) of Macrobrachium dacqueti , but is universally known as Macrobrachium rosenbergii . A series of other nomenclatural changes at the subspecific level have taken

place in the meantime, but in a nutshell it has become clear there are 2 species, one in aquaculture, from different parts of the region.

100. Stability: Usage vs. Priority Substantial confusion will result if the names are changed. Surprising proposal: set aside the holotype of Macrobrachium rosenbergii (De Man, 1879) and designate the lectotype of Macrobrachium dacqueti (Sunier, 1925) as neotype of Macrobrachium rosenbergii in its place. M. dacqueti M.rosenbergii

101. Stability: Usage vs. Priority If the Commission votes FOR the proposal The name M. rosenbergii will be retained for the commercially valuable species. The name Macrobrachium dacqueti will be taken out of circulation. For the species defined by the current holotype of M. rosenbergii , a new name has been proposed: Macrobrachium wallacei (Wowor & Ng).

102. Stability: Usage vs. Priority M.rosenbergii M. wallacei If the Commission votes FOR the proposal The name M. rosenbergii will be retained for the commercially valuable species. The name Macrobrachium dacqueti will be taken out of circulation.

Stability: Usage vs. Priority Article 23.2. Purpose. In accordance with the objects of the Code the Principle of Priority is to be used to promote stability and it is not intended to be used to upset a long-accepted name in its accustomed meaning by the introduction of a name that is its senior synonym or homonym.

104. Stability: Usage vs. Priority Separation of Nomenclature & Taxonomy Drosophila Fallen, 1832 new results suggest the genus is paraphyletic splitting the genus will bring Sophophora Sturtevant, 1939 back to valid generic use (among others) guess who won't be in the remaining Drosophila ?! ' Sophophora melanogaster'! Drosophilia melanogaster is the type species for Sophophora Sturtevant 1939

105. Stability: Usage vs. Priority Separation of Nomenclature & Taxonomy Is Drosophila melanogaster Meigen, 1830 so important that it should be designated as the type species for the genus?

106. Stability: Usage vs. Priority Separation of Nomenclature & Taxonomy

107. Stability: Usage vs. Priority Separation of Nomenclature & Taxonomy Yellow Fever and Dengue vector mosquitos Aedes aegypti changed to Stegomya aegypti Valid change under ICZN rules by Reinert et al. 2004

108. Stability: Usage vs. Priority Separation of Nomenclature & Taxonomy Yellow Fever and Dengue vector mosquitos Aedes aegypti changed to Stegomya aegypti

109. Stability: Usage vs. Priority Separation of Nomenclature & Taxonomy

110. Nomenclature and biodiversity informatics: what are the data we use to get 'the big patterns for the big questions'?

111. Nomenclature and biodiversity informatics: a common pantropical reef coral A species search engine iSpecies is a test of E O Wilson's idea of a web page for each species. The data displayed are generated "on the fly" by querying other data sources (learn how it works). Send comments to r. [email_address] . gla .ac. uk , or visit the iSpecies blog . Search: Montastrea Yahoo tags stable isotopes trace metals zooxanthellae environmental regulation biomass florida keys reef coral montastrea caribbean reproduction Genomics from NCBI TaxId: 48497 Montastraea [stony corals] Sequences: 4222 nucleotide, 206 protein Barcodes of Life Global Biodiversity Information Facility Hexacorallians of the World Integrated Taxonomic Information System Global Biodiversity Information Facility Nomenclator Zoologicus Map from GBIF Images from Yahoo   Articles from Google â € ¦ of prolonged Â " bleachingÂ " on the tissue biomass

and reproduction of the reef coral Montastrea â € ¦ â € ¦ : Physiological and Environmental Regulation of Stable Isotopes and Trace Metals in Montastrea â € ¦ Growth and form in the reef-building coral Montastrea annularis Reduced growth rate of Montastrea annularis following the 1987Â – 1988 coral-bleaching event Recovery of the coral Montastrea annularis in the Florida Keys after the 1987 Caribbean Â " bleaching â € ¦ Depth-dependent photoadaption by zooxanthellae of the reef coral Montastrea annularis   View My Stats ispecies search : Montastrea

112. Montastr ea or Montastr aea : same or different? 1 genus or 2? Biogeography of Montastr ea from GBIF

113. Montastrea or Montastr aea : same or different? 1 genus or 2? Biogeography of Montastr aea from GBIF

114. Montastrea or Montastr aea : same or different? 1 genus or 2? One coral systematist working in Caribbean spells genus correctly IWP coral systematists spell genus incorrectly

115. Questions?

116. Top 10 Species of the Year Quentin Wheeler - Int'l Institute for Species Exploration http://www.species.asu.edu/Top10

117. Holotype of Homo sapiens ?

This theory says that all metazoans start their development from a single celled egg. This is because the first ancestor for all metazoa was a single celled **Amoeba - like ancestor.** As an evidence, it is seen that the eggs of sponges and some coelenterates are amoeboid.

The egg, after fertilization, undergoes cleavage and develops into a solid spherical embryonic stage called **morula.** A morula is a ball of closely packed cells. The morula is interpreted as corresponding to a simple hypothetical amoeboid colony, **Synamoeba**.

The morula develops into a hollow ball called **blastula.** The blastula has a central cavity called **blastocoel** covered by a single layer of cells called **blastoderm.** Which resembles the present day **Volvox.**

Blastula is an embryonic stage occurring in the development of all metazoans. Hence Haeckel believed that the ancestor of all metazoans was once like a blastula. This ancestor was called a **Blastea.**

The blastula, then develops into a **gastrula** by invagination. The gastrula is cup-shaped and it is formed of two layers, namely an outer **ectoderm** and an inner **endoderm.** The endoderm encloses a cavity called **archenteron** which opens to the out side by a **blastopore.**

As all metazoans develop a gastrula stage in their life history, it is believed that once the ancestor of metazoa was like a gastrula. Haeckel named this ancestor as **Gastrea.**

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4. Origin of Metazoa

Metazoa constitute all the **multicellular organisms.** It includes sponges, Coelenterates, helminth worms, annelids, arthropods, molluscs, echinoderms and chordates.

Systematic Position of Metazoa

The animal kingdom is divided into two subkingdoms, namely **Protozoa** and **Metazoa.** The Protozoa includes unicellular animals like **Euglena, Amoeba, Paramecium,** etc.

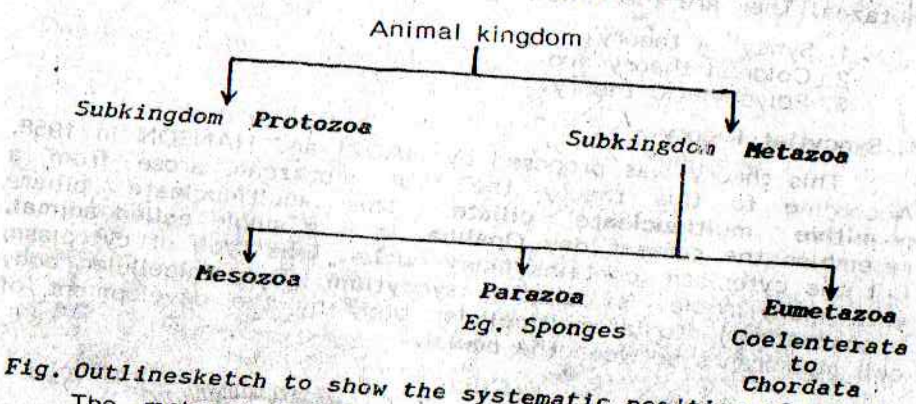


Fig. Outlinesketch to show the systematic position of metazoa.

The metazoa includes multicellular animals from sponges to chordates.

The subkingdom metazoa is divided into three branches, namely **Mesozoa, Parazoa** and **Eumetazoa.** The mesozoa are primitive animals. They are worm-like and they are intermediate between protozoa and metazoa.

The Parazoa includes sponges. The Eumetazoa includes coelenterata and ctenophora to chordata.

Place of Origin of Metazoa

It is believed that the first metazoan originated in the sea.

Time of Origin of Metazoa

The first metazoan originated **about** 2,000 million years ago. (one million years = 10 lakh years).

First Metazoan

Coelenterates are the first formed metazoans. Coelenterates are radially symmetrical animals. Hence they are called **Radiata.** So the first metazoans are radially symmetrical animals hence the origin of metazoa means also the **origin of radiata.**

Probable Ancestor

It is believed that the first metazoan originates from Protozoa. The Protozoan ancestor of metazoa might be a **colonial, hollow, spherical flagellate.**

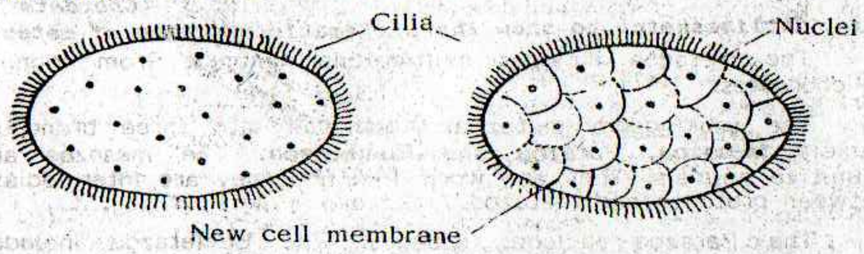
Theories for the Origin of Metazoa

There are three main theories to explain the origin metazoa. They are the following:

1. Syncytial theory
2. Colonial theory and
3. Polyphyletic theory.

1. Syncytial Theory

This theory was proposed by HADZI and HANSON in 1958. According to this theory the first metazoan arose from a **primitive multinucleate ciliate**. This multinucleate ciliate resembles the present day **Opalina.** It is a single-celled animal. But the cytoplasm contains many nuclei. This type of cytoplasm with many nuclei is called a **syncytium.** This unicellular body is converted into a multicellular body by the development of cell membranes between the nuclei.



A multinucleate ciliate **Formation of cell membrane**

Fig.P.1-1: Syncytial theory.

2. Colonial Theory

The colonial theory was proposed by HAECKAL in 1874 and it was supported by LANKESTER (1877), METSCHNIKOFF (1886) and HYMAN (1940). According to this theory the first metazoan was originated from a **colonial ancestor.** HAECKEL stated that this colonial ancestor was a **hollow, spherical, Volvox-like, flagellate, protozoan colony.** LANKESTER proposed a **solid, colonial, flagellete protozoan** like the **Pandorina** as the ancestor.

METSCHNIKOFF also believed a solid **colony** like a **Pandorina** This ancestor resembles a **Planula larva.** This ancestor

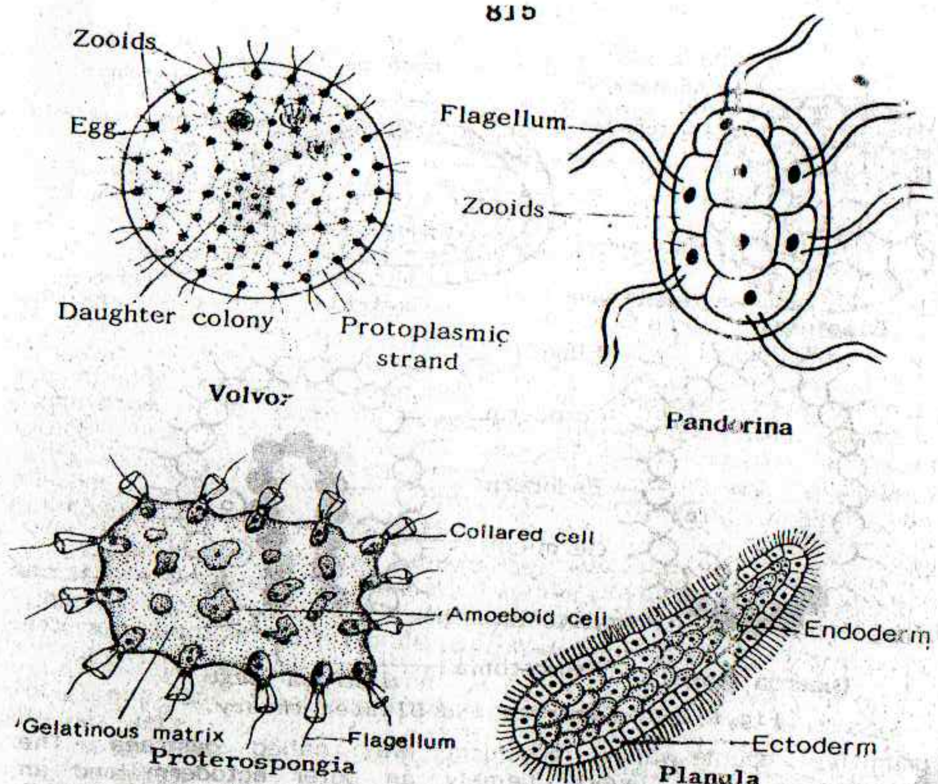


Fig.P.1-2: Colonial theory.

resembles the existing colonial protozoan called **Proterospongia. Proterospongia** is a **choano flagellate.** It has an outer layer of collared cells. The interior is filled with **amoeboid cells.** The collared cells lose their collars and flagella and move into the interior as amoeboid cells.

Origin of Metazoa from Volvox-like Colony

HAECKEL believed that the first metazoan originated from a Volvox-like colony. His explanation is based on his **recapitulation theory.** He proposed a theory for the origin of metazoa. This theory is called **gastraea theory.**

Gastraea Theory: This theory explains the origin of metazoa from a **Volvox**-like colony. According to this theory the metazoan was originated from a hyphothetical ancestor called **blastea.** The blastea resembles the existing **Volvox.** In all multicellular animals the blastea stage is represented by the **blastula** stage of development.

The blastea is spherical and hollow. It has a single layer of flagellated cells.

The first metazoan was originated from the blastea by the **invagination** of the cells present in the posterior region. This invagination produced a double-walled organism. This

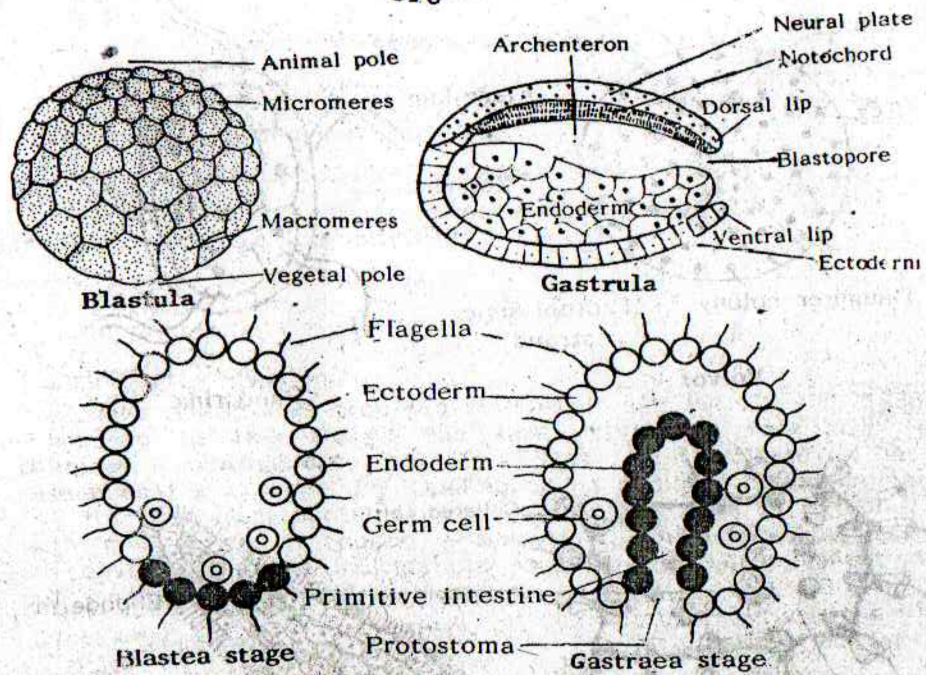


Fig.P.1-3: Gastraea and Blastea theory.

primitive double-walled organism was called **gastraea.** The gastraea has two layers, namely an outer **ectoderm** and an inner **endoderm.** The endoderm encloses the cavity which functions as a gut. The opening of this cavity functions as the mouth.

In modern days the gastraea stage is represented in all multicellular animals by the **gastrula** stage of development.

3. Polyphyletic Theory

This theory was proposed by GREENBERG in 1959. This theory proposes two different types of ancestors for the metazoa. One ancestor is **colonial flagellate.** It gave rise to sponges and coelenterates. The second ancestor is a **ciliate.** It gave rise to ctenophores and flatworms.

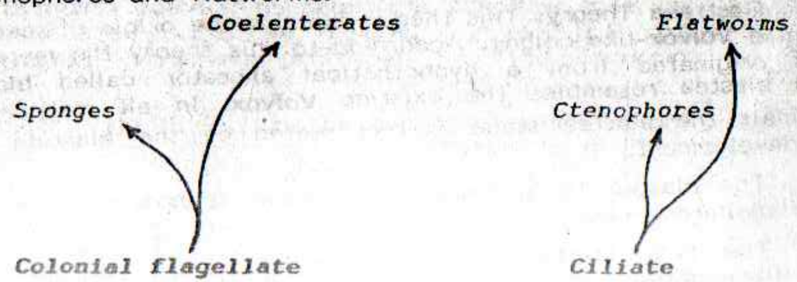


Fig.P.1-4: Polyphyletic origin of metazoa.

5. Origin of Bilateria

Bilateria includes bilaterally symmetrical animals. In bilateral symmetry the body can be split into two equal halves in only one plane. Here the body parts are arranged on the two sides of the central axis. The animals exhibiting bilateral symmetry are called **Bilateria.**

Systematic Position

The Bilateria are multicellular organisms. The animal kingdom is divided into two subkingdoms, namely **Protozoa** and **Metazoa.** The Protozoa includes unicellular organisms. The Metazoa includes multicellular organisms. The metazoa is further sub divided into three branches namely, **Mesozoa, Parazoa** and **Eumetazoa.** The mesozoa includes primitive parasitic worms intermediate between protozoa and metazoa. Parazoa includes sponges. Eumetazoa includes coelenterata, ctenophora, platyhelminthes, Aschelminthes, Annelida, Arthropoda, Mollusca, Echinodermata and Chordata.

Eumetazoa is further subdivided into two groups, namely **Radiata** and **Bilateria.** Radiata includes radially symmetrical animals. Eg. Coelenterata and Ctenophora. Bilateria includes bilaterally symmetrical animals. Eg. Platyhelminthes to Chordata.

The bilateria is divided into two sub groups, namely Protostomia and Deuterostomia. In protostomia the blastopore develops into the mouth. Eg. Platyhelminthes to Mollusca. In deuterostomia the blastopore develops into anus. Eg. Echinoderms and chordates.

The Bilateria is also subdivided into three groups on the basis of the presence or absence of coelom. They are **acoelomata, pseudocoelomata** and **eucoelomata.** From acoelomata coelom is absent. Eg. Platyhelminthes. In pseudocoelomata a **false coelom** is present. Eg. Aschelminthes. In Eucoelomata a **true coelom** is present. Eg. Annelida to Chordata.

The eucoelomata is further subdivided into two groups, namely **Schizocoela** and **Enterocoela.** In schizocoela the coelom develops from mesoderm. Eg. Annelida, Arthropoda and Mollusca. In enterocoela the coelom develops from the gut (endoderm).

Place of Origin

The first bilateria originated in the sea.

Time of Origin

The first bilateria originated about 2000 million years ago (one million years = 10 lakh years).

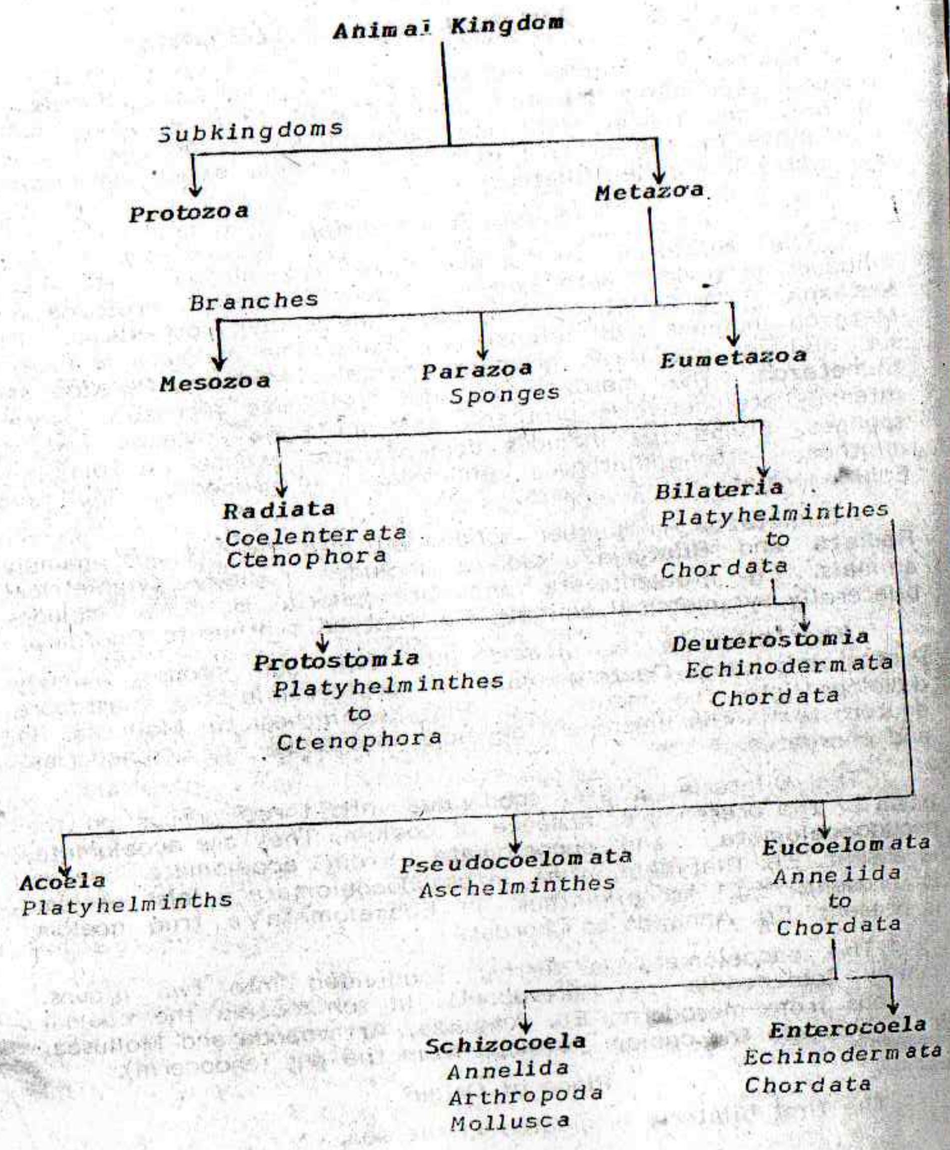


Fig. 2 -1 : Outline sketch to show the systematic position of Bilateria

First Bilateria

The **flatworms** included in the class **Turbellaria** of phylum Platyhelminthes are primitive bilateria. The turbellarian flatworms are **acoelomate.**

Probable Ancestor

The bilateria are multicellular organisms. The primitive multicellular organisms are coelenterata and ctenophora. The bilateria are highly advanced than the coelenterates and ctenophores. So the ancestors of bilateria should be with in these two groups only.

The coelenterates and ctenophores are radially symmetrical animals. If these radially symmetrical animals are considered to be the ancestors of the bilateria, it is evident that **bilateria originated from radiata.**

Theories for the Origin of Bilateria.

There are four theories to explain the origin of bilateria. They are the following:

1. Trochophore theory
2. Syncytial theory
3. Planuloid theory and
4. Ctenophore - polyclad theory.

1. Trochophore Theory

This theory was proposed by HATSCHEK in 1878. Trocophore is the larva of Annelids and Molluscs. It resembles the

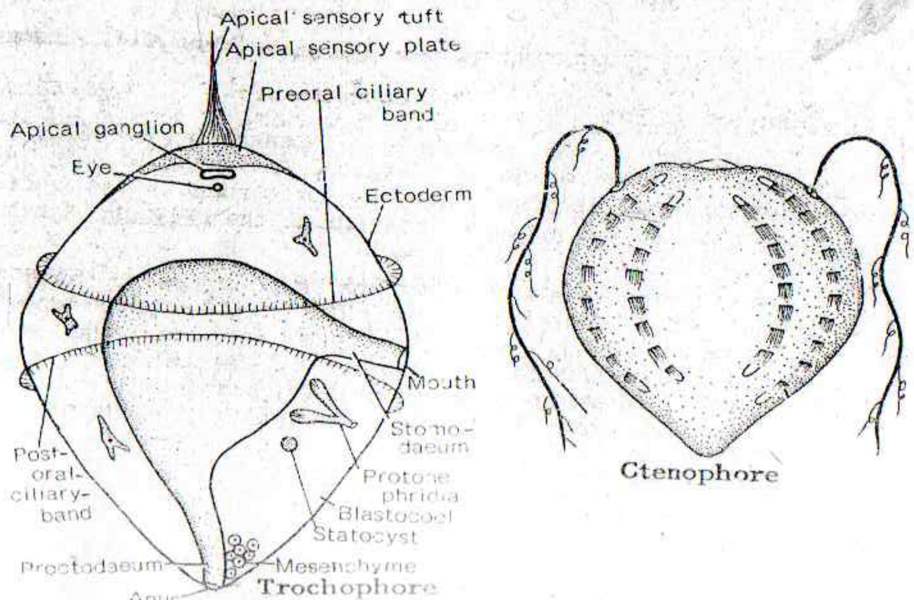


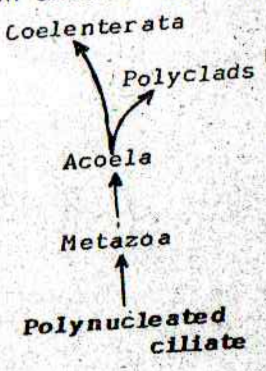
Fig.P.2-2: Trochophore theory.

ctenophore. Hence it is believed that the annelids might have originated from the ctenophore. So according to this theory **ctenophore is the ancestor for bilateria.**

If this theory is correct platyhelminthes should have originated from annelids. But platyhelminth worms are more primitive than annelids. So this theory is not accepted.

2. Syncytial Theory

This theory was proposed by HANSON and HADZI. This theory states that multinucleated ciliate protozoan is the ancestor for bilateria. This multinucleate protozoan becomes the multicellular animal by the division of the cytoplasm. This acoela animal gives rise to the acoelomate flatworms. The acoela gives rise to the **coelenterates** in one line and the **polyclads** in another line. This theory is also not accepted.



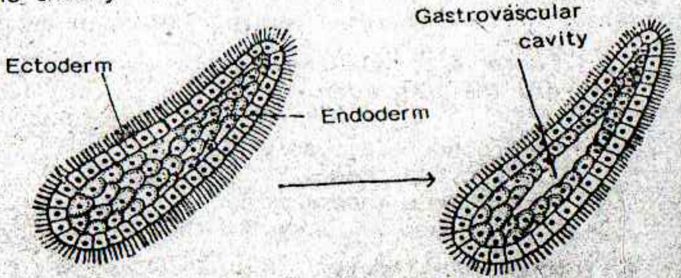


Fig.P.2-4: Planuloid theory.

Fig.P.2-3: Outline sketch to show syncytial theory

3. Planuloid Thoery

This theory was proposed by Lankester in 1877. This theory explains the origin of Metazoa. According to this theory a **solid spherical colonial flagellate** protozoan is the ancestor for metazoa. This ancestor resembles the **Planula** larva of coelenterates.

This theory **explains** that the first ancestral form was a single celled **Amoeboid form**. The single celled amoeboid form developed into a **morula** like ancestor. The morula developed into a blastea as explained by **Haeckel** in his gastrea theory. The blastea ancestor then developed into a solid form called **planuloid** form because it resembles the **Planula** larva of coelenterates. The Planula larva is oval in shape and has a **radial** symmetry. It is solid in nature. It has a covering of flagellated cells. It is without a mouth and a digestive cavity.

As the ancestor resembles a planula larva, this theory is called the **planuloid** theory.

During the origin of acoela from planula the following changes occurred:

1. The body became shortened along the oral-aboral axis.
2. The body became flattened.
3. The mouth was developed on the ventral side.
4. The nerve centre moved to the anterior end.
5. The endoderm cells organised into a digestive canal.

4. Ctneophore-polyclad Theory

This theory was proposed by LANG in 1881. According to this theory, ctenophores are the ancestors for bilateria. The ctenophores **Coeloplana** and **Ctenoplana** resemble in many respects the polyclads. The polyclads are **turbellarians.** The **Muller's larva** of polyclad is very much like the ctenophora. This makes the author to believe that the polyclad turbellarians might have originated from ctenophores.

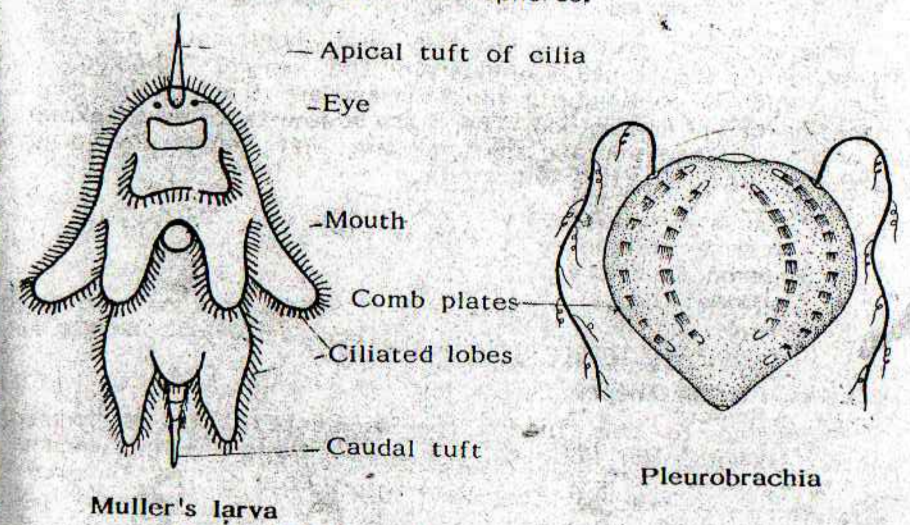


Fig.P.2-6: Ctenophore - Polyclad theory

6. Origin and Phylogeny of Annelida

Annelida includes multicellular, bilarerally symmetrical, triploblastic, metamerically segmented, coelomate, worm-like animals. They are the first coelomate animals in the animal kingdom.

Spiral Cleavage: Both Annelida and Mollusca have **spiral cleavage.** The cleavage is holoblastic.

Though there are a number of similarities, Annelids differ from mollusca on the formation of mesoderm.

2. Non-Metameric theory

Unsegmented platyhelminth worms were the ancestor for mollusca. The turbellarians are resembling **Neopilina** and **Chiton** in the mode of locomotion and in the presence of ladder - like nervous system.

3. Archi- mollusc Theory

This theory was proposed by **Yonge** and **Stesek.** According to this theory all the mollusca were originated from a hypothetical ancestor called **Archimollusca**. The **Archimollusc** is a marine, bilateral, unsegmented animal with a distinct head, mantle, radula and foot. This theory also stresses, the non-metameric ancestry.

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13. Phylogeny of Mollusca

Mollusca are multicellular, triplablastic, coelomate, bilaterally symmetrical, soft bodied animals with shell, head, foot, visceral mass and mantle.

Phylum Mollusca is divided into 6 main classes. They are the following:

1. Monoplacophora Eg. **Neopilina**
2. Amphineura Eg. **Chiton**
3. Scaphopoda Eg. **Dentalium**
4. Gastropoda Eg. **Pila**
5. Pelecypoda Eg. **Lamellidens**
6. Cephalopoda Eg. **Octopus** , **Sepia, Nautilus**

1. Monoplacophora

In monoplacophora, the shell is made up of a **single piece.** This is the only mollusc displaying **internal metamerism.**

This class had been thought to be extinct since the Devonian. But in 1957, a living monoplacophora was found out by Dr. Henning Lenche from the pacific waters (3500 meters) of Mexico. It was named as **Neopilina galatheae**. Other living species are **N. ewingi** discovered

in 1959 from **Peru** at a depth of 6000 meters, **N. veleronis** discovered from Mexico in 1961 and **N. adenensis** was discovered in 1967 from the Gulf of Aden.

All these species are living the deepest part of the sea.

This is a primitive group having many primitive characters. The internal metamerism of this group speaks annelidan ancestry for the mollusca. But **this group is not the** ancestor for other molluscs. The segmented body suggests a common ancestor for Annelida and Mollusca.

2. Amphineura

Amphineura have **ventral nerve cords** and the nervous system is **ladder-like.** It is a more primitine group like that of monoplcophora. It is also **not the ancestor for other molluscs.**

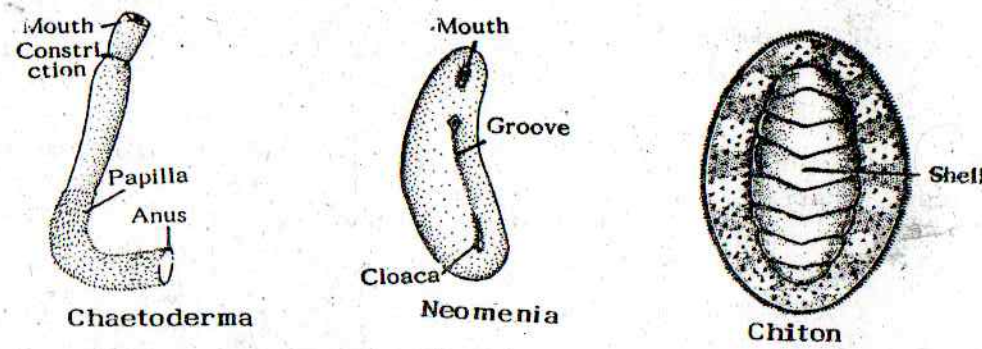
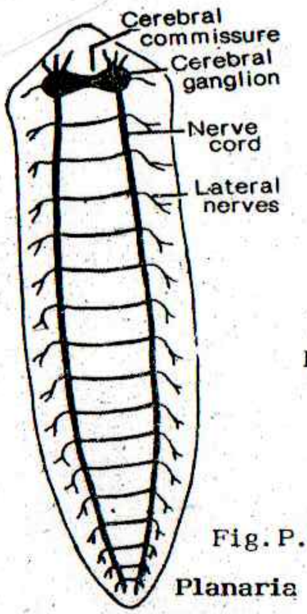


Fig. P.13.1: A few amphineuran molluscs.

Amphineura includes two orders, namely **Aplacophora** and **Polyplacophora.** Aplacophora includes **Neomenia Chaetoderma, Solenogaster,** etc. where the shell is absent and the foot is vestigial or absent.

Polyplacophora includes **Chiton** where the shell is formed of 8 plates and the foot is large and flat.

The **ladder-like nervous system** of this group resembles that of Turbellarian platyhelminth. Hence this group is primitive and suggests the possibility of origin of mollusca from Turbellaria.



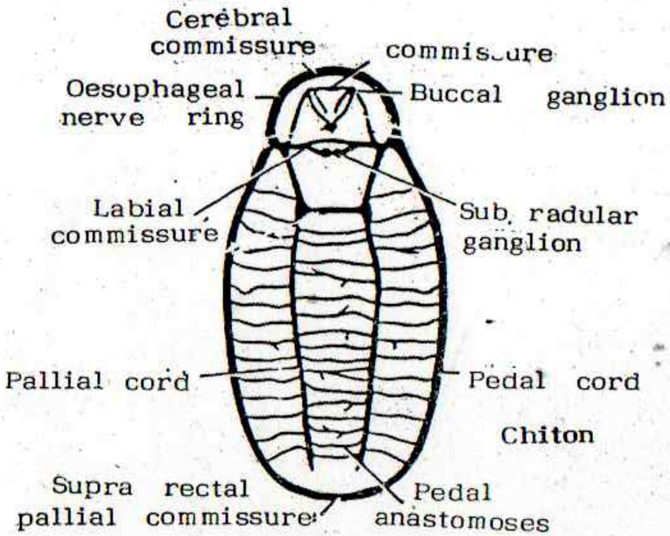


Fig. P.13.2: The ladder like nervous system of **Chiton** resembles that of **Planaria**, a turbellarian.

3. Scaphopoda

Scaphopoda includes tusk shells with boat-shaped foot (**Skaphe**= Boat, podos=foot). All of them are marine. They resemble Pelecypoda because of the following reasons.

1. Reduction of head
2. Nature of foot
3. Bilobed mantle and shell of the post veliger.

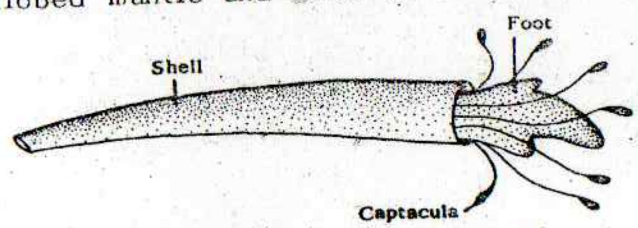


Fig. P.13.3: **Dentalium**, a scaphopod.

4. Gastropoda

Gastropoda (**Gastros**= stomach, podos= foot) includes asymmetrical mollusca having undergone **torsion** or torsion. They have a head and a spirally coiled shell. a result of torsion the structures which were lly posterior have moved to an anterior versa.

The first gastropods originated in the sea. Later they invaded the fresh water and land.

Gastropoda includes four main groups, namely Diotocardia, Monotocardia, Opisthobranchia and Pulmonata.

Diotocardia includes the primitive gastropods. Eg. Patella, **Haliotes** etc. Torsion **occurs in these animals But they** retain bilateral symmetry and two sets of visceral organs such as 2 ctenidia, 2 auricles and 2 nephridia.

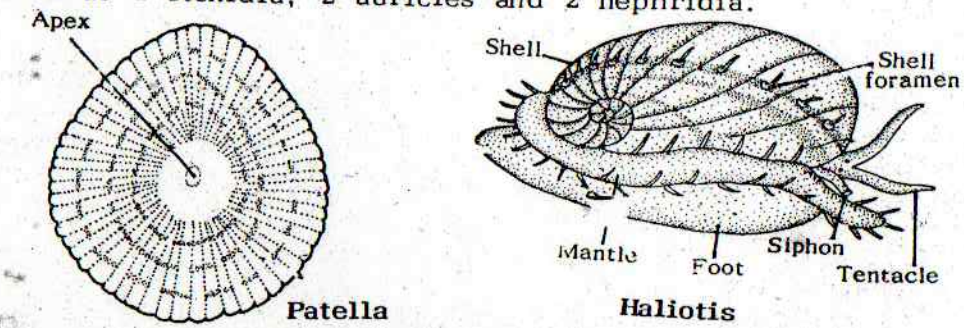


Fig. P.13.4: A few diotocardia.

Monotocardia, on the other hand, have lost their organs on the right side and hence they retain only one set of organs. **Eg. Pila Cypraea** etc. These animals develop torsion.

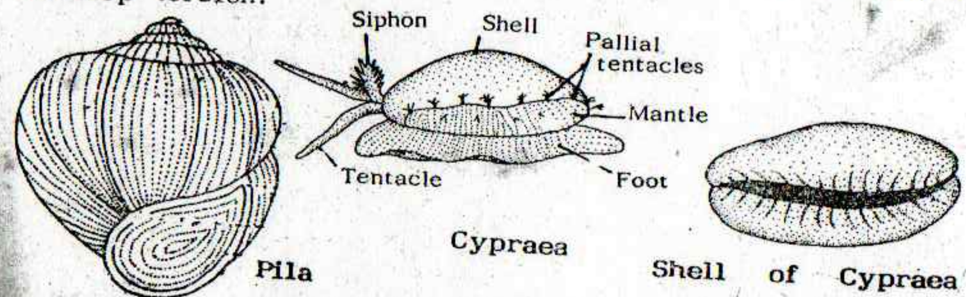


Fig. P.13.5: A few monotocardia.

Opisthobranchia includes **Aplysia**, **Doris** etc where **detorsion** occurs. They also retain only one set of organs; mantle cavity opens posteriorly in them. The viscera and nervous system are secondarily unwound.

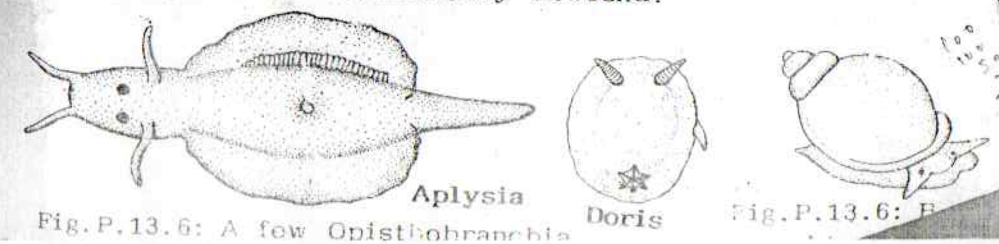


Fig. P.13.6: A few Opisthobranchia

Fig. P.13.6: B

Pulmonata includes **Helix**, **Lymnaea**, **Planorbis**, etc. They have lungs for respiration.

Opisthobranchia and Pulmonata have arisen from monotocardia.

5. Pelecypoda

Pelecypoda includes bilaterally symmetrical animals with two shells, two mantles, two etenidia and a wedge-shaped foot. They do not undergo torsion. The gills are immensely enlarged and are used for respiration and filter feeding. The head is very much reduced.

Among Pelecycpoda, **Protobranchia** (Eg. **Nucula, Yaldia**) are primitive. Other groups of Pelecypoda such as **Filibranchia**, **Eulamellibranchia**, **Pseudolamellibranchia** and **Septibranchia** have originated independently from Protobranchia.

6. Cephalopoda

Cephalopoda includes the most advanced molluscs such as **Nautilus**, **Sepia**, **Loligo**, **Octopus**, etc. They are more complex. They are bilatelly symmetrical.

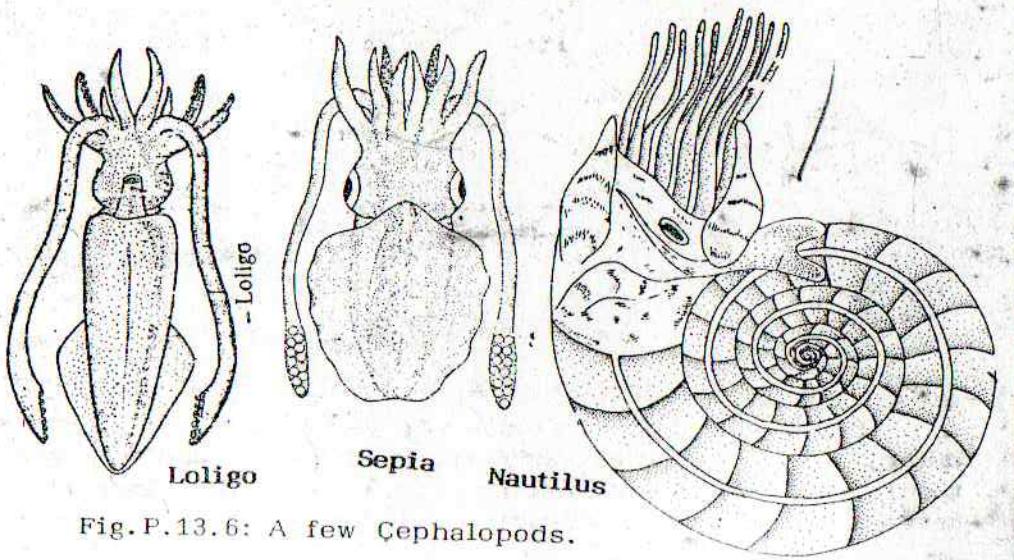


Fig.P.13.6: A few Çephalopods.

The foot is modified into tentacles which are attached to the head. The foot and head are completely fused together. There is a siphon by which water may ...rcibly ejected from the mantle cavity. The ... is better developed.

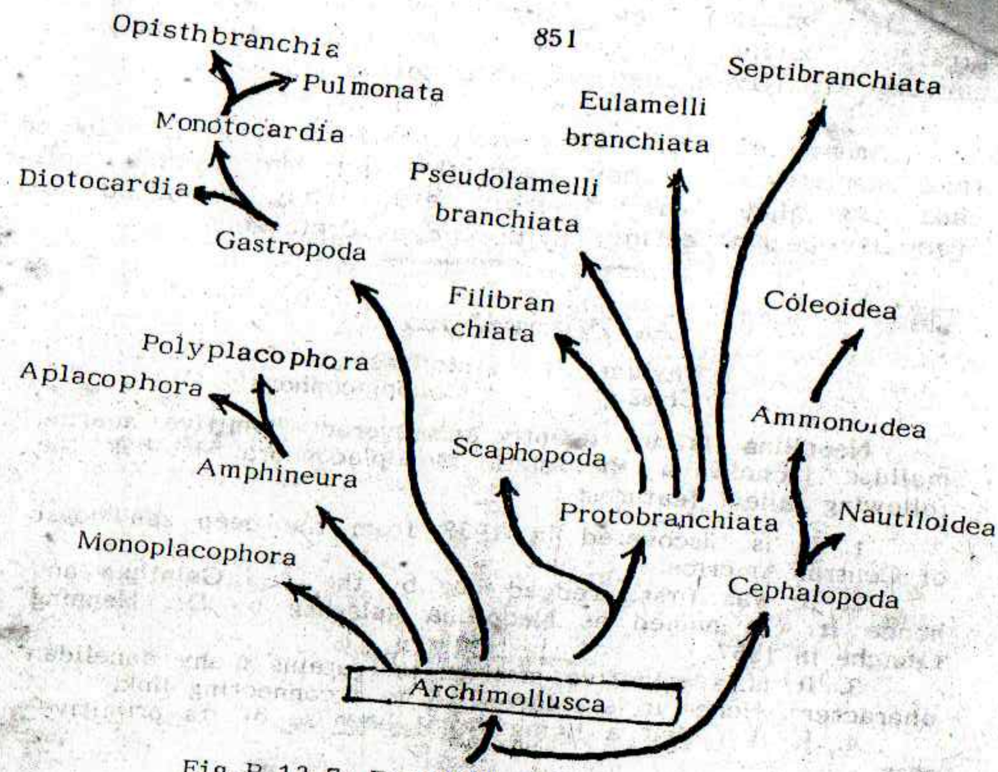


Fig.P.13.7: Evolution of molluscs.

The nervous system is highly centralised and the eyes are like those of vertebrates.

Class Cephalopoda includes 3 subclasses, namely **Nautiloidea**, **Ammonoidea** and **Coleoidea**.

The nautiloids and ammonoids have four gills and hence they are called **Tetrabranchiata**. The Coleoids, on the other hand, have two gills and hence called **Dibranchiata**.

Nautiloids and ammonoids have **external** shells where as Coleoids have **internal** shells.

Among cephalopods Nautiloids were primitive. They had **chambered external shells**

Nautiloids appeared in the Cambrian period and rapidly assumed a dominant position in the marine fauna. They reached their peak of dominance in the Silurian period and then gradually declined. In the present day they are represented by only Nautilus primitive Nautiloids the shell was long and . During the course of evolution, the shell was , strongly arched and then coiled.

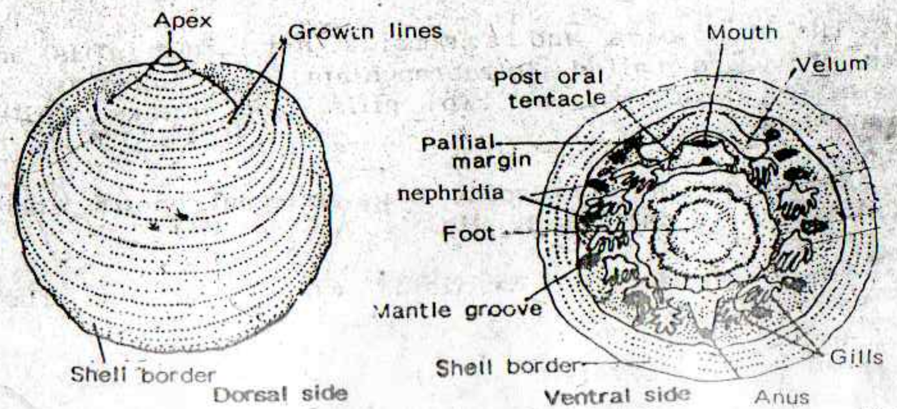
Ammonoids were completely extinct. They originated from Nautiloids. They were the dominant marine mollusca throughout the mesozoic era. They dwindled and gradually became extinct by the end of Cretaceous.

14. *Neopilina*

Phylum : Mollusca
Class : Monoplacophora

Neopilina is a recently discovered primitive marine mallusc included in the class Monoplacophora. It has the following salient features:

1. It is discovered in 1952 from the deep sea coast of Central America.
2. It was first dredged out by the ship **Galathea** and hence it was named as **Neopilina galathea** by Dr. **Henning Lemche** in 1957.
3. It is a primitive mollusc and retains many annelidan characters. Hence it is believed to be a connecting link.
4. It is called a living fossil because of its primitiveness.
5. It is a deep sea form.
6. It is the only segmented mollusc.
7. It has a cup-like shell.
8. A mantle is present below the shell.
9. The ventral side has a foot.
10. The mouth is anterior in position and the anus is situated posteriorly.



g.P.14.1: Meopilina, the primitive and the segmented mollusc.

11. The region between the foot and the margin of mantle is called mantle groove or mantle cavity.
12. The mantle groove contains 5 pairs of branched gills.
13. It has 6 pairs of nephridia.
14. The nervous system is ladder-like.
15. A radula is present.
16. The circulatory system is of the **open-type.**
17. It has 8 pairs of pedal muscles.
18. **Annelidan Characters: Neopilina** resembles Annelida in the presence of traces of segmentation. The segmentation is represented by 8 pairs of pedal muscles, 5 pairs of gills and 6 pairs of nephridia.
19. **Molluscan Characters:** The molluscan characters of **Neopilina** include the shell, radula, mantle, open type of circulatory system, etc.

Conclusion

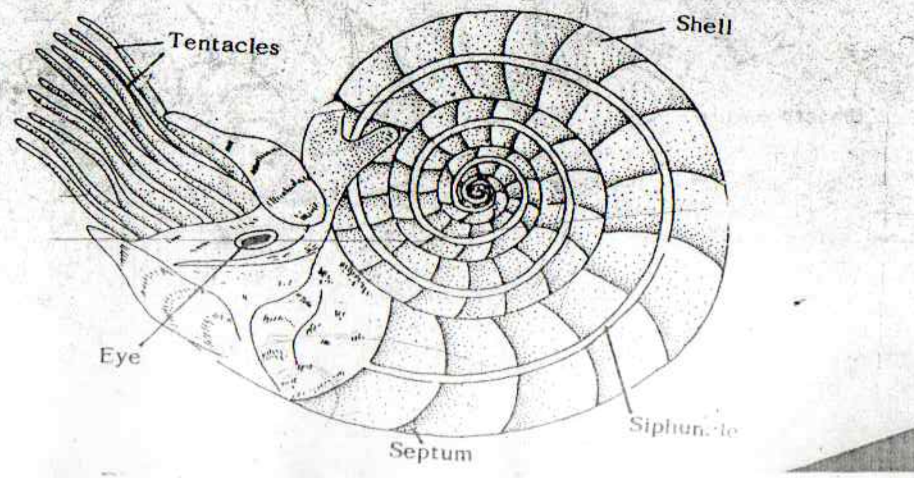
As Neopilina shows a few annelidan characters it is thought that Neopilina is a transitional form in the evolution of molluscs from Annelida. But it is **debatable.**

15. *Nautiloids*

Phylum : Mollusca
Class : Cephalopoda
Order : Nautiloidea

Salient features of Nautiloids

1. It is a group of Mollusc included in the class Cephalopoda and the order Nautiloidea.
2. This group includes extinct as well as extant animals.
3. the extant animal is represented by the **Nautilus.**



4. The nautiloids are the primitiye cephalopods.

5. They originated in the cambrian period of palaeozoic era about 500 million years ago.

6. Most of the Nautiloids except **Nautilus** became extinct during the ordovician period about 425 million years ago.

7. Nautilus is marine. It has a spirally coiled shell formed of many chambers.

8. The outermost shell is large and the innermost shell is small.

9. The chambers are separated by a septa which are perforated in the middle by a **siphon**. The chambers are filled with air. It helps the animal to float in the water.

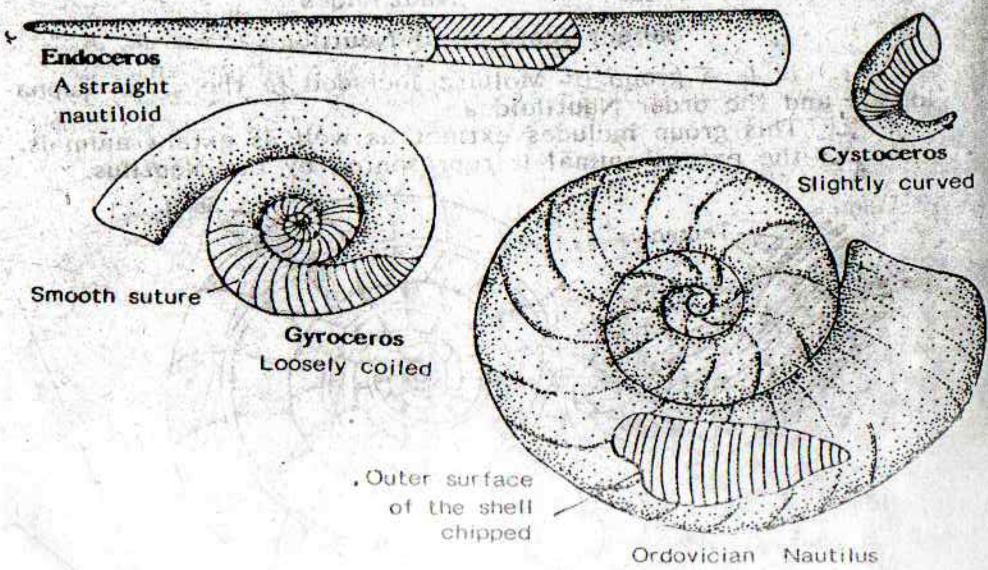
10. The junction between the chambers is known as **suture**. It is simple, curved and smooth in **Nautilus**.

11. Animals live in the outermost chamber of the shell.

12. The body has two regions, known as **head** and **trunk**. The head has two eyes and ten tentacles, arms are absent. A funnel is present but ink glands are absent.

13. It lives in Indian and Pacific oceans. As the Nautilus resembles the extinct nautiloids in many respects it is calleda **living fossil**.

14. The main difference between the shells of modern **Nautilus** and extinct Nautiloids is the coiling of the shell. Some of the nautiloids had straight shell. Eg. **Endoceros. Cystoceros** had a slightly curved shell. **Gvr oceros** had a shell in which the coils were loose. Still others had a coiled shell like that of modern Nautilus.



15 2: The extinct nautiloids. The coiled-shells evolved from straight shells.

This fact shows that the coiled shell of present **Nautilus** was originated from straight shells.

15. Some of the extinct nautiloids attained a gigantic size. Some straight shells had a length of 30 feet.

16. Ammonoidea

Phylum	:	Mollusca
Class	:	Cephalopoda
Order	:	Ammonoidea

1. Ammonoids were a group of extinct mollusc included in the class cephalopoda and order Ammonoidea.

2. They originated in the **Devonian** period of palaeozoic era about 325 million years ago.

3. They flourished well during the mesozoic era and all of them became extinct by the end of mesozoic era.

4. They originated from Nautiloids. They were marine. They had spirally coiled shell. The shell had many chambers. The chambers were separated by septa. The septa were perforated by a **siphon**. The outer chamber was larger than the inner chamber.

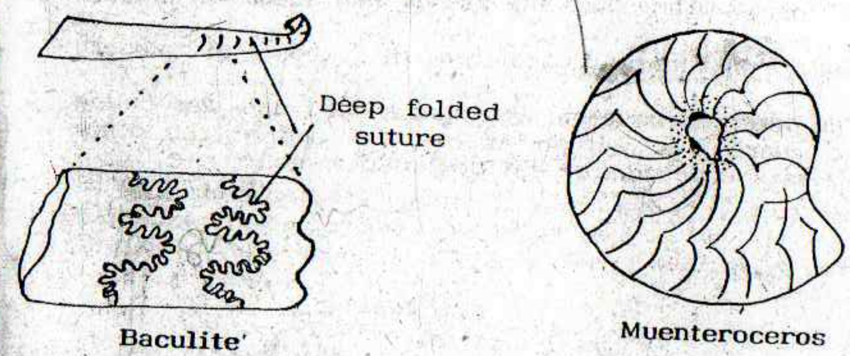


Fig.P.16.1: A few ammonoids.

5. The junction between the chambers is known as **suture**. The suture was **not smooth**. But it was ornamented with sharp foldings and it had a wavy or loop or saddle like appearance.

6. Most of the Ammonoids had a trap door arrangement (operculum).

7. The mesozoic era saw an outburst of ammonoids. About 6000 species of fossils are collected.

8. Some Ammonoids reached a gigantic size with a shell diameter of about 10 feet.

17. Belemnites

Phylum : Mollusca
Class : Cephalopoda
Order : Coleoidea.

Belemnites possessed the following salient features:

1. Belemnites were a group of extinct mollusc included in the class cephalopoda.

2. Belemnites were closly rememnling **Sepia, Loligo** and **Octopus**. It is believed that they were the immediate ancestors for modern Sepia, Loligo and Octopus.

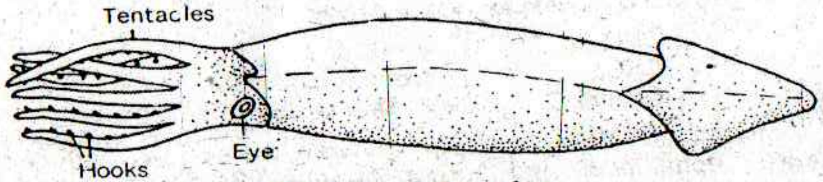


Fig.F.17.1: A **Belemnite.**

3. They originated in the beginning of Mesozoic era about 200 million years ago. They flourished well in the Mesozoic era and all of them became extinct by the beginning of Cenozoic era.

4. They originated from nautiloids.

5. Morphologically, they were resembling the **Sepia** and **Loligo.**

6. They had 6 tentacles with **hooks** (in place of suckers of modern forms). They had **ink glands** like those of modern squids.

7 They had internal skeleton like those of modern squids.

8. The internal skeleton was cigar shaped and was called **guard.** The guard was pointed at one end and at the other end there was a deep conical cavity called **alveolus.**

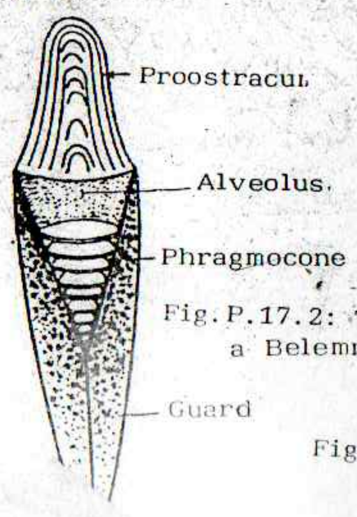


Fig.P.17.2: The guard of a Belemnite.

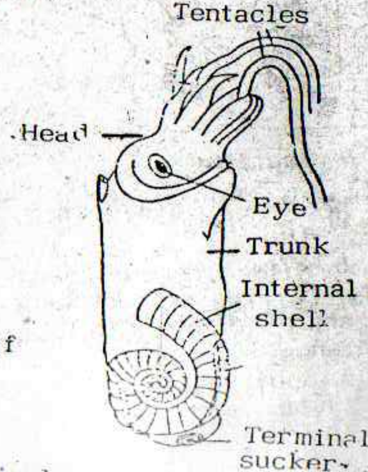


Fig.P.17.3: Spirula, the only living mollusc having a chambered, coiled internal shell.

9. The alveolus contained a chambered shell known as **phragmocone.** The **phragmocone** resembled the external shell of **Orthoceros** a straight shelled Nautiloid. It had a series of 20 chambers separated by concave **septa.** The septa were perforated by a **siphon.** The phragmocone had a shoe-horn shaped extension at the anterior end called **prostracum.**

10. The Beleminites created considerable interest because they clearly prove that the internal skeleton was a remnant of an external, chambered shell possessed by Nautiloid or possibly ammonoid ancestors.

11. The first Belemnites like **Aulaeoceros** of the Triassic period had a very small guard and it could cover only the apex. The phragmocone was larger and it was twice the length of the guard of Belemnites.

12. In the Beleminites of Tertiary period the guard was reduced to an insignificant size.

13. The Eocene **Belosepia** indicated the transition from Belemnites to modern **Sepia.**

14. In **Spirulirostrina** of **pliocene** period the guard was further reduced in size. **Beloteuthos** resembled **Loligo.** This tendency of the reduction in shell continued and resulted into the formation of numerous shelled forms such as **Octopus.**

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18. Origin of Echinodermata

Echinoderms are multicellular, pentaradially symmetrical enterocoelous coelomate deuterostomes with spiny skin. pedicellaria, water-vascular system and bilaterally symmetrical larva.

Systematic Position

Kingdom	Animalia	
	Metazoa	
	Eumetazoa	
	Bilateria	: Larvae are bilaterally symmetrical.
	Enterocoela	: Coelom develops from gut
	Deuterostoma	: Blastopore develops into anus

Affinities with Mollusca: Onychophora resembles **Chiton** and **Prosobranchiate** molluscs in the **slug like** appearance and **ladder-like** nervous system. These resemblances are only superficial.

Conclusion

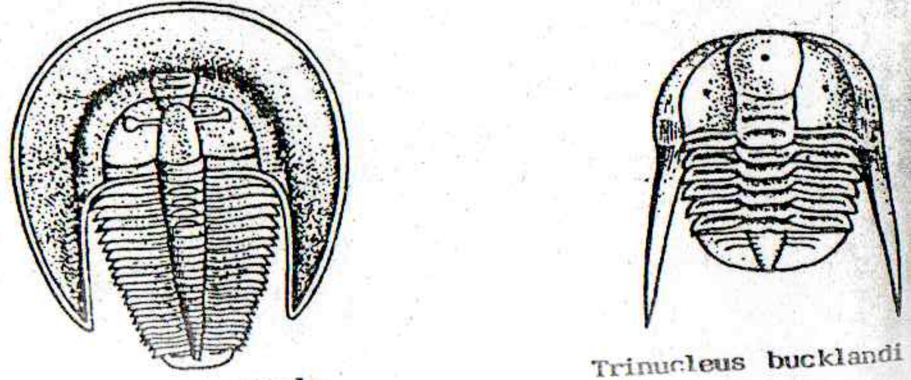
Onychophora contains **trachea**, a character unique to Arthropoda and not found in any other phylum. Hence Onychophora is definitely an arthropod group.

Though Onychophora is a **connecting link** between Annelida and Arthropoda, it is not the direct ancestor for Arthropoda. So it is not an **evolutionary link** between Annelida and Arthropoda. It is believed that **the present day arthropods** and the **Onychophores originated separately from a common ancestor**. The Onychophora remained as a blind offshoot and survived with all the primitive characters.

9. *Trilobita*

Phylum : Arthropoda
Subphylum : Trilobitomorpha

Trilobites were a group of extinct primitive Arthropods. included in the subphylum Trilobitomorpha. The body is divided longitudinally into three lobes and hence the name **Trilobita**. This subphylum contains about 17 genera and 4000 species. All of them were extinct.



Harpes ungula

Trinucleus bucklandi

Fig. P. 9. 1: Two trilobites

Place of Existence

They were marine as the fossils were found along wi

Time of Existence

They lived during the palaeozoic era for a period of 300 million years. They were abundant during the beginning of Palaeozoic era in the Combrian and Ordovician periods. But they became extinct by the end of Palaeozoic era in the Permian period.

Probable Ancestor

There are two views regarding the ancestor of Trilobita. According to **monophyletic theory** of Sharov Lobopod Annelida was the ancestor. From Lobopod Annelida, one line gave rise to Opabinia. The primitive Opabinia gave rise to Tetracephalosomita. **Trilobita** was originated from Tetracephalosomita.

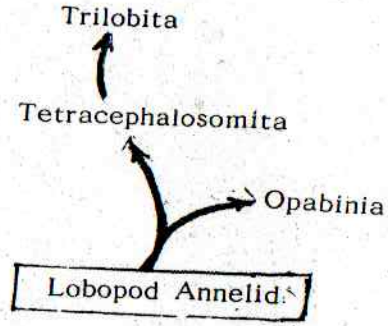


Fig. P. 2: Origin of Trilobite

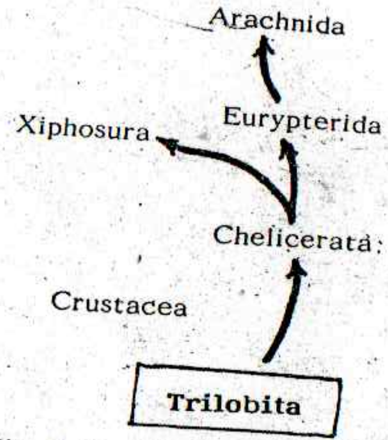


Fig. P. 3: Trilobita as the ancestor

According to **polyphyletic theory** of Tiegs and Manton, Protoannelida was the ancestor for Trilobita.

Trilobita as the Ancestor

Trilobita was the ancestor for **Chelicerata**. Chelicerata includes Arachnida (scorpion, spider, etc.) and Xiphosura (Limulus). The primitive Trilobita gave rise to crustacea. Arachnida was originated through Eurypterida.

Structure

As the name indicates the body is divided longitudinally into three distinct lobes, namely, an axial lobe in the central region and two pleural lobes on the sides. Further, the body is segmented transversely and has three regions, namely **cephalon**, **thorax** and **pygidium**.

The cephalon is semicircular. It consists of a central convex ridge known as **glabella** and the lateral portions called **cheeks**. Each cheek is divided into two

...ns by a **facial suture.** The portion between glabella ... suture is known as **fixed cheek** and the other portion lying near the border of cephalon is called **free cheek.**

The thorax consists of variable number of segments. Each segment is divisible into an **axial** and two **pleural lobes.**

The pygidum is the posterior part. It is semicircular. It is formed by the fusion of many segments. It is also divided into an axial and two pleural lobes.

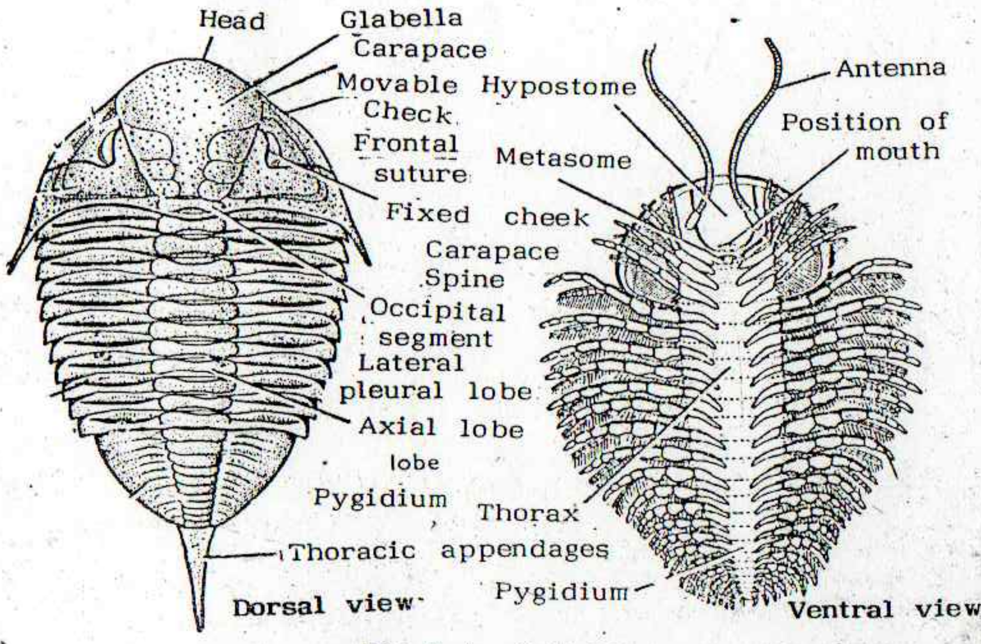


Fig. P.4: **Trilobite**

The head bears 5 pairs of appendages. They are **antennules, antennae, mandibles** and two pairs of **maxillae.** **Each** thoracic segment bears a pair of **biramous appendages.** The appendages gradually decrease in size backwards. The pygidial appendages are leaf-like.

Life History

The earliest developmental stage was called **protaspis.** It was circular or oval in shape. It had an anterior cephalon and a posterior abdomen. The cephalon is large with 5 segments in its axial part. The abdomen is small. It developed into adult by the increase in the number of segments and size.

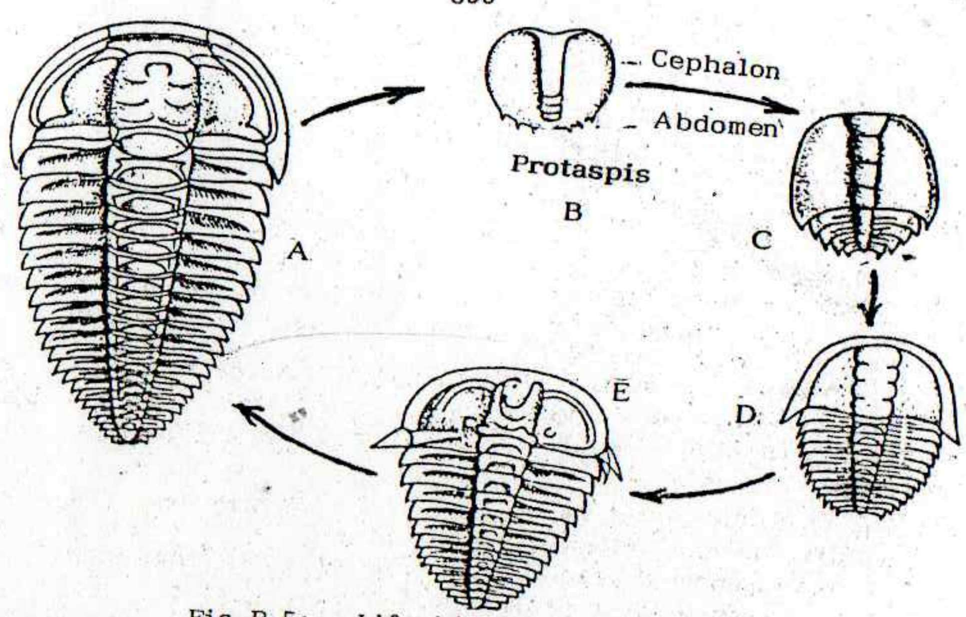


Fig. P.5: Life history of Trilobite

Affinity

Trilobites were the primitive arthropods. They possessed many primitive characters and they resembled Xiphosura and Crustacea in many aspects.

Primitive Characters : Trilobites showed the following primitive characters :

1. Presence of innumerable number of thoracic and abdominal appendages.
2. Arrangement and nature of appendages.
3. Unspecialised head region.

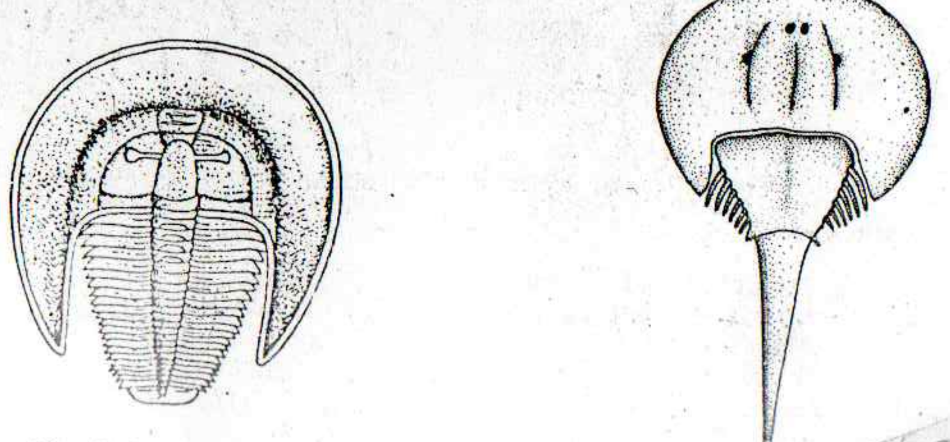


Fig. P. 6: Trilobite and

Affinity with Xiphosura Xiphosura includes the living fossil, **Limulus**. Trilobita resembles Xiphosura in the following characters.

1. Body is divided into three lobes.
2. Cephalothorax bears lateral eyes.
3. Appendages are biramous.
4. Presence of lateral spine in the pleura.
5. Larval stage of **Limulus** resembles ~~resembles~~ trilobite. Hence the larva is called **trilobitp larva**.

Trilobite differs from Xiphosura in the presence of antenna, presence of 5 pairs of appendages, absence of genital operculum and the **Protaspis larva** of trilobite has no resemblance with the trilobite larva of **Limulus**.

Affinity with Crustacea : A few groups of Crustacea such as Phyllopoda, Leptostraca, Isopoda were present in the fossil beds where the trilobites were found.

Phyllopod crustaceans **Apus and Branchipus** resemble trilobites in the following characters:

1. Presence of variable number of trunk segments.
2. Presence of a prominent labrum.
3. Presence of a single pair of antenna.

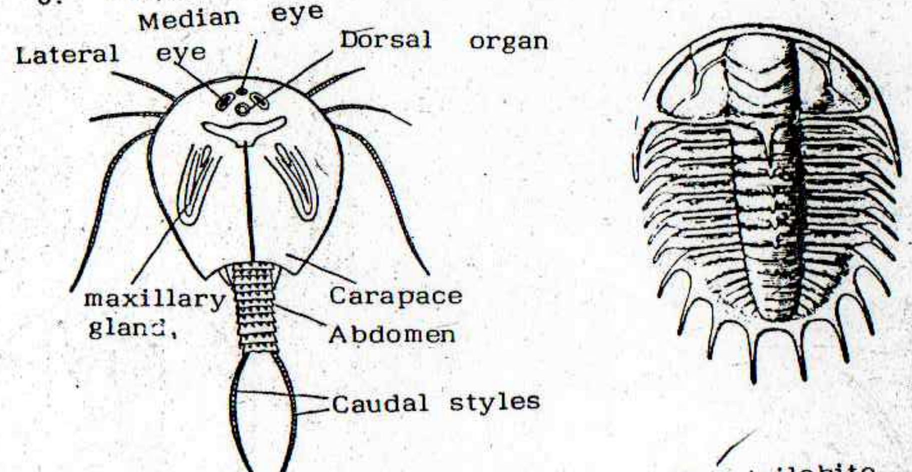


Fig.P.7: An Apus a crustacean and a trilobite

Conclusion

Trilobite was definitely an arthropod. It was the most primitive **arthropod** Fossil evidence indicates that some **Phyllopod** Crustaceans occurred at the Same time en trilobites flourished. Structural resemblances indicate trilobites were the ancestors for phyllopod Crustaceans.

10. *Eurypterida*
(Gigantostraca)

1. Eurypterida is an extinct group of Chelicerate arthropods.
2. They were marine arthropods.
3. They were gigantic arthropods and reached a large size with a length of 3 meters.
4. They existed in large numbers from the **Cambrian** period to the **Permian** period.
5. They originated from Trilobite ancestor.

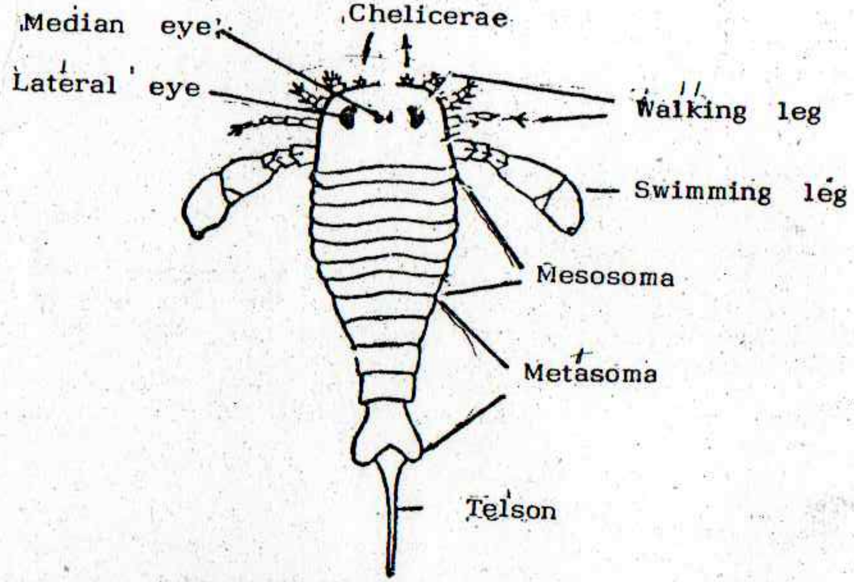


Fig.P.10.1: An Eurypterid

6. They were the ancestors of arachnids.
7. In shape, they resembled **Limulus**.
8. The body consisted of a **prosoma**, a **mesosoma** and a **metasoma**.
9. The prosoma had 6 fused segments, 6 pairs of appendages and median and lateral eyes. The appendages were one pair of **Chelicerae**, 4 pairs of **walking legs** and one pair of **swimming legs**.
10. The mesosoma had 7 segments and 6 pairs of gills.
11. The **metasoma** was narrow : 5-segmented and without appendages.
12. The **metasoma** ended in a **telson**.
13. They **originated** in the sea and later invaded brackish water, **fresh** water and even land.

Eg. **Eurypterus**, Pterygotus, Carcinosoma, etc.

3. Agnatha

(G.*a*, not + ***gnathos***, jaw)

1. Agnatha is a superclass of Vertebrata that includes jawless forms, viz., the extinct ***ostracoderms*** and the extant (surviving) ***cyclostomes.*** Eg. *Petromyzon.*

2. Ostracoderms are the fossil agnathans, characterized by a bony ***external skeleton.*** They lived in the freshwater of ***Silurian*** and ***Devonian*** periods. Eg. *Jamoytius.*

3. Cyclostomes are the living agnathans but they have no bony external skeleton. They might have lost the bony armour by ***mutations*** (***Kent***, 1967). Eg. *Petromyzon.*

4. Agnathans do not possess jaws.

5. The extinct forms were freshwater forms.

6. The extinct forms were covered by a ***bony external skeleton.***

7. Paired fins are absent.

8. A distinct head is present.

9. Gills are 6 - 14 pairs.

Comment

1. Bony armour may have been a defence against the ***eurypterids*** (aquatic scorpions) of Devonian (***A.S. Romer***, 1962). Another view is that it may have offered some protection against an excessive inflow of water from the freshwater environment in which the ostracoderms lived (***Villee***, *et.al.*, 1978).

2. Cyclostomes might have lost the bony armour by ***mutations*** (***Kent***, 1967).

3. ***Stensio*** (1958) holds the view as follows:

i. Cephalaspids might have given rise to > Lampreys

ii. Pteraspids might have given rise to > Myxinoids

4. Protein differences in the blood indicate that the lampreys and myxinoids are not closely related (***Hickman***, 1970).

5. Biochemical studies reveal that lampreys are close to the vertebrate ancestral line. The myxinoids seem to have evolved as a side branch (***Hickman***, 1970).

6. Ostracoderms were probably the ancestors of the ***Placoderms,*** the first fish to have jaws. From the placoderms, the cartilage fishes (Chondrichthyes) arose by loss of bone (***Young***, 1981). The bony fishes (Osteichthyes) also arose by the retention of bone.

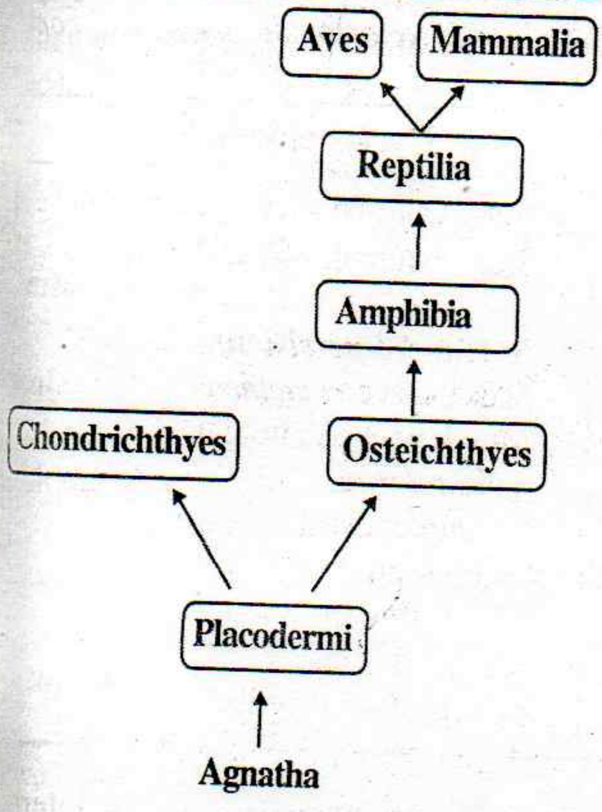


Fig.3.1: Phylogenetic tree of Agnatha.

Classification

Superclass Agnatha is divided into two classes, namely

Class 1. Ostracodermi

Class 2. Cyclostomata

Class 1. Ostracodermi

(G. ***ostrakon***, shell + ***derma*** skin)

Ostracoderms are the fossil agnathans, characterized by a bony ***external skeleton***. They lived in the freshwater of ***Silurian*** and ***Devonian*** periods.

1. Bony external skeleton i.e., ***plates*** and ***scales*** were embedded in the dermis.
2. No axial skeleton or vertebrae.
3. Mouth jawless and ventral but not suctorial.
4. Paired nostrils were present (Diplorhina).
5. Paired fins absent but some had paired ***spines*** or ***flippers.***
6. Ten pairs of gills. Eg. *Jamoytius.*

Class Ostracodermi is divided into two subclasses, namely

Subclass 1. Diplorhina

Subclass 2. Monorhina

Subclass 1. Diplorhina

Diplorhina (double nose) (= ***Pteraspidomorphi***-fin-shield) (G.***pteron,*** fin + ***aspis*** shield).

1. Fossil agnathans (ostracoderms) with ***paired nostrils*** (nasal sacs). They first appeared in Cambrian, 500 Ma ago and survived until Devonian.
2. Head and anterior part of the body were covered by a ***dorsal shield.*** It was narrow infront and prolonged into a ***rostrum,*** with a median ***spine*** behind (***Sedgewick,*** 1905).

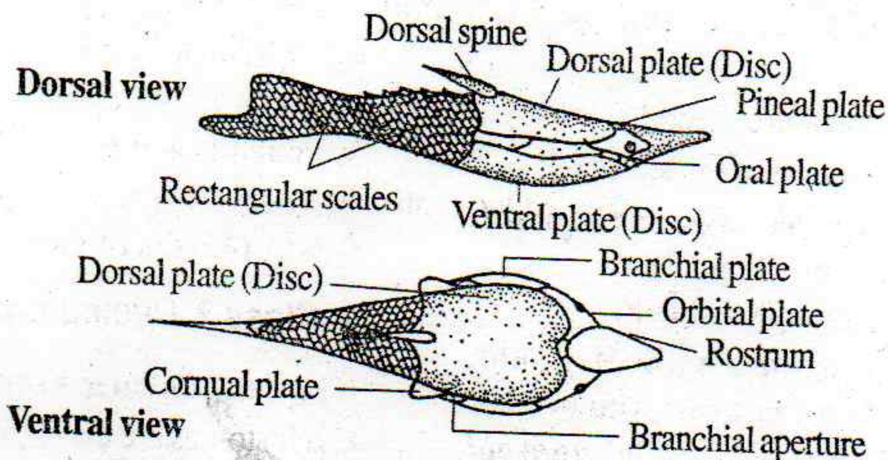


Fig.3.2: Pteraspis rostrata, an ostracoderm.

Order 2: Myxinoidea - Hagfish or slime eels.

(G.***myxa***, slime + ***oid,*** like)

1. Nostril terminal.
2. Mouth with sensory tentacles.
3. Gill slits 6 to 14 pairs.
4. Buccal funnel is absent.
5. Branchial basket ***vestigial.***
6. Dorsal fin is absent.
7. Pineal eye is absent.
8. Hermaphrodite.
9. Internal ***scavangers*** on fish.

Eg. *Myxine glutinosa,* Coast of North America.

Bdellostoma (Fig.3.4) Pacific coast of Chile.

Museum Specimens

1. Hemicyclaspis

1. A fossil agnathan (Ostracoderm) that lived in the freshwater of ***Silurian-Devonian.***

2. Dorso-ventrally flattened body with ventral mouth. This was an adaptation for bottom living.

3. It had a bony armour, i.e., the bony plates were embedded in the dermis of the head and the anterior part of the trunk. The caudal part had smaller plates (scales).

4. Head and gill region (10 pairs of gill slits) were enclosed by a solid, bony shield (head shield). Head shield had

a. a median hole for ***nasohypophysial tube.***

b. a median hole for ***pineal eye,*** a photoreceptor.

c. a pair of ***dorsal eyes*** with ***sclerotic rings*** and

d. a pair of dorsolateral and one dorsomedial ***sensory fields.***

5. It had, a. a single ***dorsal fin*** near caudal end.

b. a pair of flippers (pectoral fins)

c. a ***heterocercal*** tail covered with bony ***scales.***

6. It filtered food materials through the gills (***A.S.Romer,*** 1962).

2. Jamoytius

1. A fossil agnathan (ostracoderm without shield) obtained from Silurian rocks of England.

2. Name derived from ***J.A.Moy Thomas***, a leading ***Palaeontologist.***

3. It has a ***streamlined*** body with

a. A single, long dorsal fin.

b. a pair of ventro-lateral fins (representing the continuous pectoral and pelvic fins) and

c. a ***heterocercal*** tail.

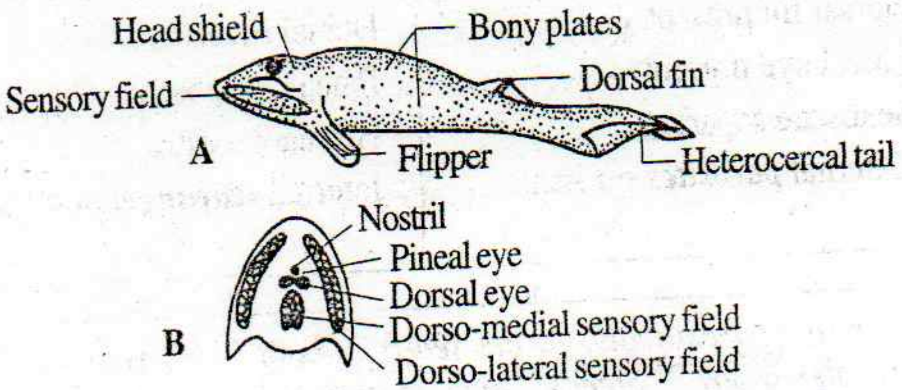


Fig.3.3: A. Lateral view of Hemicyclaspis, an ostracoderm of Silurian-Devonian. B. Dorsal view of the head of Cephalaspis.

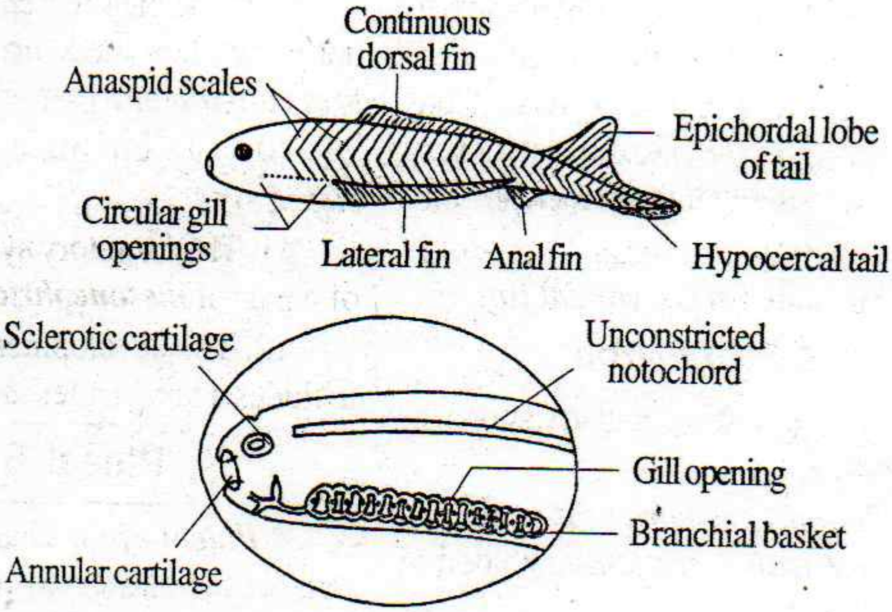


Fig.3.4: Jamoytius kerwoodi-Reconstruction of Silurian fossil anaspid. ***Note:*** *A series of transverse structures seen on the body are today considered to be anaspid scales. Formerly they were termed as myotomes. The inset shows branchial basket and unconstricted notochord.*

4. Body was covered with rows of plate-like bony scales called ***anaspid scales.*** These are not ***myotomes*** (***Young***, 1981).

5. It had a series of upto 15 circular gill openings.

6. It resembles lamprey in the following features:

a. annular cartilage round to the mouth

b. unconstricted notochord

c. a series of 15 gill pouches surrounded by a ***branchial basket.***

Therefore, it is suggested that *Jamoytius* might be the ammocoetes larva of an ostracoderm (***Young***, 1981).

3. Bdellostoma

1. It is a hagfish. It is an agnathan.

2. Eel-like body with a row of mucous pores, ventrolaterally on each side. These produce a large amount of mucous or slime, when disturbed, hence the name ***slime eel.***

3. This is also known as '***borer***' because of its habit of ***burrowing*** into fish for consumption of flesh (***Hickman***, 1970). They are internal scavangers on fish (***Smith***, 1960).

4. Buccal funnel is absent. But ***suctorial mouth*** and ***terminal nostril*** are surrounded by 4 pairs of sensory tentacles, supported by cartilages.

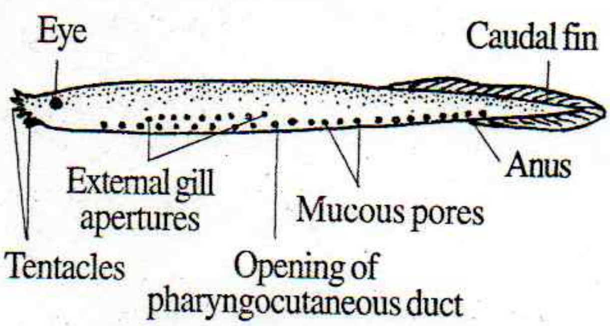


Fig.3.5: Bdellostoma.

5. Eyes are vestigial and serve as photoreceptors only.

6. Gill openings are circular and 6 to 14 in number. Behind the last gill opening is the ***aperture*** of pharyngocutaneous duct. This serves for the expulsion of very large inhaled particles (***Parker*** and ***Haswell***, 1962).

7. The only fin is a ***caudal fin.***

4. Petromyzon

1. *Petromyzon* is popularly known as ***sea lamprey***.

2. *Petromyzon marinus* is marine. It is an ***ectoparasite***. It sucks the blood of fishes and turtles.

3. It has an elongated cylindrical and ***eel***-like body.

4. The body consists of 3 regions, namely ***head, trunk*** and ***tail***.

5. The head is cylindrical and has a ***buccal funnel,*** a ***mouth***, a single ***naris***, a pair of ***eyes*** and seven pairs of ***gill slits***.

6. The mouth is surrounded by a ***cup***-like structure called ***buccal funnel***.

7. The centre of the buccal funnel has a circular ***mouth***. A ***tongue*** protrudes through the mouth.

8. The tail is laterally compressed. It has a ***caudal*** or ***tail fin***. The tail fin is also supported by fin rays.

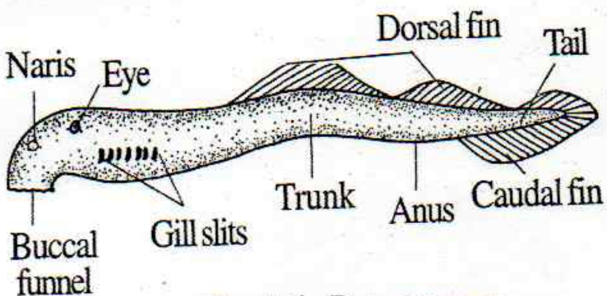


Fig.3.6: Petromyzon.

9. The skeleton is ***cartilaginous*** and not bony. It is made up of ***skull, vertebral column*** and a set of ***rods.***

10. The circulatory system is a ***closed type***.

11. The excretory system is made up of a pair of ***mesonephric kidneys***.

12. The development is ***indirect***. It includes a larva called ***ammocoetes***.

Pineal Eye

* ***Pineal eye*** is characteristic to ostracoderms and cyclostomes excluding hagfishes. It is also called ***third*** eye or ***epiphysial*** or ***median*** eye.

Location: In lampreys, it is attached to the roof of the diencephalon.

Structure: The organ is not actually median but it consists of an unequal pair of ***sacs,*** the right being larger. The right sac is ***pineal*** and the left sac is ***parapineal.*** The sac is flattened and has a narrow lumen (cavity). The inner wall of the sac contains light-receptive cells forming the ***retinal layer.*** (Fig.3.7). The bases of the receptor cells make contact with ganglion cells. There are also pigment cells which make migratory movements (***Eddy***, 1972).

Functions

1. It is a ***photoreceptor*** rather than an image forming eye (***Villee*** *et.al.*, 1978).

2. It receives stimuli that enable the organism to adjust its physiological activity to the ***diurnal cycle.*** Eg. In

Pineal eye is also present in certain reptiles like Sphenodon. In tetrapods, it assumes endocrine functions. Recent study on the rat indicates that the pineal body is a biological clock (Hickman, 1970**).*

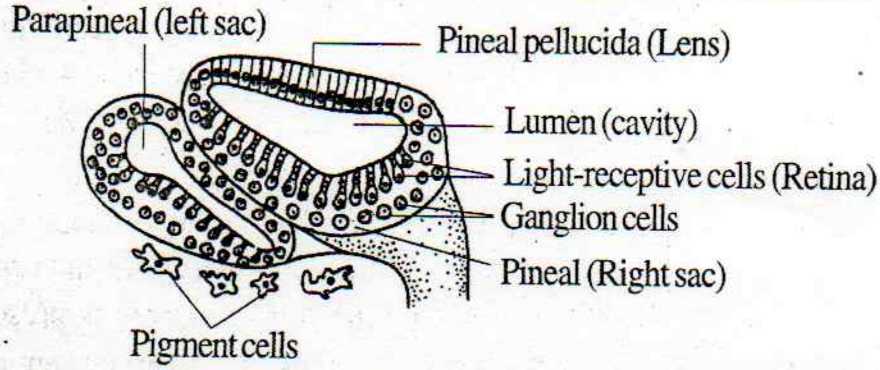


Fig.3.7: Diagrammatic representation of the sagittal section of pineal complex of a cyclostome (Geotria australis) based on the micrograph taken by Eddy, (1972).

ammocoetes larva, there is a daily ***rhythm of colour change*** - it becomes ***dark*** in the day and ***pale*** at night.

Evidence: Daily rhythm of colour change does not occur after the removal of pineal eye.

3. It ***influences*** metamorphosis of ammocoetes larva.

Evidence : Metamorphosis does not occur, after the removal of pineal eye (***Eddy***, 1972).

4. It produces a substance that contracts ***melanophores.***

5. It has also influence on ***reproduction*** (***Young*** 1981).

Detailed Study of Type

Petromyzon

Petromyzon is popularly known as ***sea lamprey***. It is the most ***primitive living vertebrate***. It has no jaws and hence it is included in the superclass ***Agnatha.*** It has a single nostril and hence it is included in the subclass ***Monorhina***. It has a circular mouth and hence it is included in the class ***Cyclostomata***.

Petromyzon marinus is marine. It is an ***ectoparasite***. It sucks the blood of fishes and turtles.

It has an elongated cylindrical and eel-like body. It is about one foot long. The body consists of 3 regions, namely ***head, trunk*** and ***tail***.

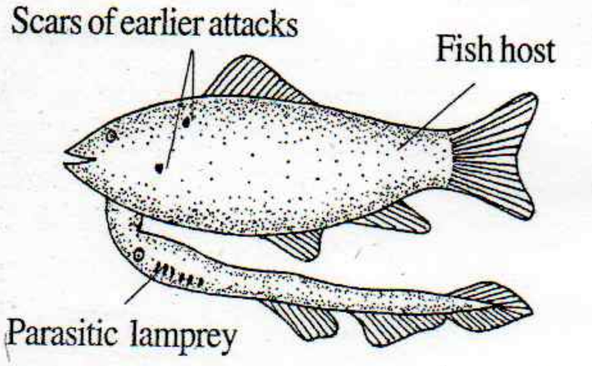


Fig.3.8: Petromyzon attached to its host.

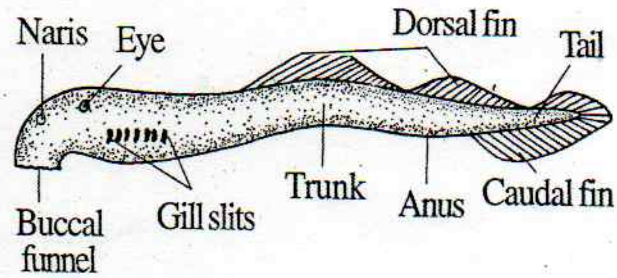


Fig.3.9: Petromyzon.

The head is cylindrical and has a ***buccal funnel***, a ***mouth***, a single ***naris***, a pair of ***eyes*** and seven pairs of ***gill slits***. The mouth is surrounded by a cup-like structure called ***buccal funnel***. The buccal funnel is a cup-like structure situated at the anterior end of the head. It is directed downwards. It functions as a

sucker. It is ***circular*** in shape. It is surrounded by a marginal membrane. This membrane is beset with numerous soft projections called ***oral papillae*** or ***oral fimbriae***. In between, the oral papillae many ***sensory cirri*** project out. The inner surface of the buccal funnel is beset with radiating rows of conical, yellowish, horny teeth. The centre of the buccal funnel has a circular ***mouth***. A ***tongue*** protrudes through the mouth. It is also beset with teeth. The tongue makes a hole on the skin of the victim by moving forwards and backwards.

The skeleton is ***cartilaginous*** and not bony. It is made up of ***skull, vertebral column*** and a set of ***rods.***

The circulatory system is a ***closed type***. The heart is made up of 2 chambers, namely ***auricle*** and ***ventricle***. A ***hepatic portal system*** is present.

The excretory system is made up of a pair of ***mesonephric kidneys***. The brain has three main divisions, namely ***fore brain, midbrain*** and ***hindbrain.***

The sensory organs include an ***olfactory organ***, a pair of ***eyes***, a pair of ***ears***

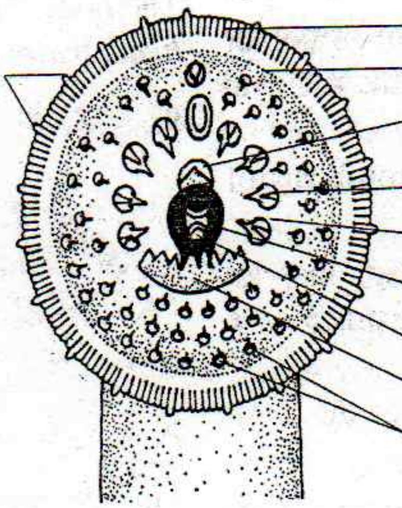


Fig.3.10: Petromyzon: Buccal funnel.

A naris is present on the dorsal surface of the head. It leads into an ***olfactory sac***. The olfactory sac is an organ to smell. Behind each eye, laterally there are seven pairs of ***gill apertures***.

The trunk is also cylindrical. It has two ***median dorsal fins***. The fins are supported by cartilaginous rods called ***fin rays***. At the junction of the trunk and tail, the ***anus*** and the ***urinogenital aperture*** are present on the ventral side.

The tail is laterally compressed. It has a ***caudal*** or ***tail fin***. The tail fin is also supported by fin-rays.

and a ***lateral line sense organ***. The sexes are separate. The development is ***indirect***. It includes a larva called ***ammocoetes***.

Breeding and Migration

Petromyzon has a peculiar breeding habit and breeds only once in its life. Mature males and females migrate from sea to rivers for breeding. This type of migration is called ***anadromous migration***.

During migration the alimentary canal becomes non-functional. They do not feed. They use the fat stored in the muscles and beneath the skin. They travel hundreds of miles and reach the place where their parents and grand parents bred. In the river, a male and a female select a site in a clear moderately fast-flowing water and they build a nest. The buccal funnel is used to remove the stones. The nest consists of a rounded pit with sandy floor. The female gets fixed onto a stone by its buccal funnel near the nest. The male attaches to the female by its buccal funnel near head. Both the female and the male wriggle forth and back and discharge eggs and sperms in the nest. This mating is repeated many times. After each mating the eggs are covered with sand brought in by the tail. After spawning the parents leave the nest and die within a few days.

Fertilization is ***external***. The development includes a larva called *ammocoetes*.

Ammocoetes Larva

Ammocoetes is the larva of *Petromyzon*. It has the following salient features:

1. ***Ammocoetes*** is a freshwater larva of the marine *Petromyzon*.
2. It looks like an *Amphioxus* in its morphology and habits.
3. It is a transparent larva.
4. It lives for 3 - 7 years.
5. In the beginning, it is about 7 mm in length and it can attain a length of 175 mm.
6. It lives inside a **U**-shaped burrow. At times it comes out of the burrow.
7. It is muddy brown in colour.
8. It has an ***eel***-like body.
9. The body is divisible into a ***head, trunk*** and a ***tail***.
10. The head has an ***oral hood*** and a pair of ***eyes*** hidden under the skin.
11. The oral hood surrounds the ***mouth*** in the place of the buccal funnel.
12. The trunk has a single ***dorsal fin***.

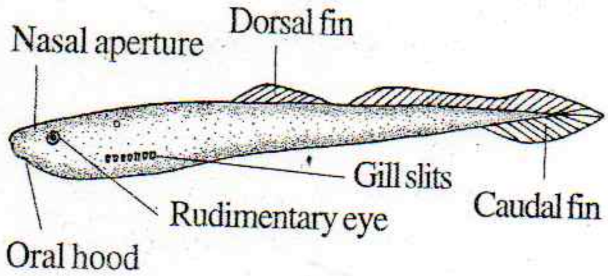


Fig.3.11: Ammocoetes larva of Petromyzon.

13. The tail has a ***caudal fin*** which is in continuation of the dorsal fin.
14. The trunk has 7 pairs of ***gill slits*** just behind the head.
15. The alimentary canal includes a ***mouth, buccal cavity, pharynx, intestine*** and ***anus***. A ***velum*** is present between the buccal cavity and the pharynx.
16. The pharynx has an ***endostyle***, a pair of ***peripharyngeal bands*** and a ***hypopharyngeal groove***.
17. Liver, bile duct and gall bladder are present.
18. The kidney is a ***protonephros***.
19. It exhibits ***filter feeding***. The water current is created by the muscular activity of branchial basket and not by the ciliary activity.
20. The respiratory current goes into the pharynx through the mouth and comes out through the gill slits. But in the adult it comes in and goes out through the gill slits.

21. A heart with ***pericardium*** is present.

22. The ***pineal eye*** is well developed.

Metamorphosis

After a prolonged period of 3 - 7 years, the Ammocoetes larva undergoes metamorphosis. During metamorphosis, the following changes occur:

1. The larva leaves the burrow and leads a free swimming life.

2. It migrates from the freshwater habitat to the marine habitat.

3. The filter feeding habit of the larva is changed into a blood sucking habit.

4. The oral hood disappears and a ***buccal funnel*** with teeth and tongue appears.

5. The continuous median fin breaks into two ***dorsal fins*** and a ***caudal fin***.

6. The two eyes get opened and functional.

7. The endostyle changes into the ***thyroid gland***.

8. The gall bladder and bile duct disappear.

9. A ***respiratory tube*** develops from the pharynx.

10. The velum is reduced and it guards the opening of the respiratory tube.

11. The pronephros is replaced by a ***mesonephros***.

12. The spinal cord becomes flattened.

Migration of Petromyzon

Migration is defined as *the long journey taken by animals from one place to another and back.* It is a regular cyclic and seasonal phenomenon. These long journeys are mainly for breeding and food gathering. Migration is a two-way journey. It includes ***emigration*** and ***immigration.*** Emigration is the outward journey from the homeland (feeding ground) to the breeding ground (where the animals breed). Immigration is the inward journey or return journey from the breeding ground to the homeland.

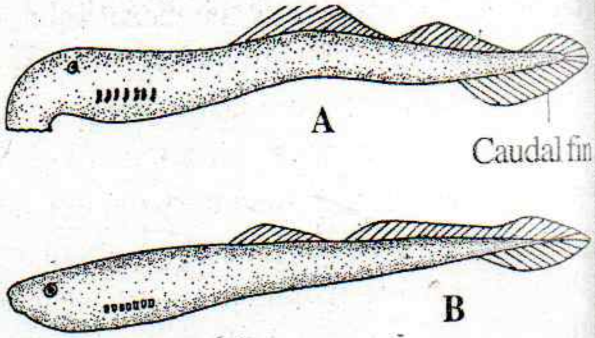


Fig.3.12: A. Petromyzon, B. Ammocoetes larva.

Petromyzon is a jawless vertebrate included in the superclass ***Agnatha*** and class ***Cyclostomata***. *Petromyzon marinus* is marine and is found in the coasts of Europe, North America, West Africa and Japan. The breeding habit of *Petromyzon* is peculiar. It is a migratory primitive vertebrate. Breeding occurs in freshwater rivers. Hence it migrates from the sea to the freshwater. This type of migration is called ***anadromous migration.***

The males and females migrate together. The female develops a large fin and the male develops a ***penis***-like organ. They travel hundreds of miles. After reaching a suitable place in the river they start building nests. The nest is made of stones on sandy bottom. The female attaches itself to a stone with the help of buccal funnel and the male is fastened to the female. They move backward and forwards. When eggs and sperms are released. After mating the parents die. Hence they mate only once in their life time.

The fertilized egg hatches into a larva in twenty days. The larva is called *ammocoetes* larva. It grows to a length of 175 mm. It lives inside a V-shaped tunnel. The ammocoetes larva has an ***oral hood*** like that of *Amphioxus*. The larva lives for seven years. Then it undergoes metamorphosis. The young *Petromyzon* then migrates downstream from the river to the sea where it changes into an adult.

Ostracoderm

Ostracoderms are popularly called '***armoured fishes***' or '***bony skin***' (Gr. *Ostrakon* - shell, ***derma*** - skin). They are the first vertebrate appeared on the earth. They are the jawless vertebrates. *Jamoytius* is the primitive and typical ostracoderm.

Systematic Position

Phylum	:	*Chordata*
Subphylum	:	*Vertebrata*
Superclass	:	*Agnatha*
Class	:	*Ostracodermi*

Occurrence

Ostracoderms originated about 500 million years ago in the late ***Cambrian*** period of ***Palaeozoic*** era. They lived upto the Devonian period for a period of 200 million years and then they became extinct completely about 300 million years ago.

Habitat

Ostracoderms were freshwater forms. They were bottom dwellers.

Origin

Barrington suggested that urochordate was the ancestor for Ostracoderm. The sessile urochordates produced free living tadpoles. Some of the tadpoles failed to undergo metamorphosis and developed into adults by ***neoteny.*** These neotenous forms reached the river through the estuaries and developed into Ostracoderms.

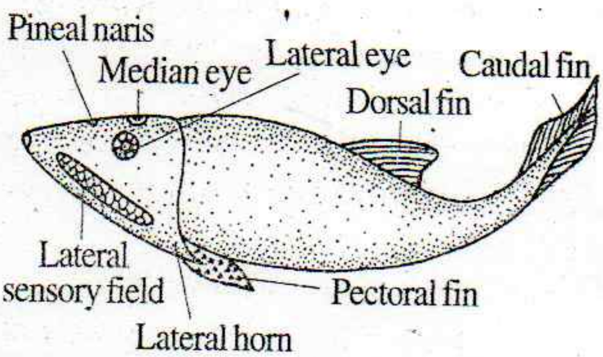


Fig.3.13: Cephalaspis, a Silurian-Devonian ostracoderm.

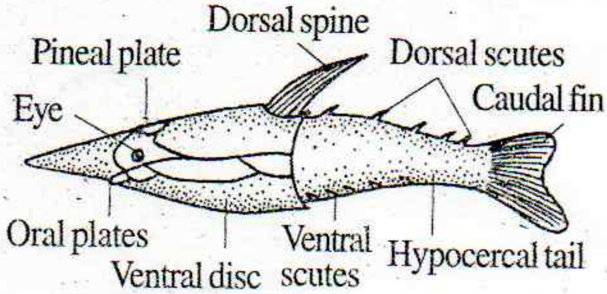


Fig.3.14: Pteraspis, an Ordovician-Devonian ostracoderm.

Salient Features of Ostracoderms

The Ostracoderms possessed the following salient features:

1. Ostracoderms were the first vertebrates.

2. They were commonly called ***armoured fishes.***

3. They originated about 500 million years ago, lived for about 200 million

years and disappeared from the earth completely about ***300 million years ago.***

4. They did not possess ***jaws*** and hence they were called ***jawless vertebrates.***

5. They lived in freshwater and they were bottom dwellers.

6. The body was ***fish***-like.

7. Paired fins were absent from Ostracoderm. Median and caudal fins were present. The caudal fin was ***heterocercal.***

8. The head and thorax were covered by a heavy armour of bones. The bony armour protected Ostracoderms from the giant *Scorpion* like ***arthropods, eurypterids.***

9. A bony ***skull*** was developed.

10. A mouth without jaws, was present on the ventral side.

11. Ostracoderms had paired ***gill slits.***

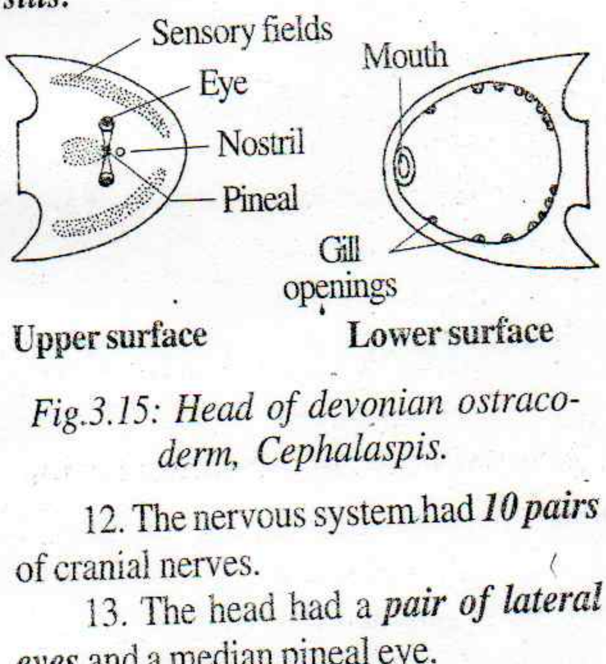


Fig.3.15: Head of devonian ostracoderm, Cephalaspis.

12. The nervous system had ***10 pairs*** of cranial nerves.

13. The head had a ***pair of lateral eyes*** and a median pineal eye.

14. They were small in size and did not exceed 30 cm.

15. They were ***filter feeders.***

16. The endoskeleton was either bony or cartilaginous.

Outline Classification

Class Ostracodermi is classified into four orders. They are:

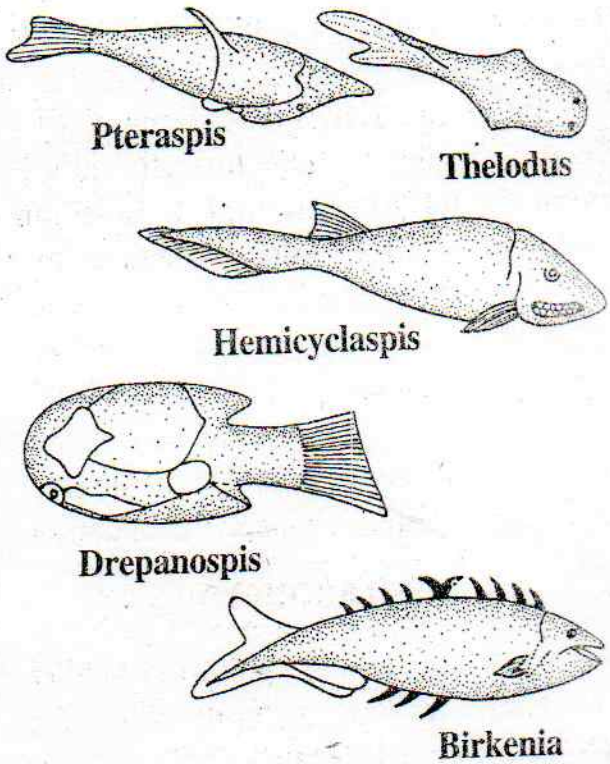


Fig.3.16: Ostracoderms.

Order 1. Euphanerida: Eg. *Jamoytius*

Order 2. Pteraspidomorphi: Eg. *Pteraspis, Thelodus, Lanarkia, Drepanospis* and *Coelolepsi.*

Order 3. Cephalaspidomorphi: Eg. *Cephalaspis, Hemicyclaspis, Ateleaspis, Benneviaspis* and *Thyestes.*

Order 4. Anapsida: Eg. *Birkenia, Pterolepis, Rhyncholepis.*

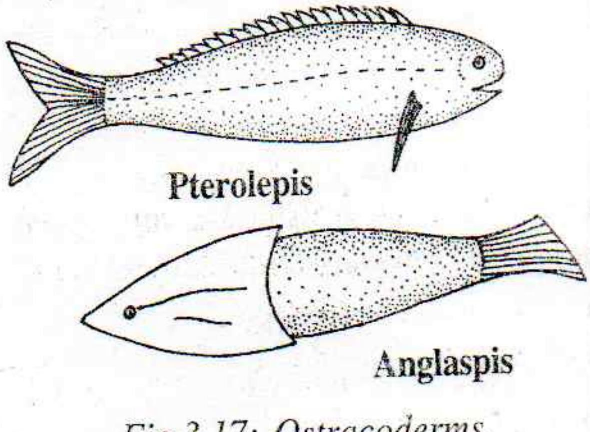


Fig.3.17: Ostracoderms.

Affinities

The Ostracoderms resembled the cyclostomes in the presence of a single median naris, pineal eye, jawless mouth and the absence of paired fins. Hence the two groups are placed together in the superclass *Agnatha.*

The ostracoderms were provided with bony skeleton but the cyclostomes are provided with ***cartilaginous*** skeleton. Hence it is believed that bone is considered to be a primitive character and cartilage is an advanced character. As per this conclusion cyclostomes are degenerate forms, having lost the bone from their skeleton.

It is believed that the armoured Ostracoderms originated from the unarmoured *Jamoytius.*

The Ostracoderms were the ancestors of ***Gnathostomes.*** They gave origin to Placoderms which inturn gave rise to modern fishes. The Ostracoderms disappeared completely from the earth after giving origin to the Placoderms.

Jamoytius

Phylum	:	*Chordata*
Subphylum	:	*Vertebrata*
Superclass	:	*Agnatha*
Class	:	*Ostracodermi*
Order	:	*Euphanerida*

1. *Jamoytius* was the first vertebrate.

2. It was a fossil animal discovered by *White* in 1946.

3. The name *Jamoytius* was derived after a leading Palaeontologist, ***J.A. Moy.***

4. It lived in the ***Silurian*** period of ***Palaeozoic era*** about 400 million years ago.

5. This fossil was found from marine sediments.

6. It had a ***stream lined body.***

7. It had no jaws. Hence it was called a ***jawless vertebrate.***

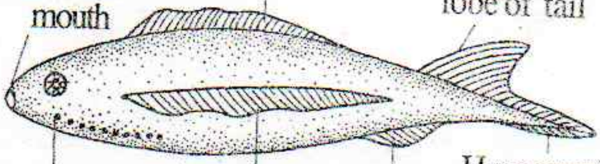


Fig.3.18: Jamoytius, the first vertebrate.

8. Generally all the Ostracoderms were covered by a bony armour and hence the name Ostracoderm. But *Jamoytius* was devoid of a bony armour. But the body was covered by bony scales called ***anaspid scales.***

9. It had a terminal mouth.

10. There were 15 pairs of gill slits arranged in two rows on the sides of the body.

11. It had a long ***dorsal fin***, a ***heterocercal caudal fin*** and a pair of ***lateral fin folds.***

12. It had a ***notochord.***

13. It resembled *Petromyzon* in the presence of ***annular cartilage*** around the mouth, unconstricted ***notochord*** and ***gill slits***. Hence ***Young*** (1981) suggested that *Jamoytius* might be the ***ammocoetes*** larva of an Ostracoderm.

Origin of Vertebrates

Vertebrates are chordates having a ***cranium*** (skull) and a ***vertebral column.*** No other group of animals possesses these two fundamental characters. As the vertebrates contain a cranium, they are also named as ***Craniata.***

Origin of Reptilia

Reptiles are a group of ***cold blooded creeping*** animals successfully adapted for ***land life.*** Though amphibians are considered as the first land vertebrates, reptiles are the first successful vertebrates independent of water. They don't have any fear of dehydration. Their success on land is mainly because they lay land eggs or ***cleidoic eggs.*** They are the first member of ***amniota*** originated on the Earth.

Time of Origin

Reptiles originated about 255 million years ago in the ***Carboniferous*** period of ***Palaeozoic*** era. They originated about 50 million years after the origin of ***Amphibia.***

Place of Origin

Reptiles originated on ***land.***

First Reptile

The earliest known reptile was called ***Hylonomus.*** It lived in the ***Carboniferous*** period. It was about one ***feet*** in ***length.*** The tail was ***long*** and the limbs were ***strong***. It lived in the wood swamps. It belonged to a group called ***Cotylosaur***, the ***stem reptiles.***

Other primitive reptiles were *Limnoscelis* and *Captorhinus*. They were collected from ***Permian*** beds. They also belonged to the group of ***Cotylosaurs.*** *Limnoscelis* was a large reptile with 2 metres length. *Captorhinus* was a small reptile.

Probable Ancestor

The reptiles evolved from the ***Anthracosaurs*** of ***Labyrinthodont amphibians***. *Seymouria* got from the Carboniferous deposits of Texas is considered as a ***connecting link*** between amphibians and reptiles. The *Seymouria* shows a strange admixture of amphibian and reptilian characters.

Connecting link between Amphibians and Reptiles

Fossil record showed some intermediate forms combining characters of advanced labyrinthodonts with those of primitive reptiles. *Seymouria* was a small tetrapod found in the upper portion of the lower ***Permian*** sediments of the town Seymour, Texas. It was a ***connecting link*** between amphibia and reptiles.

Amphibian Characters of Seymouria

1. A prominent ***otic notch*** for the accommodation of ear drum was present.

2. ***Labyrinthodont*** skull bones like ***supratemporal*** and an ***intertemporal*** bones were present behind the eye.

3. Labyrinthodont teeth were present.

4. Single occipital condyle was present in the skull.

Reptilian Characters

1. The neural arches were broad like the earliest reptiles.

2. The ***pleurocentrum*** of the vertebrae was enlarged whereas the intercentrum was reduced.

3. The interclavicle of the pectoral girdle was long.

4. The ilium of the pelvic girdle was expanded.

5. The humerus was similar to early reptiles.

6. The arrangement of toe bones was similar to those of early reptiles. The phalangeal formula was 2-3-4-5-3 (2 phalanges in the thumb, 3 in the second digit,

4 in the third digit, 5 in the fourth digit and 3 in the little finger).

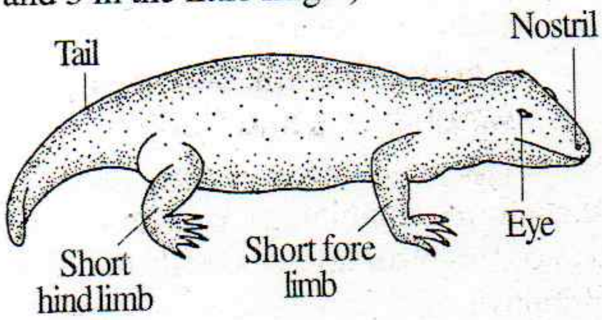


Fig.6.78: Seymouria, the connecting link between amphibians and reptiles.

Stem Reptiles

The first reptiles were ***Cotylosauria.*** Since all the other reptilian orders have arisen from this basal stock, ***Cotylosaurs*** are the ***stem reptiles.*** The cotylosaurs are considered as stem reptiles because they have primitive and comparatively unspecialized characters.

The stem reptiles have no fenestra or vacuity in the temporal region, so they are placed in the subclass *Anapsida.*

Seymouria has been considered by some authorities as a basic member of Cotylosauria. But ***Romer*** (1962) considered *Seymouria* as a ***reptile***-like amphibian and ***Colbert*** (1969) considered *Seymouria* as a **'connecting link'** between amphibians and reptiles.

The typical cotylosaur genus was *Limnoscelis.* It was a reptile with five feet in length. The roof of the skull was solid. On the skull roof there was a well developed pineal opening, a character inherited from amphibian ancestor. The intercentra of the vertebrae were reduced. The interclavicle was long and the ilium was expanded. The primitive phalangeal formula of 2,3,4,5,3 was seen.

Evolutionary Trends in the Origin of Reptiles

During the origin of reptiles from amphibians, the following evolutionary changes occurred:

1. Land Life: Reptiles became completely terrestrial. They did not depend on water for completing their life cycle. They were well protected from the danger of dehydration.

2. Land Eggs: Amphibians laid their eggs in water and they depended on water for completing their life cycle. Reptiles laid their eggs on land. These eggs were called ***land eggs*** or ***amniotic eggs*** or ***cleidoic eggs.***

These eggs were protected by an outer hard calcareous shell. Hence they were called ***cleidoic eggs***. The embryo, developing inside the egg, was surrounded by a membrane called ***amnion*** which was not found in the egg of amphibians. Hence the reptilian eggs were called ***amniotic eggs.*** The amnion enclosed a cavity called ***amniotic cavity*** filled with a fluid called ***amniotic fluid.*** The embryo develops inside this fluid. Hence the amniotic fluid is described as the ***'artificial swimming pool of the embryo'.*** Hence reptilian eggs did not depend on water for development.

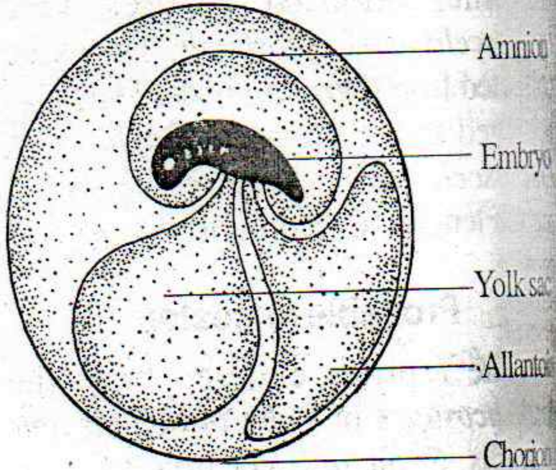


Fig.6.79: An amniotic egg with amnion.

So during the origin of reptiles from amphibians, the ***anamniotic*** egg of amphibia became ***amniotic*** egg of reptilia.

3. Internal Fertilization: In the case of amphibians, fertilization was ***external*** and this was possible because they bred in water. Reptiles bred on land and hence fertilization became ***internal.***

4. Respiration: The reptiles did not breathe by gills at any stage of their life. Cutaneous and gill respiration of amphibia were replaced by complete ***pulmonary respiration.***

5. Skin: The skin became thick and rough and scales and shields appeared to prevent desiccation.

6. Heart: The ventricle became incompletely divided.

7. Aortic Arches: Aortic arches had their independent origin from the heart.

8. Pectoral Girdle: The ***cleithrum*** disappeared.

9. Cervical Ribs: The cervical ribs disappeared.

10. Kidney: The kidney became ***metanephric*** from the mesonephric kidney of amphibia.

11. Excretion: Excretion became ***uricotelic*** from ureotelic excretion of amphibia.

12. Cranial Nerves: Cranial nerves became 12 by the addition of 2 nerves already present in amphibia.

13. Copulatory Organ: The male developed a ***penis*** for copulation and internal fertilization.

14. Absence of Larvae: The development became direct by omitting the larval stages in the life history.

15. Foetal Membranes: The embryo developed around it four types of foetal membranes, namely ***chorion, amnion, allantois*** and ***yolk sac.***

Evolution of Reptilia

In the history of the Earth, Reptiles appeared in the ***Palaeozoic*** era, played a heroic role during ***Mesozoic*** era and disappeared from the scene in the ***Cenozoic*** era leaving only a few representatives. They ruled over the earth for a very long duration of about 130 million years in the ***Mesozoic*** era. When man's duration of life on the earth (only 2 to 4 million years) is compared with that of reptiles, the duration of reptiles was very long. In the ***Mesozoic*** era, the reptiles were represented by 16 orders. But today they are represented by only 4 orders of living reptiles.

Time of Origin

Reptiles originated about 255 million years ago in the ***Carboniferous*** period of ***Palaeozoic*** era. They originated about 50 million years after the origin of ***Amphibia.***

Place of Origin

Reptiles originated on land.

Probable Ancestor

Seymouria, a Labyrinthodont amphibian was the ancestor for Reptilia. It was collected from the ***Permian*** sediments of ***Texas.*** It was a ***connecting link*** between amphibians and reptiles.

Connecting link between Amphibian and Reptiles

Fossil record showed some intermediate forms combining characters of advanced labyrinthodonts with those of primitive reptiles. *Seymouria* was a small tetrapod found in the upper portion of the lower Permian sediments of the town ***Seymour***, Texas. It was a connecting link between amphibia and reptiles.

Amphibian Characters of Seymouria

1. A prominent otic notch for the accomodation of ear drum was present.

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Reptilian Characters

1. The neural arches were broad like those of earliest reptiles.

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Adaptive Radiation

The evolution of a single group of animals in different directions invading different habitats with different types of adaptations is called ***adaptive radiation***. It is also called ***divergent evolution***. Reptiles underwent very good adaptive radiation during their evolution.

Stem Reptiles

The first reptiles were *Cotylosauria*. Since all the other reptilian orders have arisen from this basal stock, Cotylosaurs are considered as the ***stem reptiles.*** The Cotylosaurs are considered as ***'stem reptiles'*** because they have primitive and comparatively unspecialized characters. The stem reptiles have no fenestra or vacuity in the temporal regions. They are placed in the subclass ***Anapsida***. *Seymouria* has been considered by some authorities as a basic member of *Cotylosauria*. But **Romer** (1962) considered *Seymouria* as a ***reptile***-like amphibian and **Colbert** (1969) considered *Seymouria* as a ***'connecting link'*** between amphibians and reptiles.

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The stem reptiles gave rise to 5 main lines. These lines are named based on their skull roofing. They are,

1. *Anapsid line*
2. *Synapsid line*
3. *Euryapsid line*
4. *Parapsid line*
5. *Diapsid line*

1. Anapsid Line

The anapsid line has a skull resembling the stem reptiles. They have no vacuity in the skull. They arose as an early offshoot of stem reptiles. They have remained unchanged since 160 million years. Eg. *Turtles* and *tortoises.*

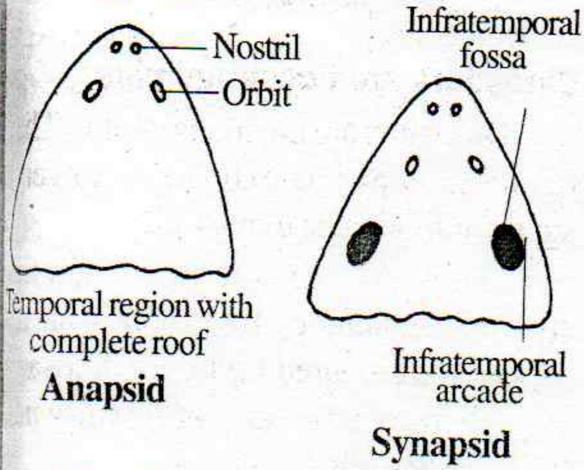


Fig.6.80: Skulls of reptiles.

2. Synapsid Line

The synapsid line has a single temporal fossa on each side of the skull. The fossa was situated ventral to postorbital nd squamosal. This line comprised of *ammal*-like reptiles. Eg. *Dimetrodon (Theromorpha)* and *Cynognathus (Therapsida).*

3. Euryapsid Line

The euryapsid line of reptiles had also single fossa. It was situated dorsal to ostorbital and squamosal. They were arine, heavy bodied fish eaters. Eg. *lesiosauria.*

4. Parapsid Line

The parapsid line of reptiles had also single fossa on each side of the skull. It as far high so that postorbital and squaosal meet far below. Postfrontal and supratemporal lie immediately ventral to the fossa. Eg. *Protosauria, Ichthyosauria, Mesosauria,* etc.

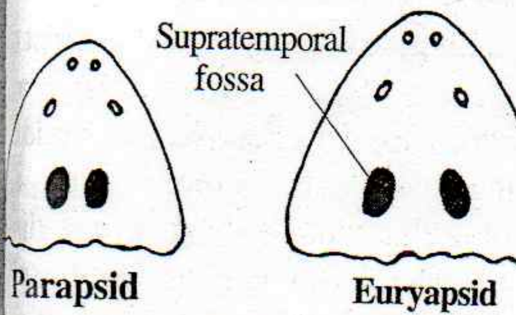


Fig.6.81: Skulls of reptiles.

5. Diapsid Line

The diapsid line of reptiles had two fossae, namely ***supratemporal fossa*** and ***infratemporal fossa.*** This group includes extinct reptiles like *Thecodonts, Pterosaurs* and *Dinosaurs* and most of the living reptiles like ***lizards, snakes, crocodiles*** and *Sphenodon.*

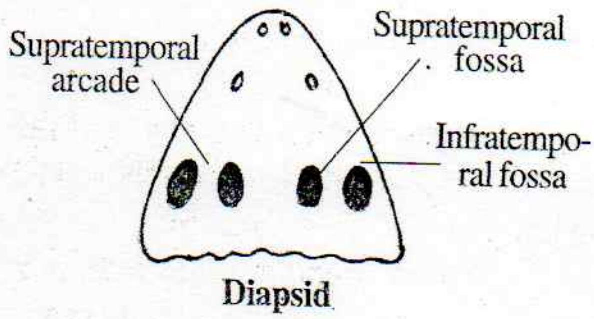


Fig.6.82: Diapsid skull of reptiles.

The earliest diapsids divided into two lines, namely ***Lepidosauria*** and ***Archosauria.*** Lepidosauria gave origin to ***modern Squamata*** (Lizards and snakes) and ***Rhynchocephalia*** *(Sphenodon).* The ***Archosauria*** were the ruling reptiles dominating the mesozoic era. They gave rise to *Pterosauria, Dinosaurs, Crocodiles* and *Birds.*

Dinosaurs were the terrible lizards. They were of two types, namely ***Saurischia*** and ***Ornithischia***. Saurischia means ***'reptile-hips'***. They had reptilian type of pelvic girdle. They were flesh eating bipedal carnivores. Eg. *Struthiomimus, Ornithomimus, Apatosaurus, Brontosaurus, Diplodocus, Branchiosaurus,* etc.

Ornithischia means ***'bird-hip'***. They had avian pelvic girdle. They were ***herbivores***. Eg. *Iguanodon, Triceratops, Stegosaurus,* etc.

bony spikes. The tail of *Stegosaurus* were armed with strong spikes of 30 cm long *Styracosaurus* had 7 sharp bony spikes on its head. *Monoclonius* had a ***single horn*** on its head-*Triceratops* (Fig.6.85) had 3 horns on the head.

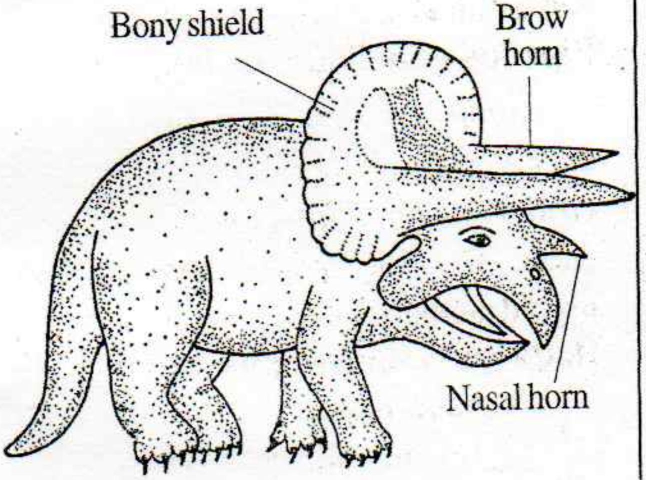


Fig.6.86: Triceratops.

Protective Bony Shields

Triceratops (Fig.6.85) and *Protoceratops* were provide with strong ***bony shields*** on their head.

Rise of Dinosaurs

Dinosaurs lived for 160 million years in the Mesozoic era. They originated 225 million years ago. They become completely extinct about 65 million years ago.

The dinosaurs were the giants. They occupied all the environments available. There were land dwellers, flying dinosaurs and aquatic dinosaurs. There were carnivores, herbivores and omnivores. They were totally dominant over other animal groups of that time. So Mesozoic era is called the ***golden age of reptiles***.

Dinosaurs

The term Dinosaurs was coined by ***Sir.Richard Owen.*** It means ***terrible Lizards***.

They were the biggest animals ever lived on land.

They lived during the ***Mesozoic era***. They were the dominant groups during the Mesozoic era. So Mesozoic era is called the ***Golden Age of Reptiles***.

No Dinosaurs live today.

Dinosaurs came in many shapes as well as many sizes.

Some walked on all four limbs, others walked only on their hind limb.

There were herbivores, carnivores and omnivores.

They lived in all the habitats. There were land dinosaurs, flying dinosaurs and aquatic dinosaurs.

By the end of Mesozoic era all the dinosaurs disappeared.

All the dinosaurs mysteriously vanished within one or two years.

Decline of Dinosaurs

Dinosaurs roamed on the Earth fo about 160 million years. Then all of then mysteriously vanished. About 67 millio years ago Dinosaurs still lived. But tw million years later all were extinct. Th rocks formed 65 million years ago, no earlier than 67 million years, contain n dinosaur fossils.

Not only Dinosaurs died out. Th flying Pterosaurs, swimming Mosasau and Plesiosaurs went with them. So di ammonites and some much smaller se invertebrates. Scientists still puzzle ov why so many animals disappeared s swiftly.

Some fossil clues suggest these mass deaths happen in as little as a year or two.

There are many theories about the cause of the extinction of Dinosaurs. They are the following:

1. Collision Theory: This theory was proposed by ***Luis Alvarez*** and his son ***Walter Alvarez***. They concluded that the mass extinction of dinosaurs might have been caused by the impact of an object from space with a diameter of 10 km. Such an object might be an asteroid or a comet. This collision kicked out enough dust in the atmosphere to block the Sunlight for months and cooled the Earth. The surface of the Earth would have grown dark and cold, killing many plants and animals on every continent.

When the dust had settled, sunshine would have reached the land and sea again. But moisture still above the Earth might have trapped the Sun heat near the ground for year. Creatures that had lasted through the cold and dark might now have died too much of heat. Even if heat did not kill dinosaurs directly it could have made their eggs all hatch out into males. Without females, dinosaurs could not have gone on breeding.

Golden Age of Reptiles

Reptiles are ***creeping***, ***cold blooded*** animals. They are credited as the first vertebrates adapted to live completely on land. They are the first vertebrates carrying out ***internal fertilization.*** They produce ***amniotic*** eggs or ***land*** eggs or ***cleidoic*** eggs.

They originated about 300 million years ago in the ***Palaeozoic*** era. They played a dominant role throughout the ***Mesozoic*** era and disappeared completely by the ***end*** of ***Mesozoic*** era leaving a few representatives.

The largest animals that ever lived on land were the reptiles (dinosaurs).

Mesozoic Era is the Golden Age of Reptiles?

The Mesozoic era, meaning the age of ***middle life*** or the age of ***mideval life,*** started 225 million years ago and ended 65 million years ago. It lasted for 160 million years. It has three periods, namely ***Triassic, Jurassic*** and ***Cretaceous.***

During the entire Mesozoic era the reptiles literally rules over the earth.

When a group of animals becomes dominant over other groups of animals in a period and occupied all the environments available, that particular period will be called the age of that particular group. The reptiles of the Mesozoic era occupied every available ecological niche and was totally dominant over other animal groups of that period. So, the Mesozoic era is called the ***Golden age of Reptiles***. Some of the Mesozoic reptiles like the ***Dinosaurs*** were giant ***land dwellers,*** some like the ***Pterosaurs*** were ***flying*** and some others like ***Ichthyosaurs*** were adapted to an ***aquatic life.***

Duration of Mesozoic Reptiles

The Mesozoic reptiles lived for 150 million years. They lived and dominated the earth for the whole of the Mesozoic era and by the end of ***Cretaceous*** they completely became extinct.

Outline Classification of Mesozoic Reptiles

The major reptilian groups of the Mesozoic era are the following:

1. *Thecodonts*
2. *Dinosaurs*

24. Diarthrognathus

Diarthrognathus was an advanced ***mammal***-like reptile from the ***Triassic*** beds of ***South Africa.*** It was an ictidosaur showing many mammalian characters like differentiation of ***teeth*** into incisors, canines, premolars and molars, double occipital condyle and the ***zygomatic arch.*** The most interesting feature was the presence of ***double jaw articulation.*** In this articulation, there was the ancient reptilian joint between a reduced quadrate and articular bone and the mammalian joint between the squamosal and dentary bones.

Evolutionary Tree of Dinosaurs

The Dinosaurs evolved during the Triassic period of the Mesozoic era from the ***Thecodonts.*** There are two main groups of Dinosaurs, namely the ***Saurischians*** (reptile-like dinosaurs) and ***Ornithischians*** (bird-like dinosaurs) which evolved from the Thecodonts. The Saurischians include the giant ***herbivorous Sauropods*** and the giant ***carnivorous Theropods.*** The Ornithischian dinosaurs include varied forms like ***plated*** dinosaurs, ***armoured*** dinosaurs, ***horned*** dinosaurs and the ***duck-bill*** dinosaurs.

Salient Features of Dinosaurs

Dinosaurs had the following salient features:

1. The term ***Dinosaurs*** was coined by ***Sir. Richard Owen.*** It means ***terrible lizards.***

2. They were the biggest animals ever lived on land.

3. They lived during the Mesozoic era. They were the dominant groups during the Mesozoic era. So Mesozoic era is called the ***Golden Age of Reptiles.***

4. No Dinosaurs live today.

5. Dinosaurs came in many shapes as well as many sizes.

6. Some walked on all four limbs, others walked only on their hind limbs.

7. There were herbivores, carnivores and omnivores.

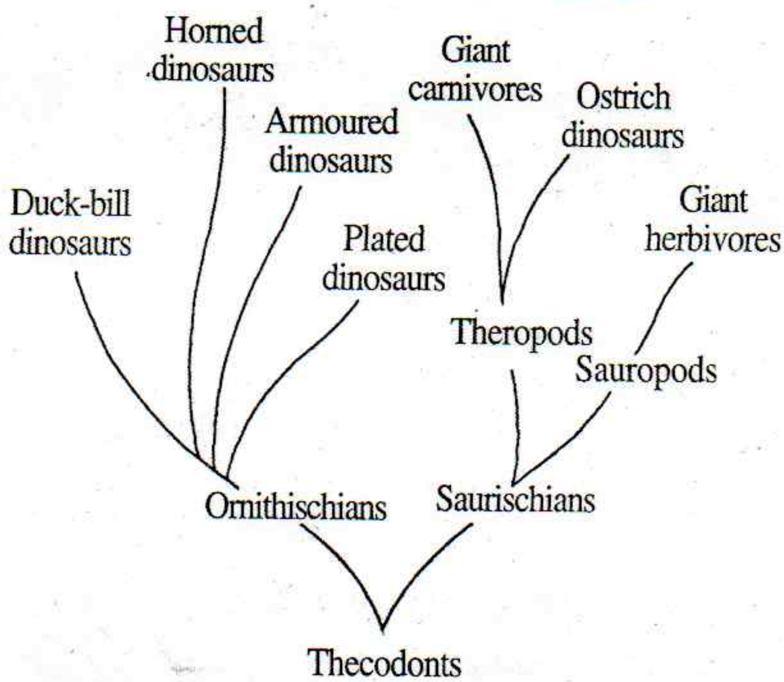


Fig.6.106: Family tree of dinosaurs.

8. They lived in all the habitats. There were land dinosaurs, flying dinosaurs and aquatic dinosaurs.

9. By the end of Mesozoic era all the Dinosaurs disappeared.

10. All the dinosaurs mysteriously vanished within one or two years. Not only dinosaurs died out. The flying Pterosaurs and swimming Mosasaurs and Plesiosaurs went with them. So did ammonites and some much smaller sea invertebrates.

Evolution of Reptiles

The ***Cotylosaurs*** gave rise to three groups of reptiles, namely ***Thecodonts, Therapsids*** and ***Ichthyosaurs.*** The thecodonts gave rise to ***Dinosaurs, Pterosaurs*** and ***Birds.*** The Therapsids were ***mammal***-like reptiles and they gave rise to mammals.

Decline of Mesozoic Reptiles

Dinosaurs roamed on the earth for about 160 million years. Then all of them mysteriously vanished. About 67 million years ago Dinosaurs still flourished. But two million years later all were extinct. All rocks formed since 65 million years ago contain no Dinosaur fossils.

Not only Dinosaurs died out. The flying Pterosaurs, swimming Mosasaurs and Plesiosaurs went with them. So did ammonites and some much smaller sea invertebrates. Scientists still puzzle over why so many animals disappeared so swiftly. Some fossil clues suggest these mass deaths happen in as little as a year or two. There are many theories about the cause of the extinction of Dinosaurs.

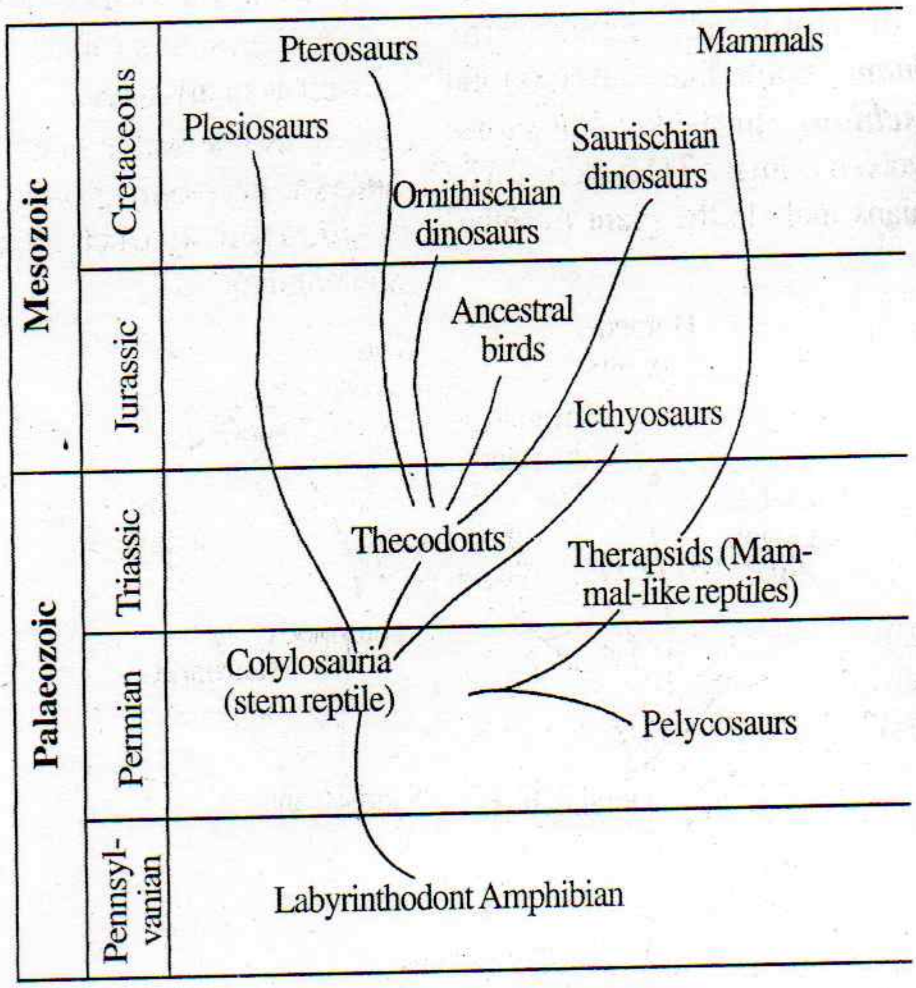


Fig.6.107: Family tree of reptiles.

They are the following:

1. Eruption Theory

This theory was proposed by ***Charles B.Officer et. al. (Nature,*** 1987). This theory explains the mass extinction of ***dinosaurs.*** This theory claims that widespread volcanism could be the real cause for mass extinction. Volcanoes led to the large scale emission of sulphur dioxide in the atmosphere. The sulphur dioxide destroyed the ozone umbrella and allowed in ultraviolet light to reach the surface of the Earth killing animals and plants. Smoke and dust blocked out the Sun. The climate cooled. Plants died. This led to the extinction of dinosaurs.

When there was rain the sulphur dioxide dissolved in rain water and this acid rain destroyed the marine life.

2. Competition

The extinction of dinosaurs is caused by the competition with the primitive mammals. The primitive mammals ate the eggs of dinosaurs and caused their downfall.

3. Epidemic

It is believed that most of the Mesozoic reptiles became extinct by epidemic, viral, bacterial or protozoan diseases.

4. Racial Senescence

It is believed that groups of organisms become old, just as individual organisms do and extinction follows from senile degeneration.

5. Large Size

Certain dinosaurs reached enormous size. They were too clumsy to survive.

6. Poor Faculty of Reproduction

The dinosaurs became extinct because they were unable to reproduce. This was caused by the failure of production of sperms because of too much heat. Too much of heat made their eggs all hatch out into males. Without females dinosaurs could not have gone on breeding.

7. Difficulty in Copulation

The dinosaurs were unable to copulate because of their large size.

8. Environmental Changes

During the end of Mesozoic era, environmental changes,began to take place. The vegetation changed. The temperature changed much. The giant dinosaurs experienced difficulties in regulating their body temperature corresponding to the environmental change.

9. Flowering Plants

Some authorities believed that the changed climate produced new kinds of flowering plants. They poisoned the plant eaters, so that the flesh eating dinosaurs were starved to death.

10. Carnivorous Habit

According to one school of thought the flesh eating dinosaurs were starved to death, because they had eaten all plant eating dinosaurs.

11. Collision Theory

This theory was proposed by ***Luis Alvarez*** and his son ***Walter Alvarez.*** They concluded that the mass extinction of dinosaurs must have been caused by the impact of an object from space with a diameter of 10 km. Such an object might be an ***asteroid*** or a ***comet.*** This collision kicked out enough dust in the atmosphere to block sun light for months and cool the Earth. The surface of the Earth would have grown dark and cold killing many plants and animals on every continent.

When the dust had settled, sunshine would have reached the land and sea again. But moisture still above the Earth might have trapped the sun's heat near the ground for years. Creatures that had lasted through the cold and dark might now have died of too much heat. Even if heat did not kill dinosaurs directly it could have made their eggs all hatch out into males. Without females, dinosaurs could not have gone on breeding.

Temporal Fossae and Arcades

The region of the skull behind the orbit is known as the ***temporal region***.

The ***temporal region*** of reptilian skull contains one or two cavities. These cavities of the skull are called ***temporal fossae***.

The temporal fossae are bordered by a set of bones. These bones form an arch or bar called ***arcade.*** The main function of the fossa is to provide space to the attachment of temporal muscles. The fossae and the temporal muscles help in the movement of lower jaw.

The temporal fossae play an important role in the classification of reptiles.

Based on the fossae, reptiles are classified into 4 groups, namely

1. *Anapsid*
2. *Synapsid*
3. *Euryapsid*
4. *Parapsid*
5. *Diapsid*

1. Anapsid

In this type of skull, the temporal region has no ***fossa.*** The stem reptiles had anapsid type of skull. Among the existing reptiles, the ***turtles*** and ***tortoises*** have retained the anapsid type of skull.

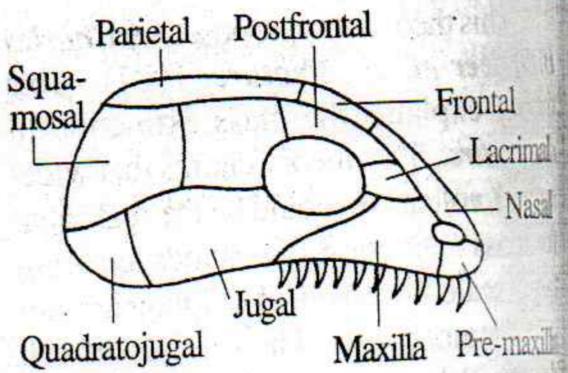


Fig.6.108: Anapsid skull.

2. Synapsid

In this type of skull, the temporal region has a single vacuity or fossa on each side of the skull. It is situated behind the orbit. The fossa is bounded above by the ***postorbital*** and ***squamosal*** and below by the ***quadratojugal*** and the ***jugal.*** The vacuity is known as ***infratemporal fossa*** and the bar of bone formed of quadratojugal and jugal is called ***infratemporal arcade. Pelycosaurians*** and ***mammal***-like reptiles had synapsid type of skull. The ***mammal***-like reptiles became extinct after giving rise to mammals. The synapsid type of skull is not present in the existing reptiles

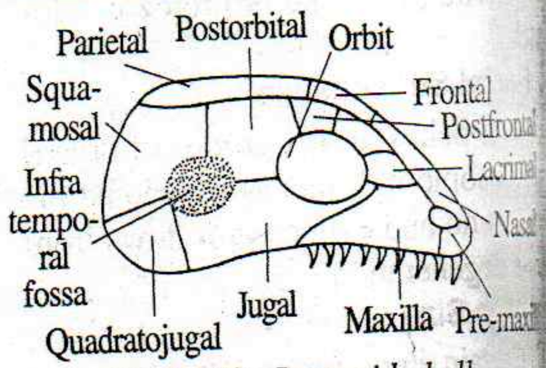


Fig.6.109: Synapsid skull.

3. Euryapsid

The euryapsid type of skull has also a single fossa on each side. But it is situated slightly above. Hence the fossa

7. It makes a nest in a hole on a tree.
8. It can be domesticated.

19. Drongo (Dicrurus adsimilis) (Karungkuruvy)

Phylum : *Chordata*
Subphylum : *Vertebrata*
Superclass : *Gnathostomata*
Class : *Aves*
Order : *Passeriformes*

1. Drongo is ***glossy black*** in colour.
2. The tail is long and deeply forked.
3. It is very often found perched on telegraph wires or near grazing cattle.
4. It is a solitary bird.
5. It is ***insectivorous*** in habit.
6. It constructs nests on the trees.

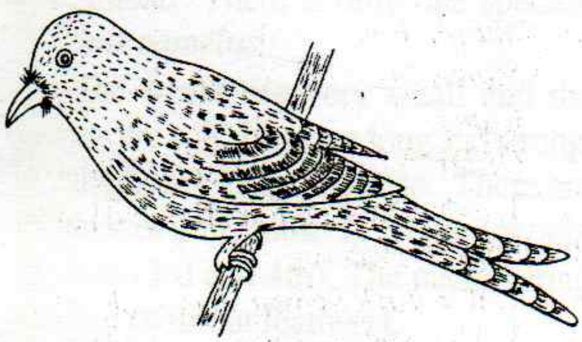


Fig.7.28: Drongo.

20. Archaeopteryx

Phylum : *Chordata*
Subphylum : *Vertebrata*
Superclass : *Gnathostomata*
Class : *Aves*
Subclass : *Archaeornithes*

Archaeopteryx is the ***first bird***.

It is a ***connecting link*** between reptiles and birds.

It is a ***fossil animal***. Hence it is called a ***missing link***.

Though it is a bird, it retains many reptilian characters. Hence it is intermediate between reptiles and birds.

Reptilian Characters

The following are the reptilian characters:

1. Jaws are provided with ***homodont*** teeth.
2. The tail is long, lizard-like and with 20 free caudal vertebrae.
3. Bones are not ***pneumatic***.
4. Cervical vertebrae are fewer, 9 or 19.

Avian Characters

The following are the avian characters of *Archaeopteryx*.

1. Presence of feathers. If the feathers of *Archaeopteryx* were not preserved in the fossil; it would have been taken for some bipedal diapsid reptile.
2. Fore limbs are modified as wings.
3. Tail bears two rows of feathers.
4. Rounded brain case.
5. Bones in the skull are intimately fused.
6. Beaks are present.

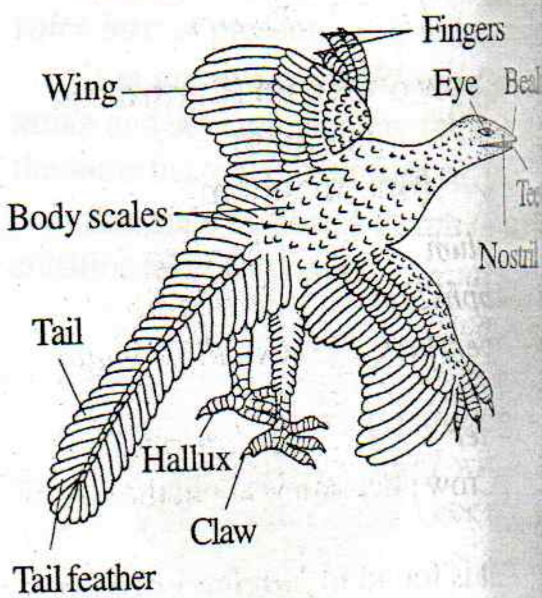


Fig7.29: Archaeopteryx, the connecting link between reptiles and birds

7. Bones of limbs and girdles are ***bird***-like.
8. A ***'V'***-shaped ***furcula*** is present.

9. Tibia and fibula are present.

10. A keel is present on the sternum.

Thus *Archaeopteryx* exhibits both reptilian and avian characters. However it is neither a bird nor a reptile.

21. Ostrich
(Struthio camelus)

Phylum : Chordata
Subphylum : Vertebrata
Superclass : Gnathostomata
Class : Aves
Order : Struthioniformes

Ostrich are the largest of living birds. They grow to a height of 2.4 metres and weigh about 157 kg. They are found in the arid and semiarid regions of Africa and Arabia. There is only one species, *Struthio camelus.*

The wings are very small and the feathers are soft. Legs are long and strong. The thighs are large and bare. There are no rectrices (tail feathers). There are only two toes (3rd and 4th). The neck is long and bare (without feathers).

Ostriches are ***omnivores*** but mainly ***herbivores.*** They have the habit of picking up and swallowing any bright or metallic objects.

Fig.7.30: Ostrich.

Ostriches are ***polygamous***. The males usually have one major hen and 2 or more minor hens. The male makes the nest in the sand about a foot deep and three feet long. All the hens lay their eggs in the same nest. The eggs are about six inches long and five inches in diameter. It weighs about 1.5 kg. The eggs hatch in 42 to 48 days. The youngones are ***precocious.***

22. Rhea americana
(South American ostrich)

Phylum : Chordata
Subphylum : Vertebrata
Superclass : Gnathostomata
Class : Aves
Order : Rheiformes

Rhea is ***flightless bird*** included in ***Ratitae***. It is an american bird.

The wings are small. The neck is long and covered with short feathers. The feathers have no aftershaft. The tail feathers are absent. The legs are long and stout. The feet bear three toes (2,3 and 4th) and all the toes bear claws. The ***syrinx*** or ***voice box*** is present.

It is ***omnivorous***. *Rhea* is ***polygamous*** and several hens lay their eggs in the same burrow (about fifty eggs).

The male incubates the eggs and incubation takes forty days.

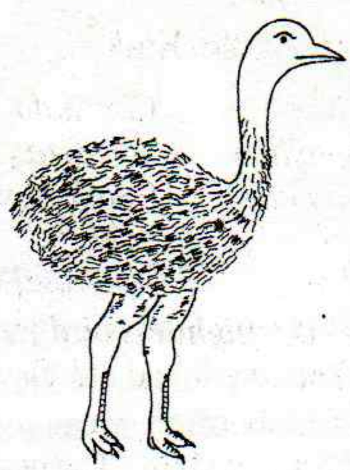


Fig.7.31: Rhea americana.

◆ Over exploitation of underground water brings in saltwater causing ***salinization*** of freshwater.

◆ The chemical ***fertilizers*** pollute the water and soil. The nitrate of the chemical fertilizer leaches into the under ground water and contaminate the drinking water.

◆ The ***pesticides*** applied on crop plants enter the human body through food chain and cause ill effects.

◆ Agriculture leads to the ***erosion of nutrient rich top soil.***

◆ In Agriculture, high yielding hybrid crop plants are produced and cultivated. Hence the traditional varieties and wild varieties are not cultivated and in the course of time they become extinct. This leads to ***genetic erosion.***

◆ Extension of cultivation leads to the destruction of natural vegetation.

◆ In Agriculture lands, there is top soil erosion. The eroded soil fill up reservoirs.

◆ Irrigation in Agriculture leads to ***water logging.***

Sustainable Agriculture and Food Production

The Agriculture must be made sustainable by creating ecosystem balance. It needs high production as well as conservation of natural environment. It is done by the following methods:

1. Regulated and limited use of pesticides.
2. Limited use of fertilizers.
3. Use of organic fertilizers.
4. Vermicomposting.
5. Maintaining proper drainage system.

36. Biodiversity and its Conservation

Biodiversity refers to the variety of plants and animals of an area.

Biodiversity is the ***degree of variety in nature.*** It is the ***totality of genes, species and ecosystems in a region.*** It indicates all inherited variations of living organisms living in a broad area. It can be defined as ***the variety*** and ***variability of life.*** It can be observed at ***gene level, species level*** and ***ecosystem level.***

The knowledge of biodiversity is very important for-

- ***Systematic studies*** on plants and animals.
- Identification of ***hot spots.***
- Ecosystem studies.
- Biogeographic studies.
- Proposing advance conservation programs.
- Enriching resources.
- Conservation of global ethics.

Genetic Diversity

Genetic diversity refers to *totality of all inherited genetic variations within a population.* A population is a group of similar individuals. All the genes of a population is called ***gene pool.***

As genetic variations usually lead to the development of new species, it seems to be the basis of species diversity.

Different ***sub-species*** of a species are distinct genetic entities. Each of such genetic entities of plants or animals is known as ***genetic resource.***

Each and every plant or animal group has its own kind of genetic material. Merging of the genetic material between the groups is not possible in conventional way. Therefore, they can easily be distinguished by ***DNA testing***. The variations may be due to ***natural hybridization.***

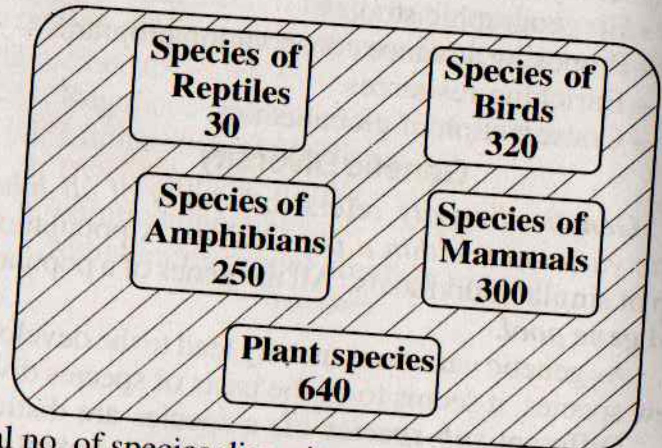
Now it is possible to transfer genes from any plant or animal to another by ***biotechnology.*** Several genes of wild plants have been introduced into plants for new industrial applications. Such genetically engineered plants or animals are genetic resources.

Species Diversity

Species diversity refers to the *total number of species of plants and animals in a biological community.* It is very important for the ***normal functioning*** and ***sustainability*** of ecosystems.

It is a product of ***species richness*** and ***species evenness*** in a community.

For example, a Wild Life Sanctuary is a ***biotic community.*** It is said that the sanctuary has 640 plant species, 300 species of mammals, 320 species of birds, 30 species of reptiles, and 250 species of amphibians. The total number of these groups 1540 constitute ***species diversity*** of the sanctuary.



Total no. of species diversity of a sanctuary = 1540.

Fig.36.1: Species diversity of a sanctuary.

The number of species and population abundance vary from community to community. Even within a community, the number of species and population abundance vary from locality to locality depending upon ***selection pressures gradients between the habitats*** (localities), ***climatic factors,*** etc.

R.H. Whittaker (1965) has pointed out three types of species diversity-

1. *α-index diversity*
2. *β-index diversity*
3. *γ-index diversity*

1. α-Index Diversity

α-index diversity is the *relative richness of different species in an area.* It represents the ***percentages of individuals*** of each and every species within a community.

The ***selection pressures common to the community*** determines the α-index diversity. For example, α-index diversity of bird species is similar in tropical and sub-tropical climates. But small variation in α-index diversity among communities within a general climate is due to ***interspecific*** and ***intraspecific competition*** among the species.

2. β-Index Diversity

β-index diversity is the *relative richness of different species along a gradient from one habitat to another habitat within the community.*

It is mainly due to variations in ***physical conditions*** of habitat.

It is determined by a ***narrow range of tolerance*** towards the particular environmental factor that shows the gradience.

Height is the factor which determines the ***pattern of diversity*** of plant and animal species between mountains and plains.

Water gradient determines the distribution of plants between forest and freshwater habitat.

3. γ-Index Diversity

γ-index diversity refers to the *richness of different species in a range of habitats within a geographical area.* It is a product of α-index diversity and β-index diversity.

Biodiversity of a continent, having seas, ocean, lakes, rivers, mountains, plains, forests, etc. is the examples of γ-index diversity.

Ecosystem Diversity

The *variation in species richness in different ecosystems of a geographical area* is called ***ecosystem diversity.***

Ecosystem is an ***ecological unit.*** It contains a variety of plants, animals and environmental factors. They interact with each other.

Forest is an ecosystem. Sea is another ecosystem.

Species diversity in River ecosystem

Species diversity in Lakes

Species diversity in Forest ecosystem

Species diversity in Ponds

Species diversity in Industrial areas

Species diversity in Agricultural fields

Species diversity in Marine ecosystem

A Geographical area

Fig.36.2: Ecosystem diversity.

Each and every ecosystem has a particular set of environmental conditions and allows a particular group of plants and animals to grow therein. Therefore species diversity differs from ecosystem to ecosystem.

Biogeographical Classification of India

The classification of land into different zones depending on the land animals and plants is the ***biogeographical classification.*** Each zone is called ***biogeographical zone.*** It has a unique ecology, biome representation, community and species.

Wallace (1876) divided the World into 6 regions. India belongs to the ***Oriental region.***

The oriental region is characterized by ***high mountains*** and ***thick forests.*** The fauna of oriental region is similar to ***Ethiopian region,*** but it differs from the latter by the ***absence of primitive forms.***

W.A. Rodgers and ***H.S. Panwar*** (1988) has divided India into ***10 major biogeographical zones.*** They are briefly mentioned below:

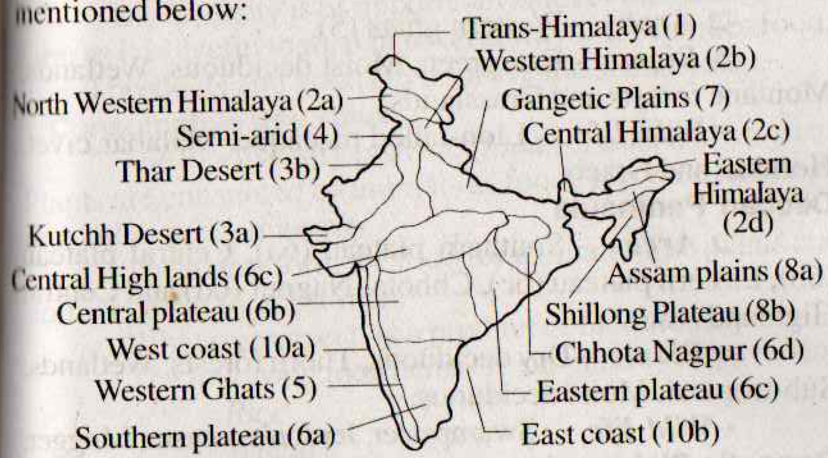


Fig.36.3: Biogeographical zones of India.

Trans-Himalaya (1)

❑ ***Area*** - Ladakh (J and K).

✲ ***Biome*** - Tundra valley, Lakes and Marshes.

• ***Wild life*** - Chiru, Black-necked Crane, Himalayan pit viper.

Himalaya

❑ ***Area*** - Himalaya, Kashmir, Himachal Pradesh, Assam.

☼ ***Biome*** - Alpine, Temperate ***conifer***, Temperate broad leaf, Sub-tropical.

• ***Wild life*** - Ibex, Red panda, Monal pheasant.

Indian Desert

❑ ***Area*** - Kutchh desert (3a) and Thar desert (3b).

☼ ***Biome*** - Salrflats, Scrublands, Desert grasslands.

• ***Wild life*** - Wild ass, Black buck, Flamingo, Desert monitor.

Semi-arid Province

❑ ***Area*** - Punjab and Gujarat-Rajuara (4).

☼ ***Biome*** - Scrublands, Bhabar forests, Wetlands, Dry deciduous hill and Thorn forests.

• ***Wild life*** - Tiger, Asiatic lion, Great Indian Bustard and Gharial.

Western Ghats

❑ ***Area*** - Western ghats (5).

☼ ***Biome*** - Evergreen, Moist deciduous, Wetlands, Montane forests and Grasslands.

• ***Wild life*** - Lion-tailed macaque, Malabar civet, Hornbill and Draco.

Deccan Peninsula

❑ ***Area*** - Southern plateau (6a), Central plateau (6b), Eastern plateau (6c), Chhota- Nagpur (6d) and Central Highlands (6e).

☼ ***Biome*** - Dry deciduous, Thorn forests, Wetlands, Sub-tropical, Moist deciduous.

• ***Wild life*** - Swamp deer, Jerdon's courser, Mugger.

Gangetic Plains

❑ ***Area*** - Lower and upper Gangetic plains (7).

☼ ***Biome*** - Alluvial plain, Wetlands, Rivers.

• ***Wild life*** - Rhino, Otter, Gangetic dolphin, Terrapin.

North-East India

❑ ***Area*** - Assam plains (8a) and Shillong plateau (8b).

☼ ***Biome*** - All plain grasslands, Woodlands, Bhatoar terai, Evergreen moist deciduous, Wetlands and Rivers, Sub-tropical temperate.

• ***Wild life*** - Pygmy hog, Serow, Yellow-backed sunbird.

Islands

❑ ***Area*** - Andaman and Nicobar (9a), Lakshadweep (9b).

☼ ***Biome*** - Evergreen moist deciduous, Sub-tropical temperate wetlands, Coastal habitat.

• ***Wild life*** - Dolphin, Narcondam hornbill, Olive ridley turtle.

Coasts

❑ ***Area*** - West coast (10a) and East coast (10b).

☼ ***Biome*** - Mangrove, Brackish lakes and Lagoons, Mudflats, Sandy or Rocky littoral.

• ***Wild life*** - Dugong, Brahminy kite, Sand skink.

Value of Biodiversity

Biodiversity is of important value for the human welfare, as it is useful to man in several ways. It provides food, useful products and goods to improve the social value.

1. Consumptive Use Value

The biodiversity provides ***food*** for man and his pets. Plants are consumed by animals as food. It is the ***consumptive value of biodiversity.***

The plants form the food for animals. The plants and animals form food for man.

Whatever we eat, is a product of biodiversity.

The following food items are supplied by biodiversity:

Rice	*Fruits*
Wheat	*Milk*
Corn	*Egg*
Cereals	*Meat*
Vegetables	*Fish*, etc

2. Productive Use Value

The ***marketable items*** of biodiversity form the productive use value.

Timber is obtained from forest. Cultivation of trees for timber is called ***silviculture.***

Agriculture produces food products. It creates ***green revolution.***

Aquaculture provides ***aquafood*** like fish. It creates ***blue revolution.***

Animal husbandry produces milk, egg and meat. It creates ***white revolution.***

Sericulture (rearing of silkworms) produces ***silk.***

Apiculture produces honey.

Pearl culture produces pearl.

Wild plants supply ***drugs*** such as ***quinine, morphine,*** etc.

Pesticides are extracted from plants. Eg. *Neem tree.*

Antibiotics are synthesized by microbes. Eg. *Penicillin from fungus.*

Microbes forms ***biofertilizers.*** Eg. *Rhizobium.*

Cotton is obtained from cotton plants.

Papers are manufactured from wood.

Biotechnology and genetic engineering are applied in enhance production.

Wild plants and animals are used to select useful genes. New varieties of plants and animals are created for better production.

3. Social Value

- Biodiversity has ***religious*** and ***cultural*** sentiments.
- Trees are worshiped as God. Eg. *Banyan tree, Pupil tree, Neem tree*, etc.
- ***Flowers, Tulsi, 'Punkan' leaves,*** etc. are used in pujas.
- ***Lime fruit, banana fruit*** and many other fruits are given to God.
- ***Sandal*** obtained from trees is used as a ***cosmetic*** in pujas.
- Banyan seedlings are planted in marriage tents with an anticipation that the life will flourish like a banyan tree.
- Goats, chicken, chicks, pigs, etc. are sacrificed for God.
- Cobra is worshiped as a God.

- ***Skins*** are used to make shoes, belts, bags, purses, etc.
- ***Tribal people*** collect honey from the forests and the mountains.
- Hunting in the forests is the main occupation of tribals.
- ***Herbs, shrubs, climbers*** and their ***roots*** are used as ayurvedic medicines.
- Domesticated animals are allowed to graze on grasslands.
- Trees on the road sides give shadow to passengers.

4. Ethical Value

Ethical value of biodiversity is the use of plant and animal species in a right way. It simply means the ***moral use*** of plants and animals.

- In the biodiversity, man is only a small fraction, when compared to all other species. Every species has the right to live. Man has no right to destroy them. If he destroys, the nature will destroy him.
- In the Indian culture, people are chewing betel leaves, areca nut, tobacco along with lime in daily life and in special occasions. ***Betel transaction*** is one of the major ceremonies in Hindu marriages. Hence betel leaves are cultivated.
- Poor people construct huts with thatched roofs. The floor is seared with cowdung. Hence coconut trees and cows are reared.
- Tea and coffee are used to refresh.
- Toddy, taken from coconut and palmyra, have been used by several people.
  - Wine (grapes).
  - Whiskey (corn, rye and malt).
  - Brandy (peach, apple and orange).
  - Rum (cane and beet molasses).
- Smoking cigarettes, cigars, beedi and pipes made from *Nicotiana tobaccum* (tobacco) is one of the major health issue in recent years.
- Latex of *Calotropis procera* is used to induce abortion in some areas.

• Several plant and animal products are offered to satisfy the God.

5. Aesthetic Value

The use of plants and animals in beautifying the surrounding is said to be their ***aesthetic value.***

Biodiversity includes attractive species of plants, animals and birds, which give a natural beauty to the habitat. Examples-

• Ornamental plants are grown in hanging baskets in rooms and home gardens to beautify the surrounding.

• Beautiful birds are reared in small cabinets.

• Ornamental fishes having various colours are grown in glass containers to enhance the beauty of the indoor environment.

• Zoos and Museum harbouring different species of animals and birds attract so many people and children.

• Trees with attractive flowers and dense vegetation on hills increase the touristic value of the regions.

• Parks in cities and towns are visited by thousands of people every day because of their aesthetic value given by attractive flowers and plants.

6. Optional Value

Optional value refers to *use of different species of organisms to fulfil the specific wishes of people.* The wish may either be concerned with protection of environment or with protection of health. In these cases, biodiversity alone is the right choice for getting the wishes filled.

• In some areas, where cyclones are very frequent, dense vegetation is grown to reduce the speed of wind so that people can escape from direct effects of the cyclones.

• Genetically engineered animals and microbes give many valuable products which protect the health.

• Genetically engineered plants meet some specific needs of people-

☆ Reducing the use of fertilizers.

☆ Producing food grains rich in specific amino acids.

☆ Producing products with more storage life.

☆ Producing products which contain vaccines.

• Medicinal plants are grown and sent to far away places to get an income.

• Some poisonous plants are grown along the margin of farms to prevent the entry of cattle in the farm.

Biodiversity at Global Level

Our Earth is the natural habitat for about ***20 million species*** of living beings, including plants, animals and micro-organisms. Of these, only 1.7 million organisms alone have been described scientifically.

Among plants, Angiosperms constitute the largest number of species in the World and in the animal kingdom Arthropods are dominant.

Species diversity of plant taxa living in the World is listed below:

Taxa	Species
☆ Bacteria	4,000
☆ Viruses	4,000
☆ Algae	40,000
☆ Fungi	72,000
☆ Lichens	17,000
☆ Bryophytes	16,000
☆ Pteridophytes	13,000
☆ Gymnosperms	750
☆ Angiosperms	2,50,000

Species diversity of different animal taxa in the World is listed hereunder:

Taxa	Species
☆ Protista	31,259
☆ Mollusca	66,535
☆ Arthropoda	9,87,949
☆ Other invertebrates	87,121
☆ Protochordata	2,106
☆ Pisces	21,723
☆ Amphibia	5,150
☆ Reptilia	5,817

- Aves 9,026
- Mammalia 4,629

Biodiversity at National Level

India is a tropical country. It lies between 68'.7° and 97'.25° East and 8'.4° and 37'.6° North the equator. It covers a total of ***32 million hectares.*** It is one of the 12 ***mega diversity*** centres of the World.

India is very rich in plant diversity. It has

- *850 species of Bacteria* (21.25%).
- *Many Viruses* (Not recorded correctly).
- *6,500 species of Algae* (16.25%).
- *14,500 species of Fungi* (20.14%).
- *2,000 species of Bryophytes* (17.80%).
- *1,100 species of Pteridophytes* (8.46%).
- *64 species of Gymnosperms* (8.53%).
- *17,500 species of Angiosperms* (7%).

India accounts for ***7.31%*** of the global faunal diversity. It has

- *2,577 species of Protista.*
- *5,070 species of Mollusca.*
- *68,389 species of Arthropoda.*
- *8,329 species of Other invertebrates.*
- *119 species of Protochordata..*
- *2,546 species of Pisces.*
- *209 species of Amphibia.*
- *456 species of Reptilia.*
- *1,232 species of Aves.*
- *390 species of Mammals.*

The richness of biodiversity in India is mainly due to the ***wide variety of climatic*** and ***altitudinal conditions*** characteristic of this country. The climate varies from humid tropical area (Western Ghats) to icy mountains (Trans-Himalaya) via hot desert (Thar) and plains.

The ***ten biogeographical regions*** of this country form a wide variety of ***ecological habitats*** which give shelter to so many kinds of plants and animals.

In 1990, ***Mc Neely*** *et.al.,* have noticed that about 70% of the total flowering plants occur in 12 countries. Hence these countries are known as ***mega-diversity countries*** or ***mega-diversity centres. India*** is one of the 12 mega-diversity nations of the World.

India covers only 2.4% of the total area of the World, but it has 11% of the World's total biota, ie.45,500 species of plants and 86,874 species of animals. The total number of species is rather crude and many species may not be described yet. However, the present data confirms that India ranks 10th in the World and 4th in Asia in plant diversity.

Fungal species of India contribute 18.23% of the World's fungal flora. Angiospermic species of India contribute 13.50% of the World's Angiosperms.

Many plant species recorded in India are also found in neighbouring countries such as Malaya, Tibet, China, Japan, Europe and Africa. Some Indian species are found to be reported in far away countries like the USA and Australia.

India has more than 7% of the total animal species in the World. Even now many new species belonging to ***Nemertinea, Nematomorpha, Pogonophora,*** etc. have been reported every year.

India possesses about 86,874 species of animals, of which insects comprise 68.3% and chordates comprise 5.7%. About 35% of the insects are endemic to India. Besides this, many leeches, sponges and molluscs are also endemic to India. Endemism is also shown by amphibians, reptiles, birds, mammals and fishes.

India has only 2.4% of the World's land area but its biodiversity is ***11% of World's biodiversity.***

Many species are endemic to India and some show discontinuous distribution against migration barriers like seas. Hence, India is considered to be one of the ***mega-diversity*** nations of the World.

Biodiversity of Tamilnadu

Tamilnadu, the South most state of India, lies between 8'.4° and 13'.4° North from the equator. It possesses ***tropi-***

cal climate. It has several hill stations such as Mahendraghri hills, Tirunelveli hills, Nilgiri hills, Palani hills, Anamalai, Alagar hills, etc. which present a diverse topography to the State. Tamilnadu has humid tropical, dry and semi-dry and temperate climates.

The biodiversity of Tamilnadu State is poorly illustrated one. The number of species of bacteria, viruses, algae and bryophytes existing in this State is not yet known correctly. There are about 123 species of pteridophytes, 12 species of gymnosperms and about 2,300 species of Angiosperms.

Tamilnadu has about 4,473 species of invertebrates, 32 species of protochordates, 108 species of fishes, 88 species of amphibians, 89 species of reptiles, 43 species of mammals and 349 species of birds.

Many species of plants and animals are ***endemic*** to this State.

Hot Spots of Biodiversity

Hot spots are ***biorich*** areas. *The area which is rich in plant and animal species, of which many are endemic and endangered* is called ***biodiversity hot spot.*** The threat may be due to ***pollution, land cleaning, development pressures, salinity, weeds,*** etc.

Myers** et.al.*, (2000) have identified ***25 biodiversity hot spots in India.

Eg. *Western Ghats, Eastern Himalayas, Andaman-Nicobar islands, North-West Himalayas,* etc.

The Western Ghats is one of the diversity hot spots in India. It comprises a range of coastal hills and the adjoining coastal lowlands extending from Tapti river in Gujarat to Southern tip of peninsula. It includes Maharashtra, Karnataka, Tamilnadu, Kerala and Goa. It covers the total area of ***1,70,000*** sq.km.

The Western Ghats shows high level of endemism for ***plants, invertebrates*** and ***vertebrates.*** India has about 5,150 species restricted to the Western Ghats. That is, 30% of endemic plants in India are seen in the Western Ghats.

There are many endemic vertebrates in the Western Ghats. They include 12 species of mammals, 13 species of birds, 89 species of reptiles, 88 species of amphibians and 108 species of freshwater fishes. Thus the Western Ghats has a total of 310 endemic vertebrates among the total of 32,678 species in the World. It is 0.95% of all known vertebrates.

Endemism in invertebrates in the Western Ghats is not known clearly, but it is said that it has many endemic molluscs, insects and worms.

There has been a serious threat to the biodiversity of the Western Ghats due to ***land cleaning*** for different purposes. The biodiversity has been disappearing at a rate of 1-3% per year and many species faces the danger of extinction. Therefore, the Western Ghats is said to be a ***biodiversity hot spot.***

Threats to Biodiversity

The causes of biodiversity loss are said to be ***threats to biodiversity.*** Biodiversity loss may be caused by ***habitat loss, poaching and hunting of wild animals, man-wildlife conflicts,*** etc. As the nature of threats increases, more and more species are forced towards extinction. As a result, the species become ***endangered*** in the area.

1. Habitat Loss

The destruction of habitat of plants and animals is called ***habitat loss.*** Specific plant and animal species prefer to live in a particular habitat. When the habitat is destroyed, the species living therein are under threat of extinction.

Quarrying in natural habitat of wildlife, ***constructing dams, felling of trees, cleaning of land*** for agriculture and plantation purpose, deforestation and ***setting fires*** are the major causes for habitat loss. Examples-

• ***Begonia*** and ***Habenaria*** are plants mainly living on rocks of the Western Ghats. They formed luxuriant growth before quarrying the rocks with ***dynamite.*** As quarrying continues, these rocky species were forced to extinction.

Now these species are altogether absent in part of Western Ghats in Kanyakumari district of Tamilnadu.

• The loss of huge trees in Muthukuzhi vayal leads to reduction in the number of flying lizard (*Draco dussumieri*), the ***Great Indian Hornbill*** and ***Large Pied Hornbill.***

• In the Southern part of Western Ghats where evergreen forests occur, ***lion tailed macaque*** were once found in large numbers. It has become endangered due to loss of habitat.

• Deforestation is known to be the major cause of species extinction in the next 50 years (***P.T.Cherian,*** 1998). Because of the deforestation, 5-15% of species may be eliminated by the year 2020.

2. Poaching and Hunting of Wild Animals

Poaching and hunting of wild animals are the main causes of wildlife depletion. Examples-

❀ Passenger pigeon (*Ecotopistes migratorius*) of North America is good to eat and easy to kill. Thousands of people started to poach and hunt the passenger pigeon in 1980 for eating and commercial purposes. Therefore, by the year 2000, the pigeon species has been at the stage of extinction.

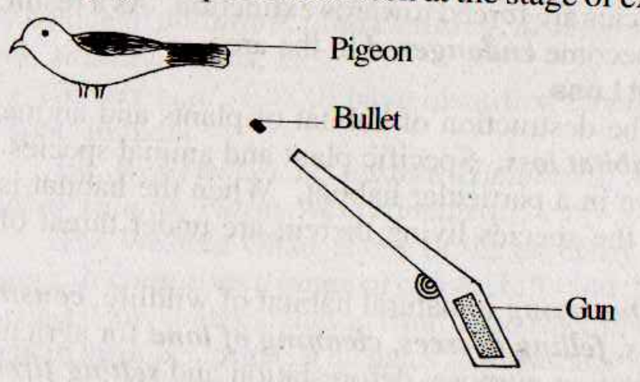


Fig.36.4: Hunting of pigeon.

❀ Nilgiri tahr (*Hemitragus hylocrius*) is endemic to the Western Ghats. Because of unrestricted poaching and hunting, this species is now seen in small numbers in the Western Ghats.

❀ Elephants (*Elephas maximus*) have been shot down at several places by poachers for their ***tusks.*** Due to unrestricted poaching and hunting the elephant species is now in threat of extinction.

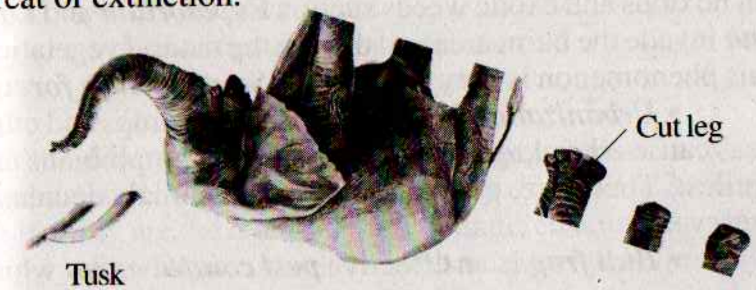


Fig.36.5: Killed elephant.

❀ In Palkulam area of the Western Ghats, a large area of natural forest has been converted into monoculture plantations of rubber and clove. The tiger (*Panthera hylocrius*) frequently enter the monoculture plantations. Therefore, private bodies have shot down them in large numbers. This species is now in threat.

Fig.36.6: Panthera tiger.

3. Man-Wildlife Conflicts

There has been a series of struggles between man and wildlife for their existence and well-being. It is often called ***man-wildlife conflicts.*** This struggle is ***harmful*** to biodiversity. Examples-

⁕ ***People of hilly regions*** catch fishes from ponds and ditches by adding extracts of roots of certain plants belonging to ***Asclepiadaceae*** and ***Apocyanaceae.*** This act is useful to catch fishes, but the entire fish population is killed.

* Some people in forests set fire to destroy ground vegetation so that fresh growth of ground flora may appear. But noxious and exotic weeds such as ***Eupatorium*** and ***Lantana*** invade the burnt area and disturb the natural vegetation. This phenomenon is very common in ***South Indian forests.***

* ***Urbanization*** in low grasslands, swamps and other areas causes shrinkage of breeding sites for amphibians and reptiles. Therefore, population of these animals decreases every year.

* ***Bull frog*** is an effective ***pest control agent*** which feeds on many types of insect pests in agricultural fields. This was ***exported*** once to other countries so that the number of ***frogs decreased*** every year. Now the export was banned by the Government.

* ***Pesticides*** and ***fertilizers*** added to the agricultural fields affects the growth and survival of many aquatic animals. It also affects the ***birds*** indirectly.

Endangered Species of India

Many species of plants and animals are facing the problems of extinction and becoming lesser in number every year. These species are called ***endangered species.***

Endangering of a species may be caused by-

- ☆ Habitat loss
- ☆ Felling of trees
- ☆ Cleaning of forest areas
- ☆ Deforestation
- ☆ Quarrying in forest areas
- ☆ Poaching and hunting
- ☆ Export to other countries

The Western Ghats is the natural and only habitat for ***lion-tailed macaque.*** Once this species was seen in large numbers in the forests; but now because of habitat loss only a few animals are seen. Now this animal, is more or less at the stage of extinction. Therefore, it is considered to be an ***endangered species.***

In India, about 450 species of plants are found to be endangered species by the ***Botanical Survey of India (BSI)*** in 1998. Examples-

- *Rhododendron arizelum*
- *Camellia caduca*
- *Meconopsis betonicifolia*
- *Psiloltum companulatum*
- *Piper barberi*

Many Indian species of animals are also found to be endangered by the ***Zoological Survey of India*** in 2000. The following are the examples of endangered animals in India:

Primates : Hoolock gibbon, Lion-tailed macaque, Nilgiri langur, etc.

Carnivora : Jackal, Indian fox, Wild dog, Tiger civet, Jungle cat, etc.

Perissodactyla : Great Indian one-horned rhinoceros, Tibetian wild ass, etc.

Artiodactyla : Andaman wild pig, Alpine musk deer, Indian bison, etc.

Logomorpha : Assam rabbit

Rodentia : 11 species of flying squirrels

Cetacea : Gangetic dolphin, Baleen Whales.

Birds : Eagles, Peacock pheasant, Hooded crane, Nicobar pigeon, Bengal florican, etc.

Reptiles : Trunk turtle, Estuarine crocodile, Monitor lizard.

Amphibia : Viviparous toad, Indian salamander.

Crustacea : Coconut crab.

Insecta : 55 species of butterflies and moths.

Endemic Species of India

The occurrence of a taxa in a small area and nowhere else, is called ***endemism.*** The species which is distributed only in a small restricted area is known as an ***endemic species.***

It is an ***isolated distributions*** of plants and animals.

The idea of endemic distribution of plants was first given be ***A.P. de Candole*** in 1813.

Biodiversity of India shows high level of endemism. Nearly 33% of plant species, identified in India, are found in the North-East Western Ghats, North-West Himalayas and Andaman and Nicobar islands. There are about 167 cultivated species and 320 wild relatives in India. So it is considered to be one of the centres of origin of cultivated plants. At present nearly 30,000-50,000 varieties of cultivated plants are found in India.

India has a total of 49,219 plant species, of which 5,150 species are endemic to the country. The endemic plants include about 200 species of ***Pteridophytes*** and 4,950 species of ***Angiospermic*** plants. Nearly 1,650 endemic species are recorded from the Western Ghats and 3,500 endemic plants are recorded from the Himalayas and the adjoining areas.

The following are examples of endemic plants of India:

- *Caryota urens*
- *Aegle marmelos*
- *Saraca indica*
- *Ficus religiosa*
- *Piper longum*
- *Elettaria cardamomum*
- *Indigofera tinctoria*
- *Aralia malabarica*

In India, there are about 17,612 species of endemic animals:

- *967 species of Mollusca.*
- *16,214 species of Insecta.*
- *110 species of Amphibia.*
- *214 species of Reptilia.*
- *69 species of Aves.*
- *38 species of Mammalia.*

The endemic species are restricted to small areas in distribution; they are forced towards extinction.

Nearly 62% of endemic amphibians of India are found in the Western Ghats. Similarly 50% of endemic reptiles are restricted to the Western Ghats.

Endemic Insects : *Chloroneura, Indoneura, Esme, Phylloneura,* etc.

Endemic Birds : *Nilgiri Wood Pigeon, Malabar Parakeet, Rufous babbler, Nilgiri pipit.*

Endemic Reptile : *Gauialis ganeticus* (crocodile).

Conservation of Biodiversity

The maintenance and preservation of biodiversity is called ***biodiversity conservation.*** It is the conservation different species of plants and animals.

The biodiversity has to be conserved to keep an ecological equilibrium necessary for maintaining a sustainable environment for future generation. The conservation of biodiversity is of two types. They are

1. *In-situ conservation*
2. *Ex-situ conservation*

1. In-situ Conservation

The conservation of genetic resources (different species) in their natural habitats or man-made ecosystems is called ***in-situ conservation.*** It is an easy and suitable method for the maintenance of many plant and animal species.

An area is selected and declared to be a protected area and special measures are taken to conserve the biodiversity. Viable populations of different species are allowed to grow by offering proper protection.

If the ecosystem of the area is badly degraded, the threatened species are rehabilitated and maintained properly.

If an animal species is threatened, it is breed in a suitable Zoo and re-introduced to preserve it in the ecosystem.

Those species which harmfully affect the sustainability of biodiversity are maintained at controlled level.

National Parks, Sanctuaries, Nature Reserves, Natural Monuments, Cultural Landscapes, Biosphere Reserves are used for in-situ conservation.

2. Ex-situ Conservation

Ex-situ conservation is the *conservation of genetic resources outside their natural habitats.* Plant, animal and microbial species are preserved in ex-situ conservation sys tems. For ex-situ conservation genetic resources are main tained in -

- Zoos (for animals)
- Botanical gardens (for plants)
- Culture collections (for micro-organisms)
- Cryobanks (for gametes, cells and tissues).
- Germplasm banks (for seeds, semen, cells, ova),

The ***Centre for Plant Genetic Resources,*** New Delhi has maintained cultured tissues, pollen, seeds, etc. The preserved specimen may be carried to in-situ conservation systems for proper maintenance.

37. Environmental Pollution

'***Pollution*** *is an undesirable change in the physi chemical or biological characteristics of our air, land water that will harmfully affect the human life and desirable species or that may waste or deteriorate our r material resources'*-***Odum.***

Pollution is the deliberate or accidental contaminati of the environment with man's waste.

Pollution is defined as *matter in the wrong place.*

According to ***Melaughlin*** pollution is defined as *th introduction by man of waste matter or surplus energy int the environment, which directly or indirectly causes damage to man and his environment.*

Edwards defined pollution as *the release of substances or energy into the environment by man in quantities that damage either his health or resources.*

Continued economic growth, mismanagement of resources and population explosion have an explosive impact on the environment. Now *our Earth has become a very sick planet and urgently needs a cure.* A disaster is looming unless everybody joins hands to take on the environmental dangers and to find ways to halt the march to mankinds destruction.

Pollutants

The substances or factors which affect the normal functioning of human life and domesticated species when introduced into the biosphere, are called ***pollutants***. The important pollutants are as follows:

20. Wild Life Conservation

Wild life refers to the *uncultivated species of plants and animals living in their natural habitat.* Wild life management refers to the protection, preservation, perpetuation and judicious control of populations of rare species of plants and animals in their natural habitat.

Aims of Wild Life Conservation

Wild life conservation has the following aims:

1. To protect and preserve the rare species of plants and animals from ***extinction***.

2. To preserve the ***breeding*** stock.

3. To prevent ***deforestation***.

4. To maintain the balance of nature.

5. To study the ecological relations of the plants and animals in natural habitat.

Necessity for Conservation

The conservation of wild life provides the following advantages and benefits :

1. Balance of Nature

Conservation of life maintains a balance of nature. Examples: a. When all the herbivorous animals in a forest are killed the tiger and lions enter human settlements and attack human beings and domesticated species. b. The killing of snakes for their skin allows the rat population to increase enormously.

Genetic Resource

The wild flora and fauna are a rich resource of genes which are used in breeding new forms of plants and animals with desirable characters like disease resistance, high productivity, ecological amplitude, etc. This calls for the preservation of wild life as an important genetic resource.

Economic Value

Wild life is a wealth of the country and it is a good source of income. Wild life yields timber, firewood, hides, ivory, horns, etc. Live and dead animals can be stored in Zoos and Museums for exhibition.

Recreation

Wild life forms a source of enjoyment and recreation to human beings.

Education

Visits to sanctuaries give education to the students of schools and colleges.

Causes for Wild Life Depletion

The decline and depletion of wild life is caused by the following factors:

1. Deforestation

2. Hunting

3. Poaching

4. Conversion of wild life habitats into house sites, into transport routes, agricultural land, industrial sites, etc. for our increasing population.

5. Establishment of hydroelectric projects. Eg. *The Silent Valley in Kerala.*

6. Pollution

7. Poor breeding potential in wild animals.

8. The breeding of wild animals near human dwellings. For example, marine turtles breed on the sea shore and their eggs are stolen by human beings.

9. Natural calamities such as flood, droughts, fires, epidemics, etc.

Endangered Species

During the last 2000 years about 106 species of ani
and 139 species of birds have become extinct. Now it is es
mated that about 600 species of birds and animals are prob
become extinct, if proper protective measures are not ta
These species are called ***endangered*** species. Most of the e
dangered species are mammals. Some of them are as follow

Mammals

Loris tardigradus - Slender loris
Nycticebus coucang - Slow loris
Macaca silenus - Lion tailed monkey
Presbytis johni - Nilgiri langur
Manis - Scaly ant-eater
Canis lupus - Wolf
C. cureus - Jackal
Vulpes vulpes - Red fox
Ursus arctos - Brown bear
U. torqualus - Black bear
Melursus - Sloth bear
Viverra megaspilla - Malabar civet
Panthera leo - Lion
P. tigris - Tiger

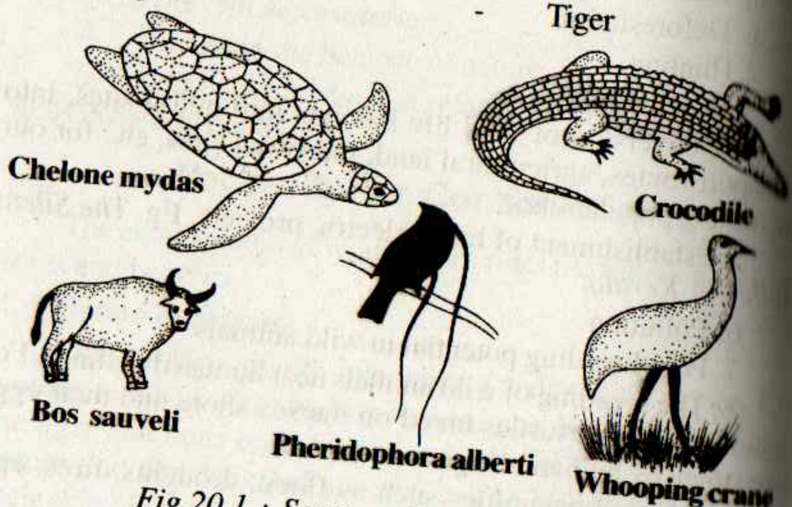


Fig.20.1 : Some endangered animals.

Panthera pardus - Leopard
Acinonyx tigris - Cheetah
Rhinoceros unicornis - Rhino
Asinus hemionus - Wild ass
Cervus elephus - Kashmir stag
C. duvauceli - Swamp deer
Moschus sifanicus - Musk deer
Antelope cervicapra - Black buck
Gazella dorcas - Indian gazella
Bos gaurus - Indian bison
Bubalus bubalis - Wild buffalo
Petinomys fuscocapillus - Flying squirrel
Loxodonta africana - African elephant
Elephas maximus - Indian elephant
Petaurista petaurista - Giant flying squirrel
Platinista gangetica - Ganga dolphin

Birds

Cairina scutalata - White winged ducks
Cygnus columbianus - Whistling swan
C. olor - Mute swan
Cygnus cygnus - Whooper swan
Avicada leuphotes - Indian falcon
Heliacetus leucogaster - Sea eagle
Galloperdix spadicea - Red spurfowl
Ophrysia superciliosa - Mountain quail
Otis tetrax - Little bustard
Ardeots nigriceps - Great bustard
Ptilolaemus - Hornbill
Pavo cristatus - Peacock

Reptiles

Dermochelys - Leather back turtle
Chelone mydas - Green turtle
Butagur baska - Box tortoise
Crocodilus porosus - Estuarine turtle
C. palustris - Marsh crocodile
Python molurus - Python
P. reticulata - Python

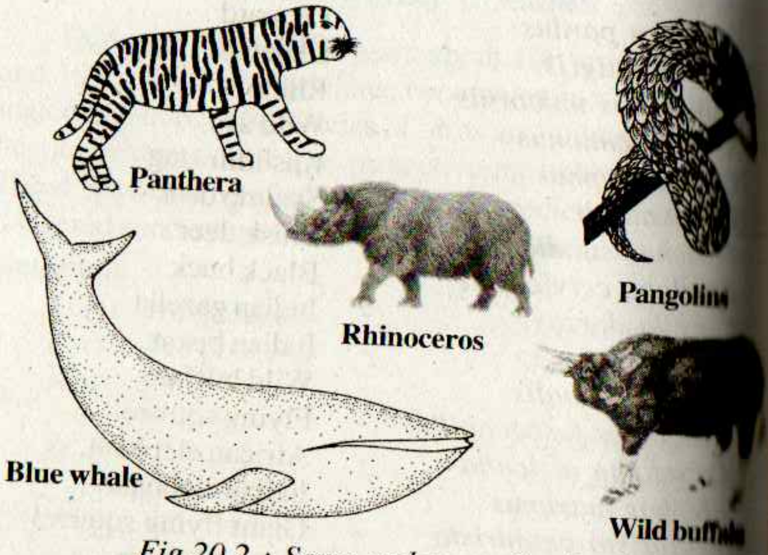


Fig.20.2 : Some endangered animals.

Amphibia

Tylototriton verrucosus	-	Himalayan newt
Nectophryne tuberculosa	-	Viviparous toad

Methods of Conservation

1. Knowledge of Wild Life

For proper management of wild life a thorough knowl of the ecology of wild animals is essential.

2. Appointment of Officials

The management of wild life is made effective by appoi ing suitable officials. These officials should have inherent l for wild life and they should be given required training.

3. Protective Laws

Restrictive laws should be framed at the Government lev to prevent the exploitation of endangered species.

India was the first country to enact a Wild Life Protecti Act. The following acts have been framed so far:

1. The Wild Birds and Animals Protection Act of 18

2. Forest Act XVI, 1927 : It was enacted for the prote tion of games.

3. Indian Board for Wild Life, 1952.

4. The Wild Life Protection Act of 1972 : This act prohibits the hunting of females. Chief Wild Life Wardens and authorized officers are appointed to watch. 1. the possession, trapping and the shooting of wild animals alive or dead; 2. the serving of their meat in eating houses; 3. their transportation and export.

5. Restriction of Hunting : When hunting licence is given instruction should be given to hunters not to hunt the endangered species.

6. Poaching : Poaching is the illegal exploitation of wild species. The offenders should be severely punished.

7. Habitat Improvement : Habitats of wild life should be improved by constructing ***water holes*** and ***salt-licks*** and by raising plantations of better and nourishing todder grasses and trees.

8. Restoration of Habitats : Disturbances caused to wild life must be removed. Forest that has been denuded earlier can be restored by reforestation. Polluted rivers can be made clean by treating the effluents.

9. Clonal Bank : The cells of rare species of plants are collected, preserved and stored safely. In case, these plants become extinct the preserved cells can be cultured and grown into plants. This is called ***clonal bank*** system.

10. Provision for Shelter and Cover : The survival of wild animals can be encouraged by providing natural shelter and cover. This can be achieved by rearing herbs and shrubs.

11. Artificial Stocking : Certain species can be introduced into a new area by importing them from another area.

12. Game Farming : The endangered species can be reared in protected areas and then they can be released in their natural habitat. Eg. *The marine turtles lay their eggs on the sea shore.* The eggs can be collected and hatched in the laboratories and the young ones are released into the sea.

13. Epidemic Control : Veterinary experts should be appointed to take care of wild life.

14. Census: Effective census operations should be adopted to measure the population sizes of various wild animals.

15. Educating the Public : Common men should be properly educated about the advantages and disadvantages of wild life.

16. Establishment of Sanctuaries and National Parks: Wild animals can be well protected by establishing sanctuaries and national parks. These sanctuaries and parks provide protection and optimum living conditions to wild animals.

Organizations Involved in Wild Life Conservation

A number of bodies and organizations are put in wild life management. They are the following:

1. International Union for Conservation of Nature and Natural Resources (IUCN)

It is established in 1948. It is an independent international agency. It convenes a General Assembly every third year. The main objective of IUCN is to promote and support action that will ensure the perpetuation of wild nature and natural resources in as many parts of the World as possible. It provides awareness, assistance and research facilities.

2. World Wild Life Fund (WWF)

It was established in 1961 in Switzerland. It has the membership of 23 countries including ***India***.

In 1986, World Wild life Fund was renamed as ***World Wide Fund for Nature***.

3. WWF-India

WWF-India was founded in 1969. Its headquarter is in ***Bombay***. Its main aims are conservation, education and research. Some of the important projects undertaken and supported by WWF-India are

1. Andaman Pig Study
2. Crane Conservation Project
3. Crocodile Breeding Project

4. Ecological Survey of Western Ghats
5. Sloth Bear Project
6. Status Survey of Sea Turtle.

Wild Life Preservation Society of India

It is a voluntary organization founded by wild life lovers in ***Dehradun*** in 1958. It is a member of IUCN. It has the following aims:

1. It promotes interest in wild life.
2. It imports knowledge in the protection of wild life.
3. It co-operates with the Government in the protection of wild life.
4. It assists in enforcing wild life protection acts.
5. It promotes wild life tourism.
6. It advises and helps the Government and wild life administrators in the formation, maintenance and protection of National Parks and Sanctuaries.

Bombay Natural History Society

It is a non-Government body founded in 1883. It is dedicated to the cause of nature conservation. It has been actively engaged in collecting information and specimens of fauna and flora throughout India, Burma and Sri Lanka. Its publication is serving the cause of nature conservation through publication of articles and new report on fauna and flora.

Indian Board for Wild Life

IBWL is constituted in 1952. It has a Bird Wing and a Zoo Wing to deal with the study and preservation of birds and animals and the development of Zoological gardens and Parks in the country. The main functions of IBWL are :

1. It helps to set up National Parks, Sanctuaries and Zoological Gardens for preserving wild life in their natural habitat.

2. It devices ways and means for the protection of wild life through co-ordinated legislature and practical measures, with particular reference to declaration of certain species of animals as protected animals and prevention of indiscriminate killing.

3. It promotes public interest in wild life and the need for its preservation in harmony with natural and human environment.

4. It prevents cruetly to beasts and birds caught alive.

5. It advises the Government on policy in respect of living animals, trophies, skins, furs, feathers, ivory and other wild life products.

7. State Boards for Wild Life (SBWL)

It is constituted at all States in India. It does the same functions as the IBWL but at the State level. It enforces legislation effectively against poaching and illegal killing of game birds and other animals. It celebrates ***Wild Life Week*** in the first week of October every year with the aim to educate people on wild life.

8. National Wild life Action Plan

The NWAP was constituted in 1983. Under this plan the protected area is proposed to be increased to cover 4% of the geographical area as against 3% at present.

9. Red Data Books

It is introduced in the 7th plan. RDB will give a complete list of all endangered animals and plants in the country. About 253 species of animals and about 2000 species of plants are reported to be endangered.

Sanctuaries and National Parks

Sanctuaries are *forest areas where the killing and capturing of animals are prohibited* except under orders of the authorities concerned. National Parks are set up for preserving the flora, fauna, landscapes and the historic objects of an area. Some well known wild life Sanctuaries and National Parks are given below:

1. Vadanthangal Bird Sanctuary

It covers an area of 0.30 sq.km over a lake, about 85 km South of Chennai. It is a bird sanctuary. Many migratory birds regularly visit this area during October and March. When summer starts, the lake becomes empty because the birds migrate

to their homelands. ***Ibis, spoon bills, open-billed stork, egrets, cormorant, darter, grey heron, pelican*** and ***dab-chich*** are some of the birds that visit this sanctuary.

2. Mudumalai Sanctuary

This sanctuary is situated in ***Nilgiri*** district. It was established in 1940. It covers an area of 321sq.kms. It is characterised by dense forests and diversity of fauna. The common wild animals of this sanctuary are as follows: ***Wild elephants, bison, sambhar, chital, barking deer, mouse deer, tiger, panther, bonnet monkey, giant squirrel, flying squirrel, wild dog, jackal, wild cat, porcupine, pangolin, flying lizard, python, rat snake***, etc.

3. Mundanthurai Sanctuary

It is situated in ***Tirunelveli*** district at Papanasam hills. Thamaraparani river passes through this sanctuary. It was established in 1962. It encloses an area of about 520 sq.km. It is formed of thick forests. The wild animals here include ***tiger, panther, sambhar*** and ***chital.***

4. Anamalai Sanctuary

This sanctuary is located in ***Coimbatore*** district. It was established in 1972. It covers an area of 968 sq.km. The wild animals of this sanctuary include ***elephants, bison, sambhar, spotted deer*** (chital), ***barking deer, Nilgiri tahr, lion-tailed monkey, tiger, panther, sloth bear, langur, porcupine, pangolin,*** etc.

5. Point Calimere

This sanctuary is situated in ***Tanjore*** district. It covers an area of 17 sq.km. The backwater of this sanctuary is inhabited by flocks of ***flamingo*** and ***pelicans*** in winter. The nearby Vedaranyam forests are inhabited by large number of ***black bucks, chital, wild boars,*** etc.

6. Muntradaippu Sanctuary

This sanctuary is situated at the National Highway between ***Nagercoil*** and ***Tirunelveli***. This sanctuary is inhabited by many migratory birds.

7. Periyar Sanctuary

This sanctuary is situated in ***Kerala*** state. It covers an area of 777sq.km. It was established in 1940 around an artificial lake. The fauna here includes ***elephants, bison*** (gaur), ***sambhar, chital, barking deer, leopards, sloth bear, wild dogs, wild boars, Nilgiri langur, grey hornbills, egrets***, etc.

8. Bandipur Wild Life Sanctuary

This sanctuary is situated in ***Mysore.*** It was established in 1941. It covers an area of 147 sq.km. It has thick forests and the fauna includes ***gaurs, elephants, leopards, sloth bear, wild dog, chital, panther, barking deer, porcupine, langur***, etc.

9. Guindy Deer Park

It is situated near ***Chennai.*** The animals here include ***chital*** and ***black bucks.***

10. Bharatpur Bird Sanctuary

It is situated at ***Bharatpur*** in ***Rajasthan***. It covers an area of 29 sq.km. The fauna here includes ***cormorants, spoon-bills, white ibis, darters, egrets, painted storks, open-billed storks, great black-necked storks, ducks, geese, siberian cranes, spotted black buck, sambhar, wildboar, python***, etc.

21. Fisheries Management

The term ***'fisheries'*** refers to *the capture of aquatic animals for the use of human beings.* Fisheries management includes all the skillful steps taken by man for the complete exploitation of aquatic resources. Fishery is the aquatic counterpart of agriculture. Both fisheries and agriculture are expected to step up the production of food. While agriculture is progressing towards ***green revolution***, fishery is progressing towards ***blue revolution.***

Divisions of Indian Fishery

The Indian fishery can be divided into two groups, namely ***marine fisheries*** and ***inland fisheries***.

1. Marine Fisheries

'Marine fisheries' refers to *the capture of fishes and other aquatic organisms from the sea.* Marine fishery is further divided into two, namely a. ***Coastal fishery*** and b. ***Off-shore or deep sea fishery***.

1. Coastal Fishery : The capture of fishes in the coastal waters along the West coast and East coast comes under coastal fishery.

2. Off-shore or **Deep sea Fishery :** The exploitation of fish fauna of the ocean beyond the area of continental shelf comes under this fishery. Deep sea fishery requires harbour facilities, mechanished boats, storage facilities, marketing facilities, etc.

CRYOPRESERVATION

The process of cooling and storing cells, tissues or organs at very low temperature to maintain their viability.

GENE BANK:

A collection of Seeds, plants or animals maintained as a repository of genetic materials, typically a to preserve genetic diversity.

SPERM BANKS:

The process of freezing sperm and storing it for future use. Sperm banking is often used to men who want to have children after having treatments. Sperm banking is a type of fertility preservation.

DNA BANKING:

DNA banking is the secure, long term storage of an individual genetic materials. DNA Banks allow for conservation of genetic materials and comparative analysis of an individual Genetic information.

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