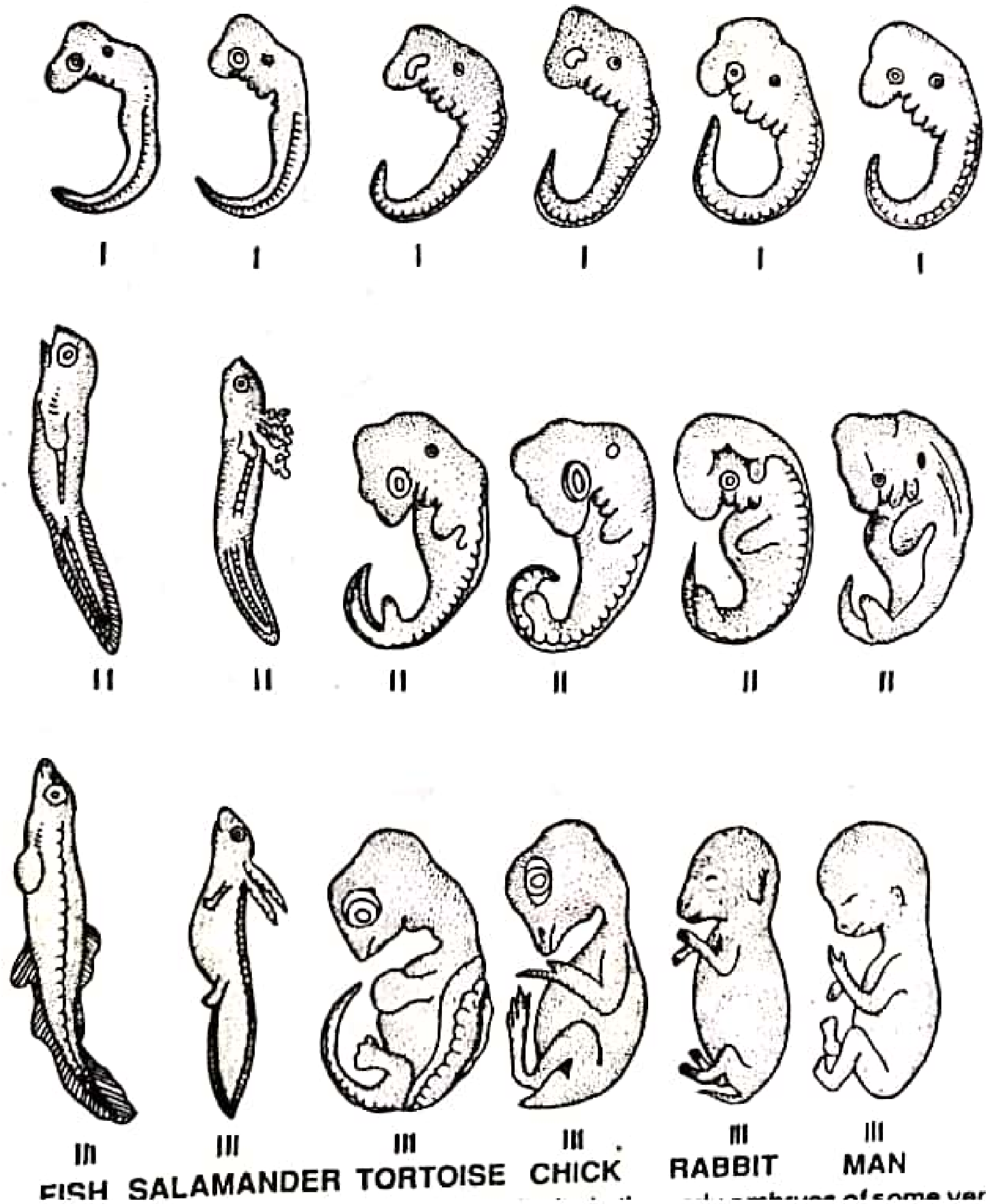
The principle of reversibility was advocated by L. Dollo in 1893 and is now known as **Dollo's law.** It states that living organisms do exhibit evolutionary irreversibility (the reappearance of ancestral characteristics). The law has no exceptions and is rather a generalization.

2. EVIDENCES FROM EMBRYOLOGY

Haeckel was much impressed by observing a generalized pattern of development and the general resemblances between the embryos of different groups of animals. **Haeckel** formulated the '**Recapitulation Theory**' or '**Biogenetic Law**'. It says "*Ontogeny recapitulates phylogeny*". Ontogeny is the life history of the individual starting from ovum and phylogeny is the series of adult ancestors of the individual which must have incurred in the evolution of the group of this individual. It means that an individual during its development briefs its ancestral history–

1. Homology in early embphyonic development
2. Homology in the embryos
3. Recapitulation
4. Retrogressive metamorphosis
5. Neoteny.



1. Homology In Early Development

All the multicellular organisms exhibit a common pattern of development. Their development starts from a unicellular **fertilized egg** or **zygote**. The fertilized egg after repeated cell divisions forms **blastula**, which finally develops into a two layered **gastrula**. The outer layer of gastrula represents future **ectoderm** and inner one future **endoderm**.

The cavity lined by endoderm forms the **archenteron**, the future digestive tract. The development after gastrula stage becomes modified in different groups of animals.

2. Homology In the Embryos

The early embryos in all the vertebrates exhibit remarkable similarity and it is not easy to differentiate a human embryo from the embryo of chick, lizard, frog or fish in early stages. The study of Fig. 3.15 reveals the great similarity of early embryonic stages of all the forms.

These similarities in the embryonic stages of different vertebrate groups are–

(i) Similar form and structures, like presence of gill clefts, notochord, tail and rudiments of eyes and ears.

(ii) Replacement of notochord by vertebral column.

(iii) Similarity in the development of limbs in the tetrapod embryos as limb buds.

(iv) Embryos of closely related vertebrates resemble more and for a longer period.

The embryos in the first horizontal row are so similar that only an expert could identify them, if they were misplaced. The stages presented in second row, represent differentiation of embryos of fish and salamander, whereas others could not be identified. Even in the third row their similarities are quite remarkable.

It has also been observed that the early embryos of all individuals are much alike, later those of different classes become, recognizable and still later family and species characters become evident, i.e. the embryos during their development become progressively more and more different from those of other animals.

The common pattern of development or resemblances in the embryos of different animals could be explained as having been inherited from an ancestor common to all the animals possessing similar embryonic developments.

3. Recapitulation Theory and Biogenetic Law

The development of man can be taken as an example to illustrate the theory of recapitulation. The fertilized egg may be compared to the single celled ancestor of all the animals and the blastula to a colonial protozoan of some spherical multicellular form, which might have been the ancestor of all the Metazoa. Gastrula (two-layered cup-shaped mass of cells) represents the coelenterate ancestor and the embryo with the development of mesoderm represents triploblastic stage like a flatworm.

The early human embryo with a dorsal hollow nerve cord, a well developed notochord and a series of gill-slits represents the fundamental chordate characters. With the development of a piscine heart, paired arotic arches, primitive pronephros and a tail, it resembles a fish embryo. Later on, it resembles reptilian embryo, and finally develops mammalian characteristics. During the seventh month of intrauterine development the human embryo resembles a baby ape, being completely covered with hair and having proportionately longer forelimbs. This provides support to recapitulation theory.

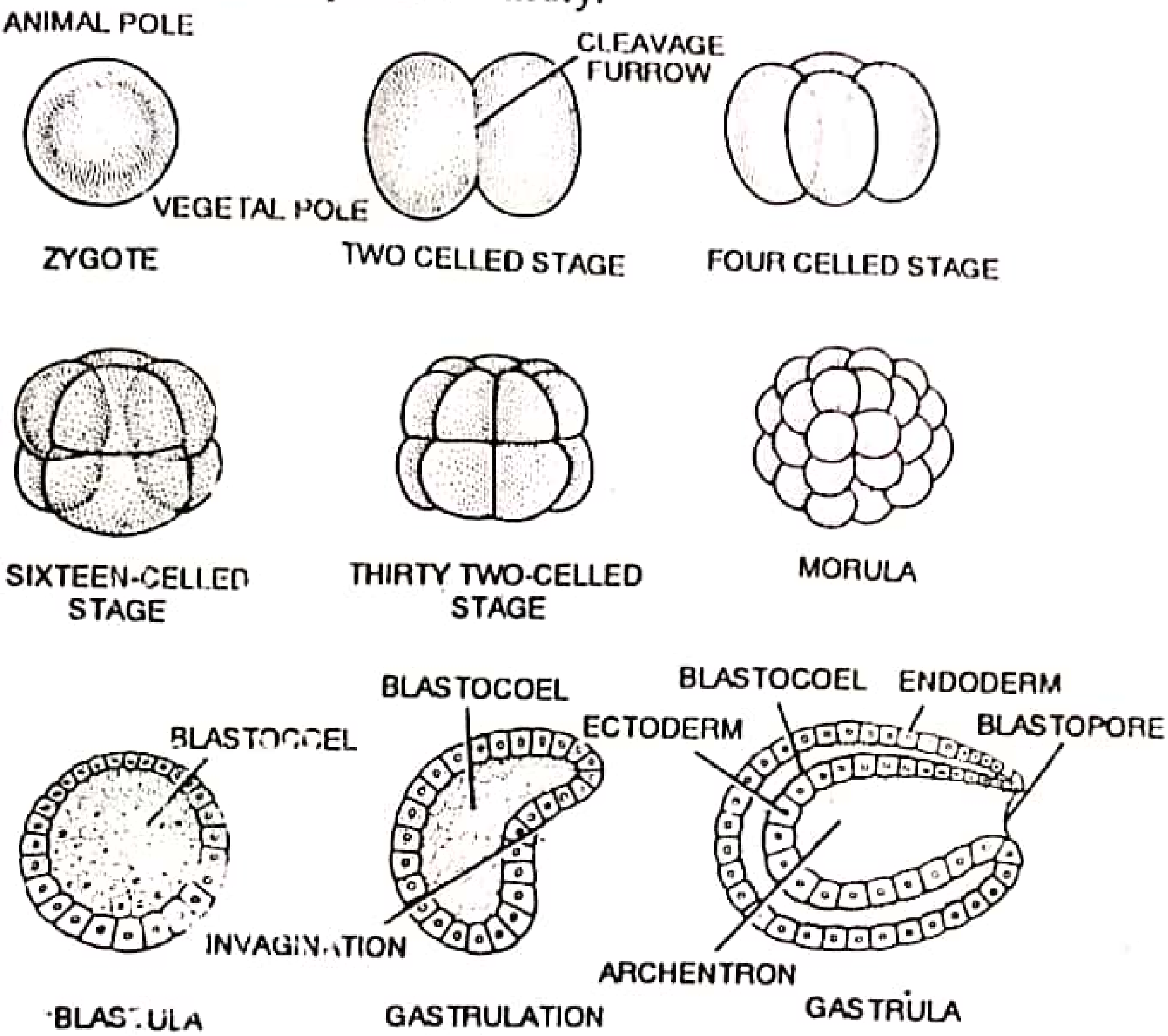


Fig. 3.16. Diagram to illustrate the typical early embryonic development in a multicellular organism.

Other examples of recapitulation are–

(i) Presences of fish-like characters like gills, gill-slits, tail, tailfin, lateral-line sense organs in tadpole larva of frog.

(ii) Presence of flagellated sperm and water dependency for fertilization in both terrestrial plants (Pteridophytes and primitive Gymnosperms) and animals.

(iii) Presence of filamentous protonema during development of moss (*Funaria*).

Von Baer's principles of embryonic differentiation constitute a better guide to embryological evidence for evolution. These principles are as follows –

1. General characteristics appear in the development before specialized characters.
2. From the more general, the less general and finally the specialized characters appear.
3. An animal during development departs progressively from the form of other animals.

8. EVIDENCES FROM BIOCHEMISTRY AND PHYSIOLOGY

The most convincing evidence of common ancestry comes from the similarities in the biochemical composition, reactions and physiological activities of living beings–

1. Metabolic processes–A remarkable similarity is noticed in the biochemical processes occurring during metabolism in all living beings from bacteria to man and in all plants and animals. For example, the process of protein synthesis, biosynthesis of various organic molecules in the body and catabolism of organic substances during respiration involves the same biochemical reactions and the same organic substances. For example, energy in all living beings is released by the biological oxidation of glucose and is stored in ATP. The various biochemical pathways involve identical steps or reactions.

2. Enzymes–In the above mentioned biochemical pathways the various steps are regulated by the same enzymes from bacteria to man and all plants.

In all animals the same digestive enzymes are present, for example, trypsin digests proteins and amylase helps in the digestion of starch.

3. Cytochrome C–It is a respiratory pigment present in all eukaryotic cells. It forms a part of the electron transport system and in all eukaryotes accepts electrons from H^+ ions. It is formed of 104 amino acids.

(i) In chimpanzees and humans cytochrome-C molecules are identical.

(ii) Cyt. C of *Neurospora* differs from human's cyt. C in 44/104 amino acid position.

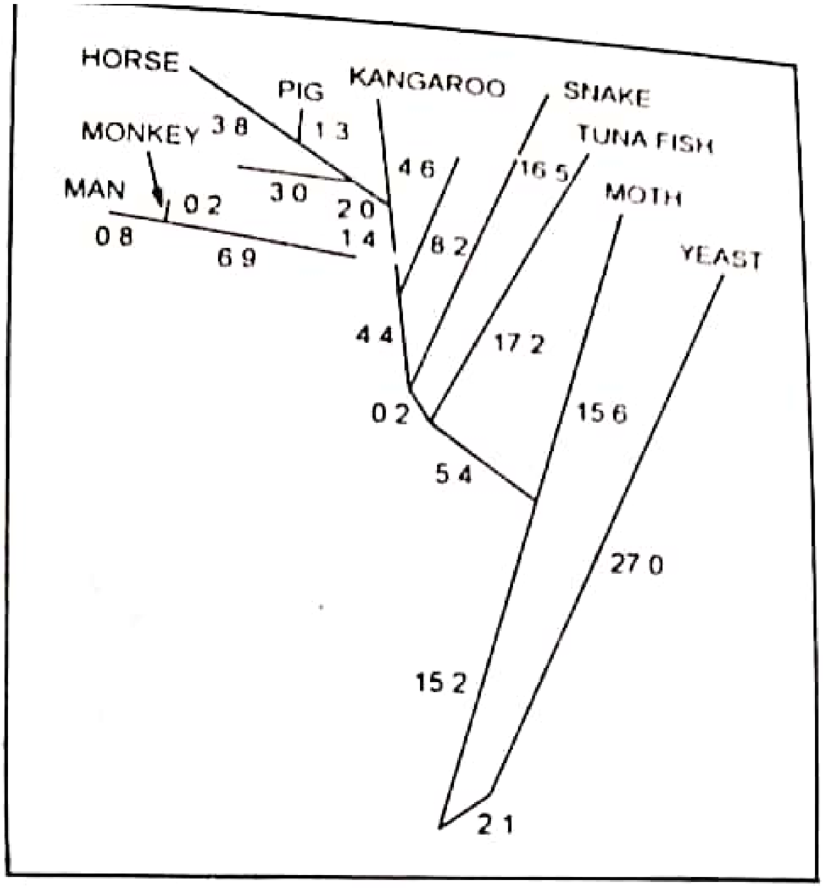


Fig. 3.35. Phylogenic tree of living beings prepared by computer analysis of cytochrome-C.

4. Insulin–Insulins analysed from different animals (beef, sheep, pig, whale, horse, rabbit) differ only in one to three amino acid positions. Beef insulin is so similar to human insulin that it has been used for treatment of human diabetes. Even human immune system fails to detect the diffferences.

5. Hormones–In th . same manner similar or identical hormones are found in large number of animal groups. **Thyroid hormone** which is found in all vertebrates is found to be identical and interchangeable. Beef thyroid can be used in the treatment of human thyroid deficiencies and even human thyroid can induce metamorphosis in frog tadopole.

6. Haemoglobin–Haemoglobin is a conjugated protein. It is formed of two identical alpha chains and two identical beta chains. Each alpha chain has 141 amino acids and each beta chain has 146 amino acids. β-chain of haemoglobin of human and gorilla differ in one amino acid, of human and pig in ten amino acids and of human and horse in 26 amino acids.

The above account makes it clear that gorilla is the nearest living relative of human beings and that the two species have evolved from a common ancestor.

7. Blood and lymph– The body fluids like blood, lymph and tissue fluid are similar in their composition and physiologyical role in all vertebrates. This indicates relationship among vertebrates. All vertebrates have haemoglobin in their RBCs, but in annelids it is dissolved in plasma.

8. Blood groups–Blood groups also help in tracing out relationship. Human beings have four blood groups A, B, AB and O. Apes are found to possess blood groups A and B but not monkeys. This indicates human beings are more closely related to Apes than to monkeys, though they have common ancestry.