Course name - Developmental Biology
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Unit- 9: Basic concepts of developmental biology

Dr Mukta Joshi
Department of Zoology
Uttarakhand Open University,
Haldwani

Developmental Biology

- Development biology is a fundamental aspect of biology.
- Development depends upon complex mechanisms and many layers of "biological information" that are superimposed one upon another.
- Developmental biology was mostly descriptive (ie. descriptive/ comparative embryology).
- Modern developmental biology is mostly experimental.
- **Embryogenesis** (embryo formation) determines the overall body plan.
- **Organogenesis** (organ formation) determines subsections of the body (examples: vertebrate limb, Drosophila eye).

Developmental biology

- Developmental biology provides understandable explanations to varies aspects of cell biology, genetics, physiology, ecology, evolution, histology and anatomy.
- Developmental biology and genetics have become closely related to form a distinct biological discipline, called developmental genetics.
- Developmental biology has also provided convincing explanations to various problems of evolution and phylogeny.
- Ecology is also related to developmental biology. Study of nitrogen metabolism during development or the evolution of viviparity or metamorphosis provides crucial evidence of ecological adaption of animals.
- The embryology is of primary importance of medical students because it provides a comprehensive and rational explanation of intricate arrangement of human anatomy.

A preview of Developmental Biology

- The embryogenesis of animal species includes various stages or phases:

I) **Gametogenesis:** The embryogenesis is started form the time of differentiation and specialization of haploid male and female sex cells, **sperm** and **ova** respectively, from diploid somatic cells of each parent during a process called gametogenesis. The gametogenesis includes spermatogenesis and oogenesis.

II) **Fertilization:** The second phase of embryogenesis is fertilization, which is the fusion of two gametes (sex cells), the male gamete (or sperm) with female gamete or (ovum), followed by the joining together of their nuclei. As a result of fertilization single fertilized cell is formed which is known as zygote or egg.

III) **Cleavage:** The third phase of embryogenesis, the cellulation, segmentation or cleavage. Cleavage is the progressive subdivisions of the zygote by mitotic cell divisions in to increasing number of cells of progressively decreasing size.

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iv) **Gastrulation:** following the cleavage phase, there occurs an extensive movement and rearrangement of cells of blastoderm of blastula, transforming the one-layered thick embryo (blastula) into a two or three-layered thick embryo, the **gastrula.** These three layers of gastrula are complex rudiment from which are derived the various organs of animal body, so they are called primary germ layer. The outermost germ layer is called ectoderm, the innermost endoderm and the middle one is called mesoderm. The movement (called morphogenetic movements) by which these germ layers are brought into position, collectively comprise gastrulation.

v) **Organogenesis:** During the fifth phase of embryogenesis, the organogenesis or organ formation , the continuous masses of cells of the three germ layers split up into smaller groups of cells called the primary organ rudiments each of which is destined to produce a certain organ or part of the adult animal body.

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vi) **Growth:** The sixth phase of embryogenesis is the period of growth. Growth, by definition, simply means development increase in mass. The increase in mass of embryo is achieved by synthesis of new nuclear material and cytoplasm and by subsequent cell multiplication. In this ways the embryo gradually achieves the size of its parents.

vii) **Differentiation**: The differentiation refers to the events by which parts become different from one another and also different form what they were originally. During development differentiation include following kinds:

a) Morphological differentiation- The cells of organ rudiments multply, the individual cells and group of cells become structurally different form one another.

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b) **Behavioural differentiation or physiological differentiation:** Although all cells exhibit common basic attributes such as metabolism and irritability, special functional capabilities are eventually superimposed on these general properties. Thus , nerve cells come to transport electric, disturbance, muscles to contract, gland cells to secrete special products, and so on.

c) **Chemical differentiation:** The cytodifferentiation and physiological differentiation of cell are the products of chemical differentiation, which in turn, is based on enzyme which direct the synthesis of organic compounds that give the cell its uniqueness. Therefore it has been said that ‘ *the differentiation is the production of unique enzymatic patterns.”*

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viii) **Morphogenesis**: The acquisition of the body form of organism during its embryonic development is called morphogenesis. It involves those development processes that lead to the characteristic size and shape of the tissue or organs that make up an organism. The form of an organism depends on two main factors, the form of individual cells and the relative position of the different cells.

xi) **Metamorphosis:** The growth differentiation and morphogenesis transform the embryo into a young animal which can have its independent existence- an existence in which it has to procure food from the surrounding environment.

Cell theory

- Organisms are composed of cells. Cell is the basic unit of life.

- Both animals and plants are multicellular composites that arise from a single cell, therefore development must be epigenetic and not preformational since a single cell (the fertilized egg) results in many different types of cells.

- Only the germ cells (egg and sperm) pass characteristics on to the offspring.

- Somatic cells are not directly involved in passing on traits to the next generation and characteristics acquired during an animal's life are not passed onto the offspring.

Meiosis and Fertilization

- **Meiosis** is the reduction division that allows diploid precursor cells to generate haploid germ cells.

- Fertilization is the process of sexual reproduction in which a male gamete and female gamete fuse to form a new cell.

- The diploid zygote contains equal numbers of chromosomes from each of two parents.

- In sea urchin observed eggs revealed that after fertilization the egg contains two nuclei which fuse to form a single nucleus.

- The nucleus must then contain the "physical basis of heredity."

Genetics has been key to Development

- The developmental genetics of *Drosophila melanogaster* and mice are best known.
- Homologous genes identified in these organisms are found in other species.
- Dominant (or semi-dominant) mutations: one copy of mutant gene produces mutant state.
- Recessive mutations: two copies of a mutant gene gives the mutant state.
- Mutants can arise spontaneously but induced mutation and screening has become the standard way to identify developmentally important genes.