

Chapter 1

Basic Concepts

1.1. Definitions

Embryology is the science that treats the origin and development of the individual which is designated as the embryo. Since there is more to the developmental process than life between fertilization and birth, the term "**Developmental Biology**" came into use. Used in this course, **Developmental Biology** will refer to the complete development of an individual from gamete production into the adult state. This development of the individual is referred to as **Ontogeny** (ontogenetic development), as contrasted against **Phylogeny** (phylogenetic development), which is evolution. An individual animal may originate either sexually or asexually. Development from an egg is referred to as **embryogenesis**. Development by asexual means (i.e. budding) is referred to as **blastogenesis**. *blasto (Gk bud, sprout)*

1.2. Outline of the Phases of Development

1. The **first phase** of sexual development, in an individual is **gametogenesis**. Gametogenesis is the formation of the gametes (sex cells). This involves the process of **meiosis** which reduces the chromosome complement to one half that of the original.
2. The **second phase** of development is **fertilization** (the union of two gametes). This may involve specific mating behaviour on part of the parents, the ability of the sperm to locate the egg, the penetration of the egg by the sperm and the *Activation* of the egg, *which is a myriad of chemical and physical changes which occur in the egg when the sperm penetrates the egg membrane*.
3. **Cleavage** is the **third phase** of development. During this phase the zygote undergoes rapid cell division so the number of cells (called blastomeres) increases but the overall size of the embryo does not. As a result of these numerous cell divisions, the embryo takes the shape of a hollow ball, called the **blastula**. The central hollow part of the blastula is the **blastocoele**.
4. **Gastrulation** is the **fourth phase** of development. During this phase, cells from the surface of the blastula **invaginate** through an opening called the **blastopore** to the inside of the blastula. These invaginating cells push the blastocoele aside and form a new cavity called the **archenteron**. During the process of gastrulation the cells come to form three germinal layers: **ectoderm, mesoderm and endoderm**. The cells of these layers are now partially determined, (that is, ectoderm cells can form only ectodermal structures, mesoderm → mesodermal structures, and endoderm → endodermal structures).

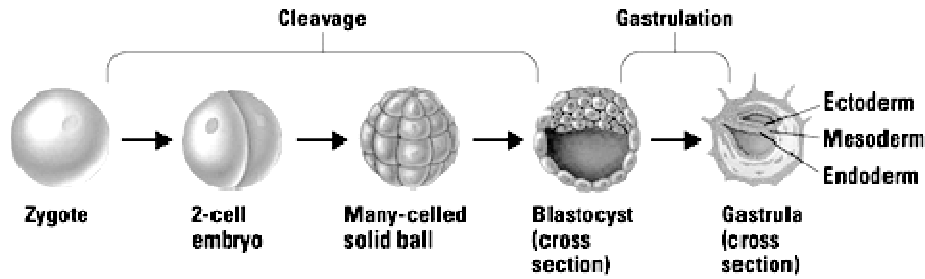


Fig.1.1a. Basic Concepts of Embryology

5. The **fifth phase** of development is **organogenesis**, the formation of organs. During this phase, cells group together to form **organ rudiments** which then develop into **organs**.
 - a. In some cases animals emerge from their eggs as **larvae**. These larvae are quite different from the adult forms and usually lead different modes of life. In insects, the larva then pupates and a process of rapid organogenesis ensues whereby the organs of the larva are replaced.
 - b. Organogenesis also occurs during **regeneration** after the loss of a part of an animal. Among vertebrates, this is especially apparent in **amphibians**.
6. The **sixth phase** of development is a time of **growth and histological differentiation**. During this time, the animals grows in size and the **tissues** of the organs differentiate in their **structural** and in **physiological** aspects. The culmination of this phase is the adult animal.

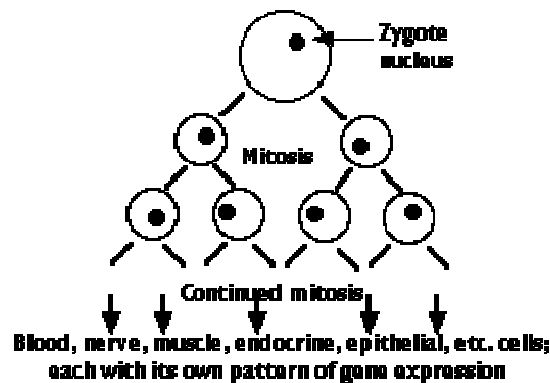


Fig.1.1b. Basic Concepts of Embryology

1.3. History of Embryology

In the 17th and 18th centuries, it was generally believed that embryos were preformed in the sperm or egg and merely grew in size during embryonic life. This is the **Preformation Theory**.

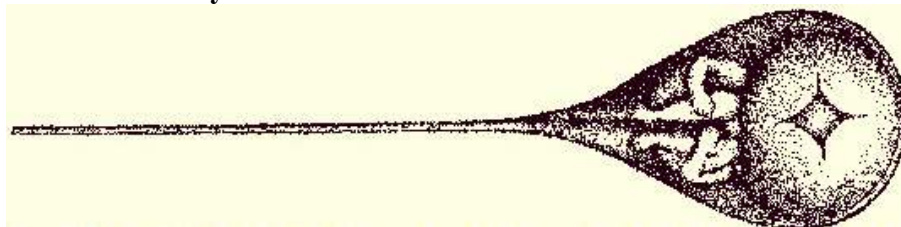


Fig.1.2. Preformation Theory illustration

To be consistent, this doctrine had to admit that all future generations were encased, one inside the sex cells of the other, like so many Chinese boxes." Mathematically unsound. The preformationists were divided into two camps:

1. The *ovists* believed the ovum had the miniature individual and sperm only started growth or that sperm were parasites of semen.
2. The *animalculists* believed the animalcule (as spermatozoa were then called) carried the miniature individual and the egg merely provided nutrition.

The ovists eventually won out. Alternatives to the Preformation Theory:

1. **Wolff** (1759) proposed the **theory of epigenesis**. This states that by progressive development, from simpler to the more complex, organisms develop from building units called **cells**. Wolff used the observation of chick development as his argument.
2. **Driesh (1891) Endres (1895) and Spemann (1901)** and others finally disproved preformation by showing that whole embryos can develop from the individual daughter cells of the fertilized egg.

With the theory of preformation dead, researchers sought the egg factor which transmits information to the next generation.

3. **Darwin** and others had thought that each part of the individual contributes something to the sex cells, and that these representative tokens (gemmules) made heredity possible.
4. **Weisman** (1893) put forth the **germ plasm theory**. He pictured germ plasm as self-perpetuating and being passed from one generation to the next. At each new generation a temporary body is built up around the germ cells.

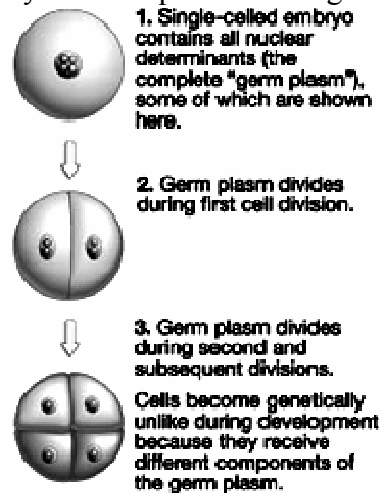


Fig.1.3. Germ Plasma Theory

5. Modern investigation, starting with **Thomas Hunt Morgan** in 1910, has shown that the self-perpetuation elements are in actuality genes. These are identical in every cell of the body. A body (somatic) cell nucleus can substitute for an egg nucleus, if it is transplanted into an enucleated egg.