UNIT-I

DEVELOPMENTAL BIOLOGY

- Developmental biology is one of the most existing and fast growing fields of biology.
- Development refers to the gradual transformation of the egg in to a new adult individual.
- There are two type of development

Antogenetic development: Transformation of fertilized egg into a new adult.

Phylogenetic development: Gradual transformation of a group of animals from simple forms to complex form.

Historical thoughts and Concepts

- Aristotle (384-322 B.C) wrote “The Treatise on Embryology” He described the ontogenetic development of chick and many other animals. He postulated that human embryo develops out of mother’s menstrual blood.
- William Harvey (1578-1657) believed that all animals came from egg.
- Malpighi (1628-1694) explained that the egg contained in the miniature of the adult animal.
- Graaf (1672) described the ovarian follicles.
- Leeuwenhoek (1677) observed sperm of man and other mammals.
- Bonnet (1745)discovered that eggs of some of the insects could develop parthenogenetically.
- Pander(1817)reported three germ-layers from which the different parts of chick embryo are developed.
- Von Baer (1827) observed mammalian egg.

SCOPE OF EMBRYOLOGY

- Embryology is a highly valuable branch of biology.
- It helps to understand other branches of biology like genetics, cytology, physiology, evolution etc.
- It helps to understand the phylogenetic relationship between the different groups of animals.
- In the medical field, embryology is immensely helpful. It helps to understand the origin of certain diseases.
- It provides adequate facilities for birth control. In the modern days embryology helps to produce test tube babies and desired sexes.

GAMETOGENESIS

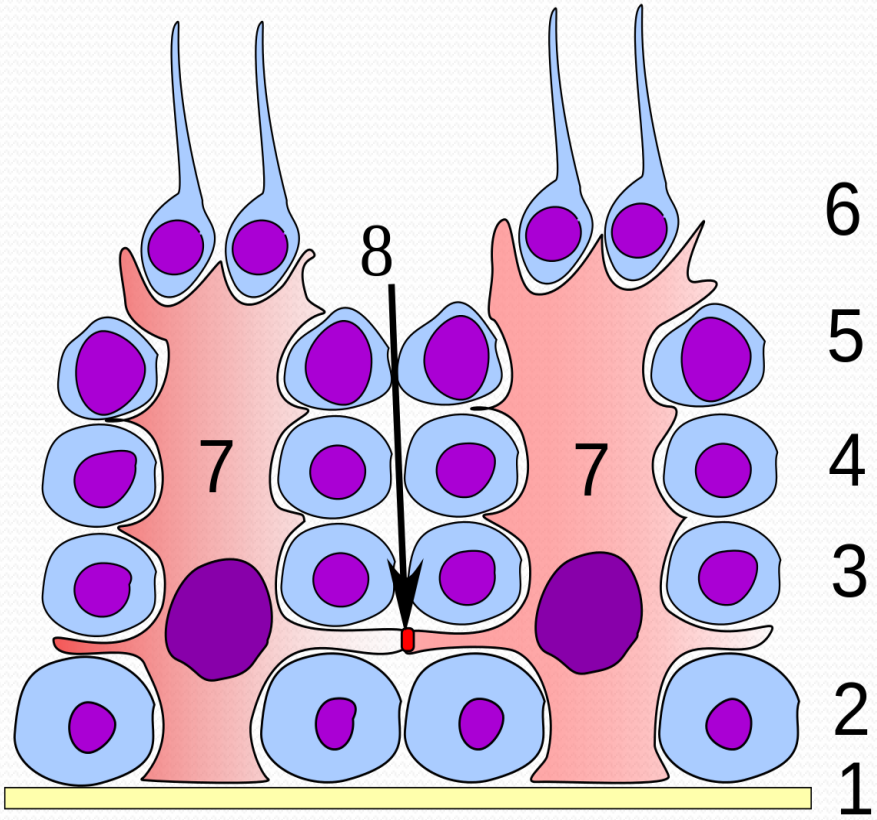
The development of gametes from the primordial germ cells is called gametogeneis. They are two type of gametes. The female sex cell-ova, the male sex cells spermatozoa.

The gametogenesis is subdivided into two types:

- Spermatogenesis → development of spermatozoon
- Oogenesis → development of ovum

Spermatogenesis

The process of maturation of primordial germ cell in the tests of male to form spermatozoa (sperm) is known as spermatogenesis.



1. Wall of the seminiferous tubule
2. Spermatogonium
3. Primary spermatocytes
4. Secondary spermatocytes
5. Spermatid
6. Spermatozoa
7. Sertoli cell
8. Connective tissue

T.S of a portion of seminiferous tubule of mammalian testis

- The entire process of spermatogenesis can be discussed in two stages namely.

    1. Formation of spermatid and

    2. Spermiogenesis.

1. **Formation of Spermatid**

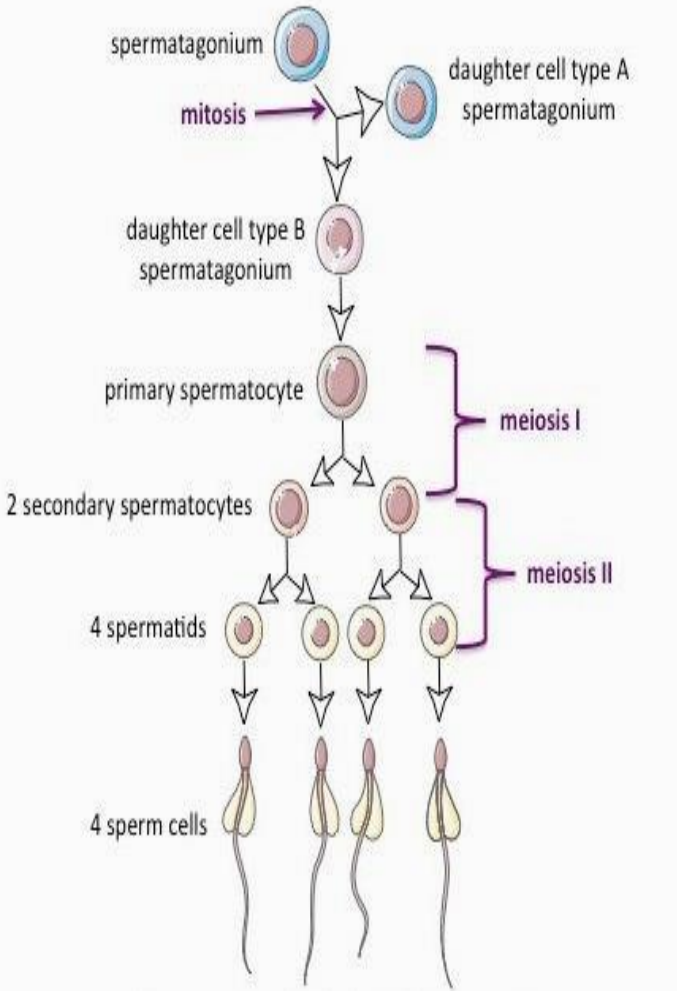
The cells of germinal epithelium which produce the spermatozoa are called primary germinal cells or primordial germ cells. The formation of spermatid starts from the primordial germ cells of testes. The entire process can be separated into three phases.

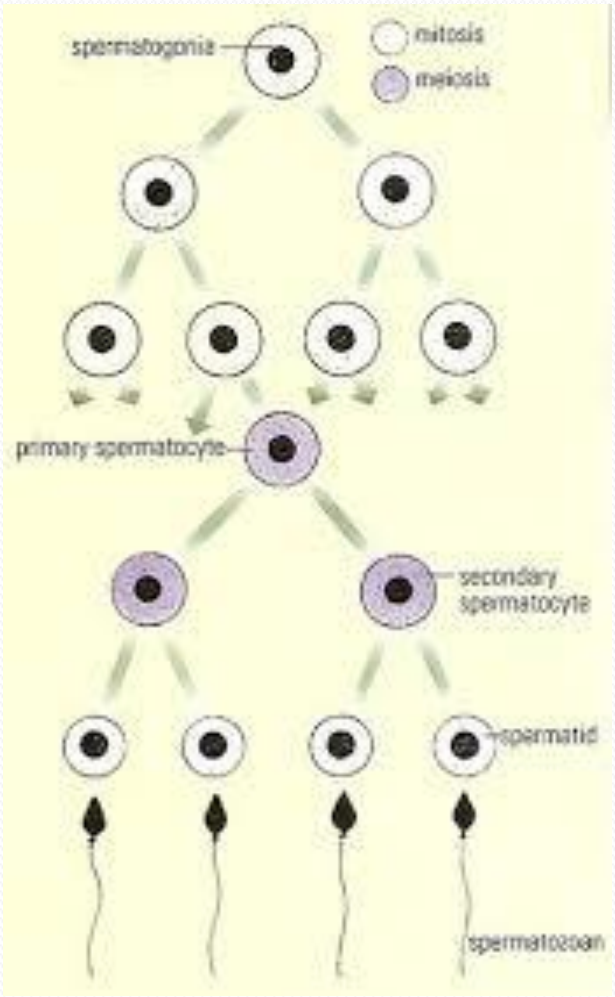
A. Multiplication phase

B. Growth phase

C. Maturation phase

Spermatogenesis





A. Multiplication phase

The primordial germs cells are large in size and chromatin rich nucleus. They undergo repeated mitotic cell divisions. The resulting cells are called spermatogonia or sperm mother cells. Each spermatogonium has a diploid number (2n) of the chromosomes.

B. Growth phase

After the last spermatogonial division, the spermatogonium grows by accumulating nourishing material obtained from germinal cells to become double in volume. Such cells are called primary spermatocytes.

C. Maturation Phase

The primary spermatocyte, then enter the maturation phase where each cell divides by meiosis. Meiosis consists of two divisions.

- First meiotic division produces two secondary spermatocytes.
- In the second meiotic division, each secondary spermatocyte divides into two cells called spermatoids.
- The spermatids differentiate into spermatozoa.

2. Spermiogenesis

The transformation of the spermatid into spermatozoan is called spermiogenesis. During spermiogenesis, the two major parts of sperm, the head and tail are formed by following methods.

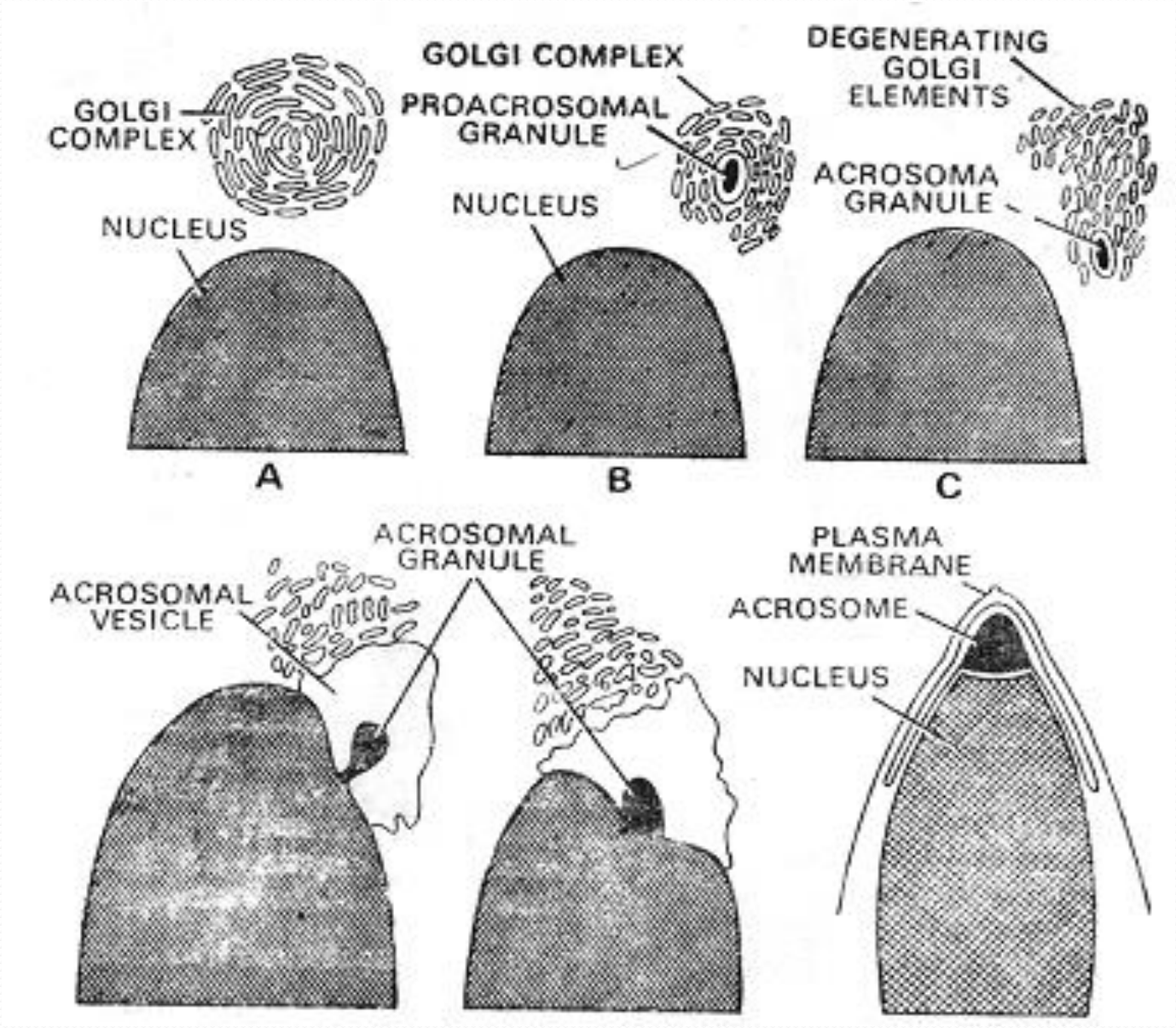
2.1. Formation of head of spermatozoon

The two major parts of sperm head i.e, the nucleus and acrosome, undergo following changes to form a sperm head.

(a) Changes in nucleus

(b) Acrosome formation (changes in the Golgi bodies)

Formation of Acrosome and Head



2(ii) Formation of the tail of Spermatozoon

A. Formation of axial filament (changes in centrosome)

B. Formation of mitochonodrial spiral

C. Formation of manchette

- **Factors Controlling Spermatogenesis**

In animals the production and liberation of spermatozoa are controlled either environmentally or physiologically.

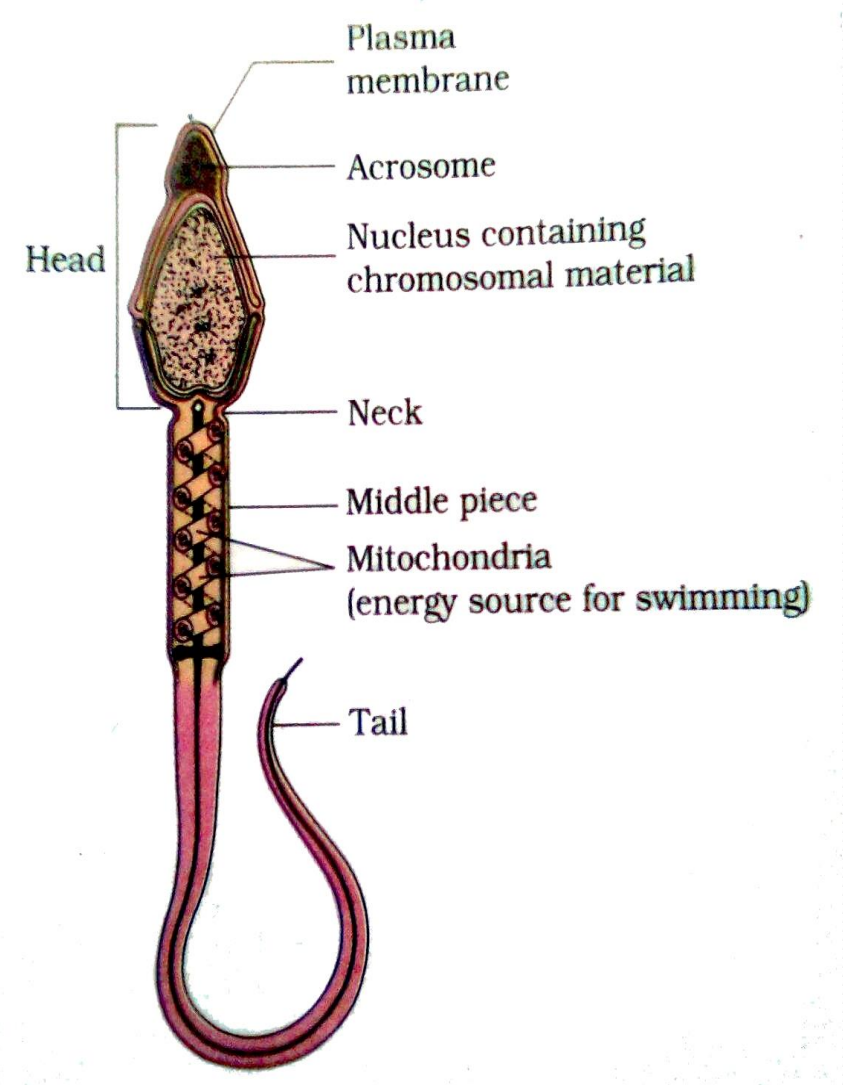
- **Structure of mature sperm**

- The mature sperm contains four main regions, Head, Neck, Middle piece and tail.
- The head contains two important parts.

  Acrosomal part and Nuclear part.
- The tail has two distinct regions namely

  Main piece and end piece.

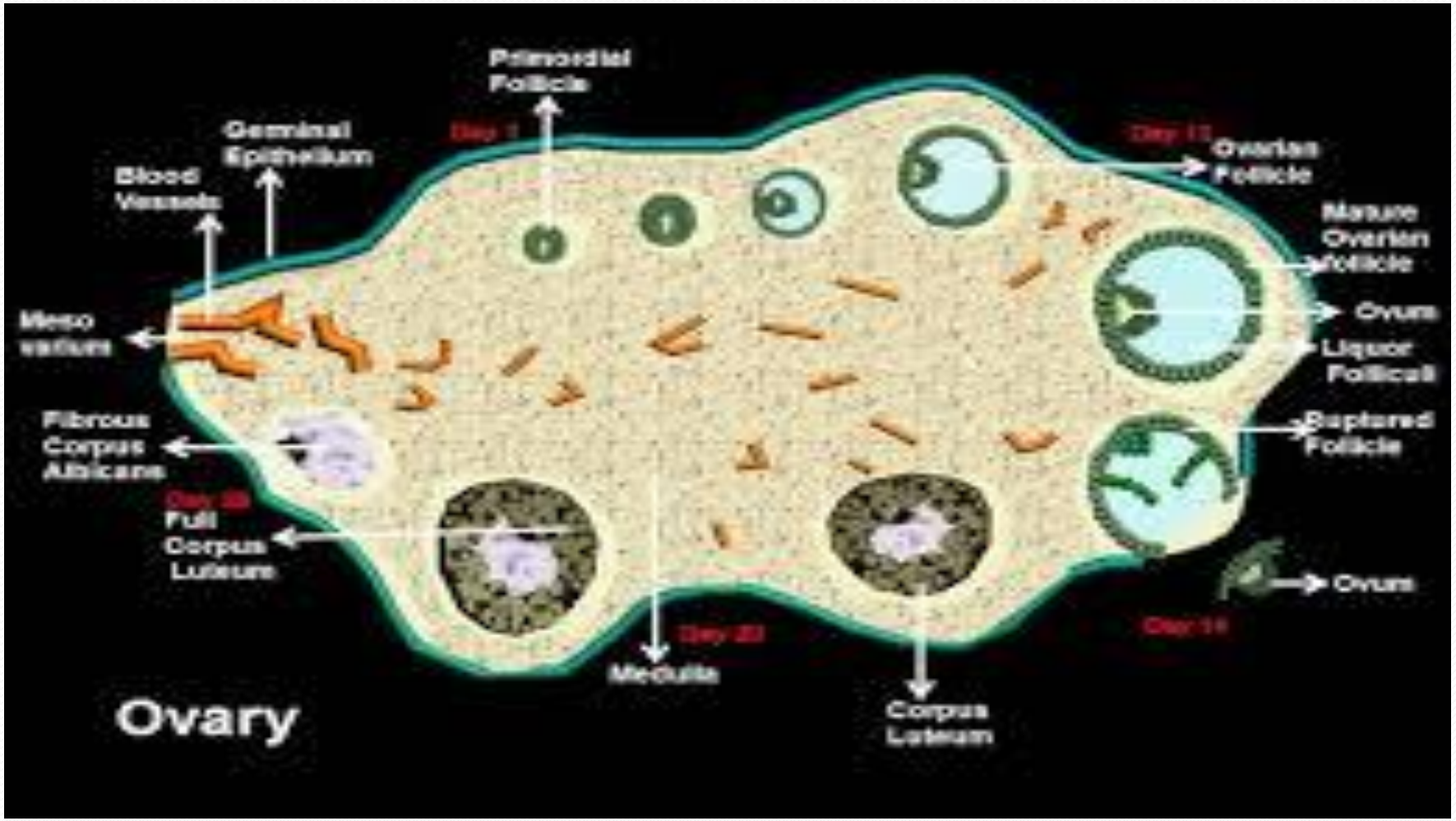
Structure of Sperm



OOGENESIS

- Oogenesis is a process by which the ovum develops in the ovary.
- THE OVARY
  - The vertebrates are provided with two ovaries with the exception of birds which have only one.
  - The shape and size of the ovaries differ from species to species.
  - They may be elongated, oval, rounded or in the form of a bunch of grapes.
  - Generally, the vertebrate ovaries are grouped into two types. They are
  - COMPACT TYPE : It is solid in nature and found in cyclostomes, fishes, turtles, crocodiles, birds and mammals.
  - SACCULAR TYPE: It is formed of hundreds of lope-like structure and found in amphibians, lizards and snakes.

- STRUCTURE:

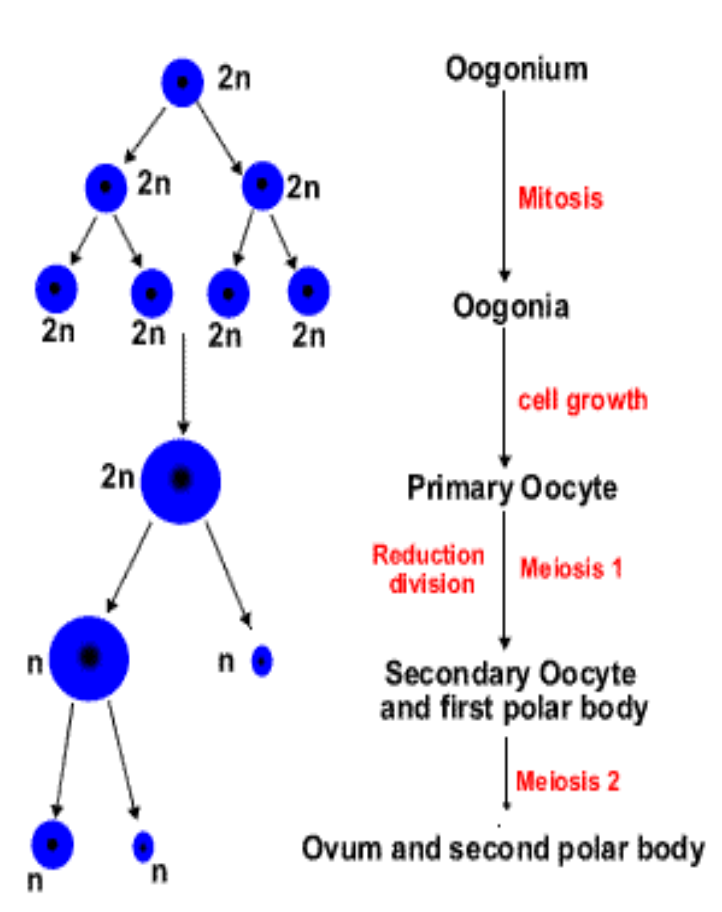

Primordial Follicle
Germinal Epithelium
Blood Vessels
Ovarian Follicle
Mature Ovarian Follicle
Ovum
Liquor Folliculi
Ruptured Follicle
Ovum
Fibrous Corpus Albicans
Full Corpus Luteum
Medulla
Corpus Luteum
Ovary

- The entire process of oogenesis can be divided into three phases.
- Multiplication phase
- Growth phase (two stages)
  - Previtellogenesis
  - Vitellogenesis
- Maturation phase

1. Multiplication phase

The germinal epithelial cells separate from the surface and enter the cortex. These cells are called primordial or primary germ cells. They divide repeatedly by mitosis and the resulting cells are called oogonia or egg mother cells. The oogonia again divide repeatedly by mitosis, to produce a large number of daughter cells, which are the oogonial cells. The oogonial cells contain the diploid number of chromosomes.

Oogenesis


2n
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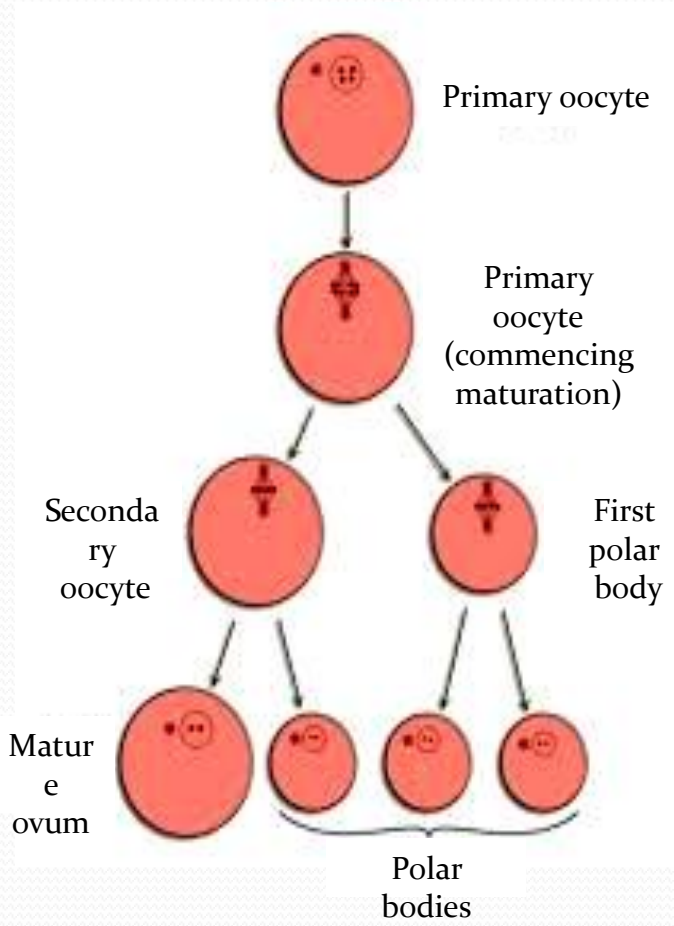
Oogonium
Mitosis
Oogonia
cell growth
Primary Oocyte
Reduction division
Meiosis 1
Secondary Oocyte and first polar body
Meiosis 2
Ovum and second polar body


Primary oocyte
Primary oocyte (commencing maturation)
Seconda ry oocyte
First polar body
Matur e ovum
Polar bodies

2. Growth phase

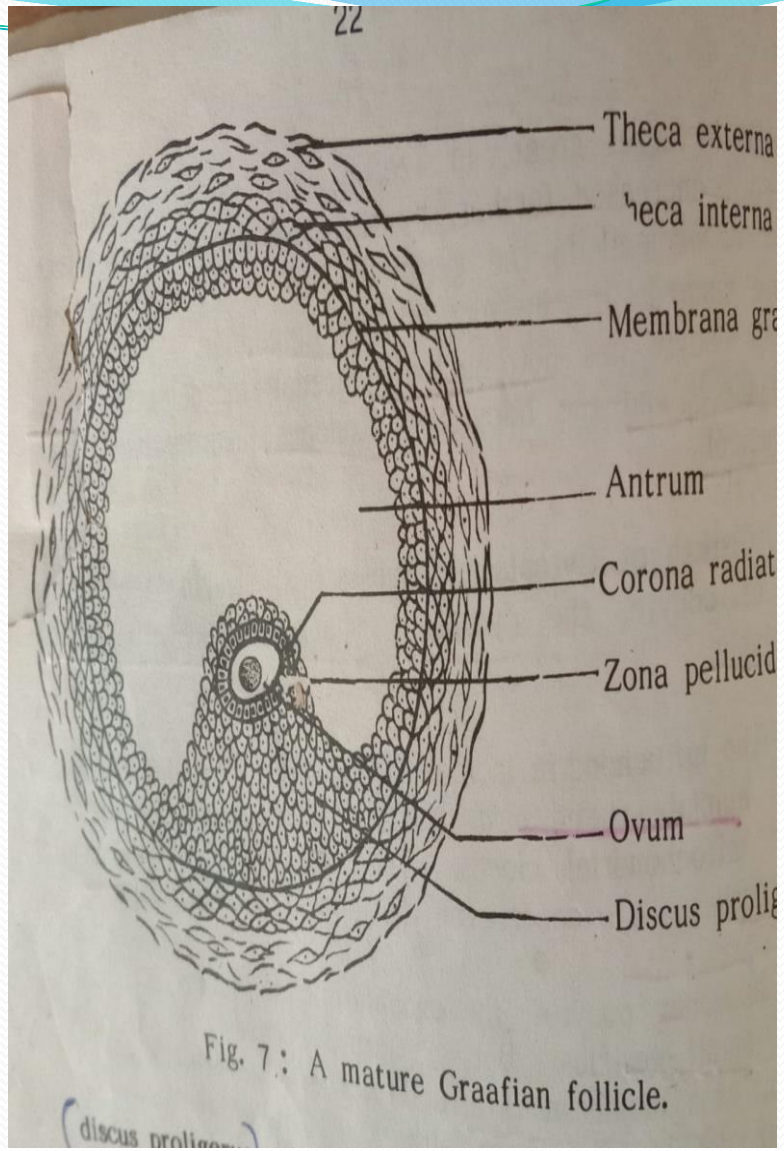
- Multiplication phase is replaced by growth phase, when the mitosis division stops, one of the oogonial cells simply enlarge in size due to the absorption of nutritive material from the surrounding medium. These oogonial cells are named as primary oocyte.
- Growth is an important phenomenon in oogenesis.
- The growth phase of oocyte is divide into two stages, namely previtellogenesis and vitellogenesis.
- During previllogenesis the nuclear and cytoplasmic substances of oocyte increase.
- During vitellegenesis the yolk is synthesized.

A. Previtellogenesis

- (i) Period of growth
- **(**ii) In crease in size
- (iii) Nuclear Changes
  - a. Lamp brush chromosome
  - b. Informosomes
  - c. Nucleolus
- (iv) Growth of cytoplasmic substance
  - a. Mitochondria
  - b. Ribosome
  - c. Endoplasmic reticulum
  - d. Golgi complex
  - e. Cortical granules

(v) Accessory cells of oocyte

- a. Follicle cells
- b. Nurse cells



B. Vitellogenesis (Synthesis and accumulation of yolk)

Vitellogenesis is the second period in the growth of oocyte. The process of formation deposition of yolk in the oocyte is called vitellogenesis.

a. Granular yolk

b. Yolk platelets

3. Maturation phase

The primary oocyte contains a diploid number of chromosomes. The diploid chromosome number is reduced to haploid number by meiosis or reduction division. The primary oocytes is changed into the ovum. This is called maturation.

Egg membranes

- The egg are well protected by egg membranes. Like all other animal cells, the egg is covered by a plasma membrane.
- The egg membranes are produced either by the egg itself or by the follicle cells of the ovary or by the genital ducts of the mother.
- Accordingly the egg membranes are classified into three types. They are
  - Primary membranes
  - Secondary membranes
  - Tertiary membranes

1. Primary membranes

The membranes secreted by the egg-cytoplasm. They are closely attached to the surface of the egg. In different animals eggs, the primary egg membranes have different structure and are known by different names, they are

- 1.Plasma membrane 2.Vitelline membrane 3.Zona radiata

4.Zona pellucida 5.Jelly coat

1.Plasma membrane

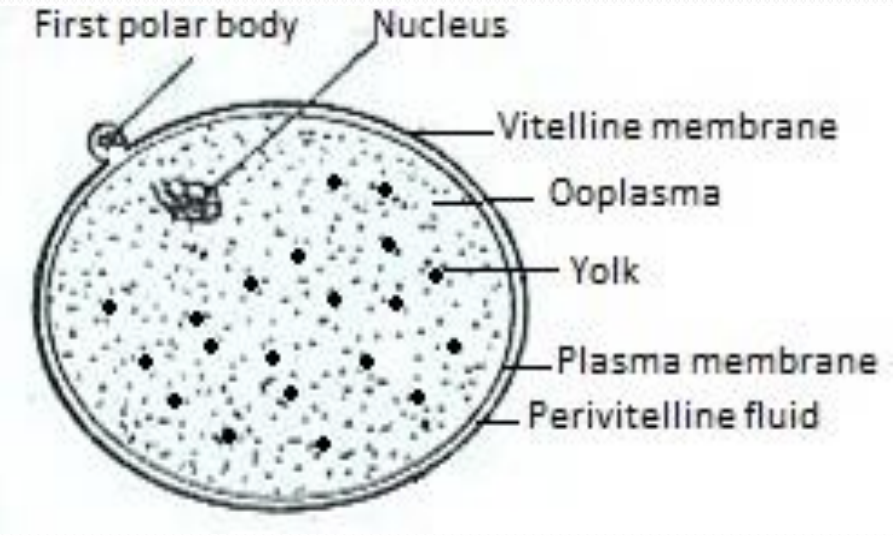
- It is the membrane covering the egg immediately over it.
- It is found in all the egg.
- In structure, it resembles the plasma membrane of a typical cell.

2.Vitelline membrane

- It is closely attached to the plasma membrane of the egg.
- It is found in the egg of majority of animal like insect, molluscs, echinoderms, Amphioxus, amphibians, birds etc.
- It is very thin and transparent.
- It is formed of mucopolysaccharides and fibrous protein.
- Immediately after fertilization, this membrane become separated and lifted off from the surface of the egg.
- After fertilization this membrane is called fertilization membrane.

- The space formed between it and plasma membrane is called perivitelline space filled with a fluid called perivitelline fluid.

Egg of AMPHIOXUS



3.Zona Radiata

- The egg of the shark has two primary membranes produced by the surface ooplasm.
- The outer membrane is the vitelline membrane and the inner membrane has a radiating appearance and hence called zona radiata.
- The eggs of teleost fishes are also covered by zona radiata.

4. Zona Pellucida

- All mammalian egg are surrounded by a membrane called zona pellucida. It is also named zona radiata.
- It is so named because it gives a striated appearance under the microscope.
- The striations are due to the presence of microvilli and macrovilli in this zone.
- The microvilli are produced by the surface of the egg and macrovilli are produced by the follicle cell. They protrude into the zona pellucida.

5.Jelly Coat

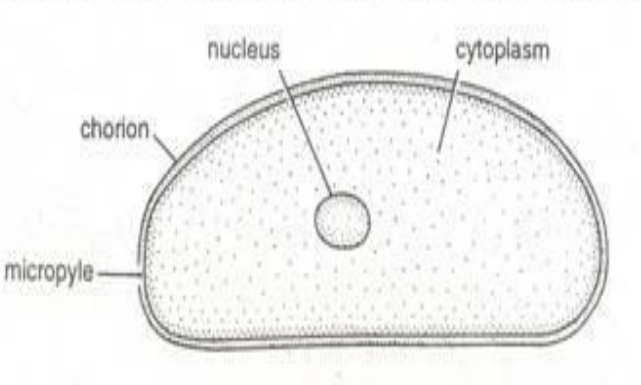
- The egg of aquatic invertebrates, especially the homolecithal eggs of marine invertebrates, are covered by anon-living , jelly-like layer outside the vitelline membrane called jelly coat.

Secondary membrane

The secondary membranes are produced by the follicle cells of the ovary. These membrane are usually tough and impermeable. The secondary membranes are **chorion** and **corona radiata**

- **(a) Chorion:** This is a common outer covering in the egg of inject, ascidians and cyclostomes. It is found outside the vitelline membrane.
- As the chorion is tough and impermeable it is provided with one or more opening called micropyles through which the sperms enter the egg.

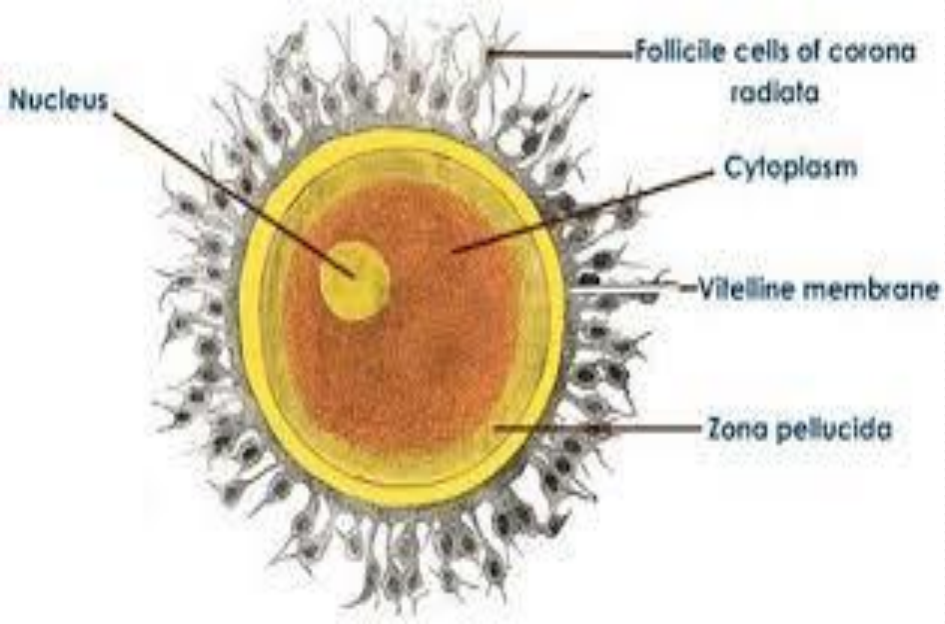
Insect Egg



(b)Corona Radiata

- It is found in mammalian eggs. This membrane is formed of a layer of follicle cells. The cell are radially arranged around the zona pellucida.

Mammalian Egg

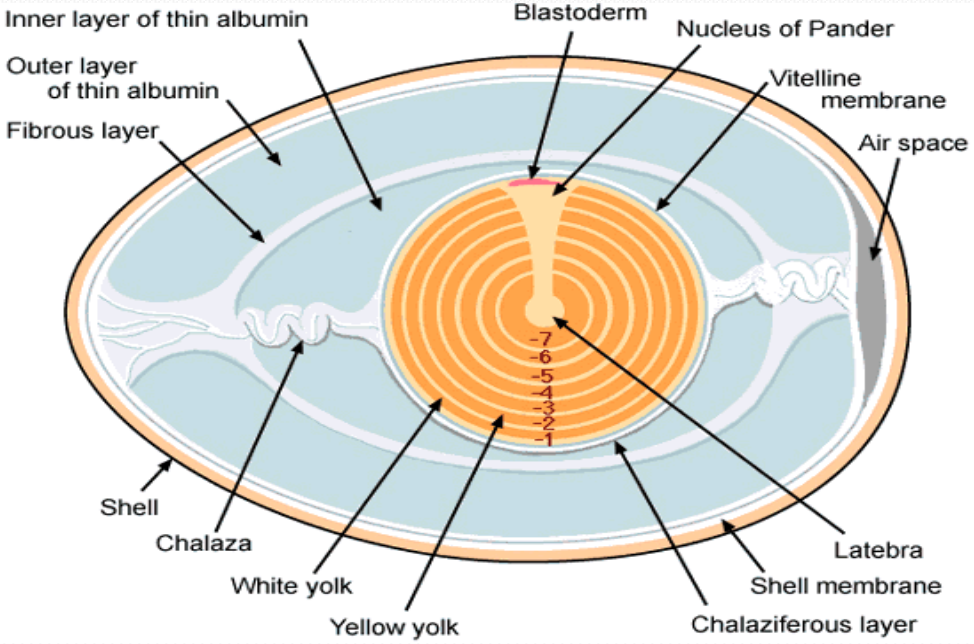


Tertiary membrane

The tertiary membranes are produced by the oviduct as the egg passes down the oviduct towards the cloaca. In the egg of frog, reptiles, birds and oviparous mammals, secondary egg membrane is covered by another hard or gelatinous material, which constitutes the tertiary egg membranes.

Eg.,

1. White albumin,
2. Shell membrane,
3. Shell,
4. Jelly coat
5. The Mermaid purse



Hen's Egg

TYPES OF EGGS

- Eggs are classified mainly

1. On the basis of the amount of yolk
2. On the basis of the distribution of yolk
3. On the basis of the presence or absence of shell and
4. On the basis of type of development

1.On the basis of amount of yolk

- **Alecithal egg**: when the egg contain no yolk. Eg . eutherian mammals.
- **Microlecithal egg**: When the egg contain a small or negligible amoun of yolk. Romer (1962) and Balinsky (1970) named these eggs **oligolecithal egg**. Eg. Amphioxus and tunicates.
- **Mesolecithal egg**: The amount of yolk present is not very high. Eg. Amphibians, dipnoi and petromyzon.
- **Macrolecithal or Megalecithal egg**: When the egg contains a large amount of yolk. It is also called **polylecithal egg**. Eg. Bony fishes, amphibians, reptiles and birds etc.

2.On the basis of distribution of yolk

- **Homolecithal or isolecithal** : The yolk material are uniformly distributed throughout the eggs. Eg. Echinoderms and Amphioxus.
- **Telolecithal**: The yolk is highly concentrated towards the vegetal pole. The amount of yolk gradually decreases from the vegetal pole towards the animal pole. Eg. Fishes, amphibians, reptiles and birds.
- **Centrolecithal**: The yolk takes up a central position and is surrounded by a thin layer of cytoplasm. Eg. Insects

3.On the basis of the presence or absence of shell

- **Cleidoic eggs**: The eggs which are laid on dry land must be protected well.Hence they are covered by calcareous shells. Eg. Reptiles and birds etc.
- **Non -cleidoic eggs**: The eggs are not protected by shells. This type of egg in whose case the development is internal. Eg. Mammals.

4.On the basis of the type of development

- **Determinate or Mosaic egg**: In the development of certain animals the fate of every portion of the egg is predetermined. If a particular portion of the egg is removed the developing embryo will be lacking in a particular organ. Eg. Polyclads, annelids, molluscs and ascidians etc.
- **Indeterminate or Regulative eggs**: In majority of animals, there is no pre-determination. If a particular portion of the egg is removed it can develop into a normal embryo without any defect. Eg. Amphioxus and mammals.ss