The Structure of a typical Ovum

- Ovum is the female gamete.
- Oocytes or Ovum with the egg membrane are called the Egg.
- It stores food required for the entire process of development in the form of yolk.
- The nucleus of egg is called Germinal vesicle.
- It has three important functions:

❖ It supplies a haploid set of chromosomes to the future embryo.
❖ It contributes almost all cytoplasm to the zygote.
❖ It supplies food to the developing embryo.

Shape and Size

- Typically, the eggs are spherical or ovoid in shape.
- But in a few animals like insects, the eggs are elongated and cylindrical in nature.
- Eggs are generally larger than the sperms and average somatic cells.
- The size of a mature egg depends on the amount of yolk present in it.
- The smallest known egg is that of mouse (0.07mm); the birds possess larger eggs.
- Ostrich lays the largest egg having a diameter of about 85 mm.
- The egg is covered externally by a plasma membrane or plasmalemma. Within the plasma membrane is the granular cytoplasm

Organization of Egg Cytoplasm

- The cytoplasm of egg cell is known as ooplasm. It is granular and contains in addition to the usual cellular organelles certain other inclusions like yolk, pigments and cortical granules.
- The peripheral layer of ooplasm is more viscous and gelatinous. It is known as the egg cortex which is provided with many microvilli and cortical granules. The microvilli are formed by the outpushings of the plasmalemma and they help in transportation of substances from the outside into the ooplasm during the development of egg.
- The cortical granules are very small spherical bodies varying in diameter from 0.8 µm to 2µm. They are rnembrane bound and are formed from golgi complex. They contain homogeneous and granular mucopolysaccharides.
- Cortical granules are present in the eggs of sea urchins, frogs, fishes, bivalve molluscs, several annelids and certain mammals.

Yolk

- Nutritive substances are stored in the cytoplasm of egg in the form of yolk or deutoplasm.
- This stored food is utilized by the embryo for its early development. The process of formation of yolk is known as **vitellogenesis.**
- The yolk is a complex material consisting of proteins, fats, carbohydrates, inorganic salts, vitamins, enzymes, pigments and water.
- The yolk may be called "protein yolk" when it has more proteins than lipids, or “fatty yolk" when it has more fat contents than the proteins.
- Most animal eggs contain both kinds of yolk. Since the yolk is heavier, large quantities of yolk, such as those of the frog and chick.
- The accumulation of yolk in one region is so marked that they are known as telolecithal eggs. In eggs containing lesser amount of yolk, like those of Amphioxus and man, t
- The yolk is distributed more uniformly, hence they are known as isolecithal or homolecithal.
- The size of the egg is determined by the amount of yolk present in it.
- It influences the differentiation of ooplasm and the patterns of cleavage.
- Yolk exercises an important influence on the morphogenetic movements of blastomeres during gastrulation.
- The nature of development whether indirect with larval forms or direct with juvenile stages is governed by the amount of yolk present in the egg.
- **Pigment granules** are present in the cytoplasm of eggs of many species. The granules may be brown, black, red, yellow, green or- grey in colour.
- As the pigment granules are not common to all eggs, they do not play any significant role in development.

Polarity

- The constituents of egg are not uniformly distributed throughout the cytoplasm. These are distributed in such a way that two poles distinct can be identified in the egg. These pores are known as animal pole and vegetal pore.
- The cytoplasm is concentrated in the upper portion or animal hemisphere and the yolk material is concentrated in the lower portion or vegetal hemisphere.
- A plane passing through these two poles constitute the polar axis.
- The nucleus is always located in the polar axis, more or less towards the animal pole.
- The yolk shows a gradation from the animal pole towards the vegetal pole. There is also a metabolic gradation along the polar axis.
- Metabolic processes are highest at the animal pole and progressively diminish towards the vegetal pole

Classification of Egg

A. On the Basis of the Amount of yolk

Eggs are grouped into three types on the basis of the amount of yolk present in them.

a. Alecithal Egg

- When the egg contains no yolk, it is called alecithal egg.
- Ex. The eggs of eutherian mammals

b. Microlecithal Egg

- When the egg contain small or negligible amount of yolk it is said to be Microlecithal.
- Romer and Balinsky named these eggs as Oligolecithal eggs of Amphioxus, Tunicates

c. **Mesolecithal egg**

- The amount of yolk present is moderate and is not high Hence these eggs are also named as mesolecithal egg.
- Ex, in amphibian, Dipnoi and Petromyzon

d. Macrolecithal or Megalecithal Egg

- When the egg contains large amount of yolk it is said to be macrolecithal or megalecithal egg.
- It is also called Polylecithal egg egg.
- Ex. Boney fishes, Amphibians, reptiles and birds, tnonotentcs, etc.

B. On the Basis of the distribution of yolk

a. Isolecithal or Homolecithal Egg

- In isolecithal eggs, the very little amount of yolk present is uniformly distributed throughout the ooplasm (eg. Echinoderms, Amphioxus, mammals).
- This condition is usually observed in eggs with very little amount of yolk.

b. Telolecithal Egg:

- In eggs containing moderate or large quantity of yolk, the distribution of yolk is not uniform.
- It is concentrated more towards the vegetal pole. Such a type of egg, in which the yolk is concentrated towards one pole, is called telolecithai egg.
- Telolecithal eggs may further classified into three types:

i. Slightly Telolecithal

- This type of egg contains only a small quantity of yolk which is distributed unevenly. The vegetal pole has the highest concentration and the animal pole the lower (e.g. eggs of fishes).

ii. Moderately Telolecithal egg

- This type of egg contains a moderate quantity of yolk which is

Distributed unevenly. Due to high concentration of yolk in the vegetal hemisphere, the nucleus is shifted more towards the animal hemisphere

- Ex. amphibian egg.

iii. Extremely Telolecithal Egg

- In this type of egg, due to the heavy deposition of yolk, the entire vegetal hemisphere and a major portion of the animal hemisphere are occupied by yolk. Due to this extremely uneven distribution of yolk, the ooplasm and nucleus are displaced towards the animal pole.
- Ex. Reptilian and avian eggs.

c. Centrolecithal Egg

- Egg of many arthropods and some coelenterates are described as centrolecithal. They are relatively large and elongate and have a very great amount of yolk.
- The nucleus lies at the geometric centre of the yolk mass, surrounded by a small amount of cytoplasm.
- A thin cytoplasmic layer covers the surface of the yolk. Fine strands of cytoplasm extend from the peripheral layer to the zone occupied by the nucleus.

C. On the basis of shell

1. **Cleiodoic eggs**
    - Eggs are surrounded by a hard shell are known as cleidoic eggs.
    - These eggs are found in those animals which have a terrestrial mode of life or which lay eggs on land.
    - These eggs have more amount of yolk.
    - These are adaptation to terrestrial mode of life.
    - Shell prevents the egg from desiccation.
    - Ex. Eggs of reptiles, birds, terrestrial insects and prototherians.
    - Reptile's eggs are leathery eggs.
2. **Non Cleiodoic egg**
    - Egg which are not surrounded by a hard shell are called Non Cleiodoic eggs.
    - All viviparous animals (Mammals and all oviparous animals which lay eggs in water, Amphibians).

Discoidal Egg

- A type of Telolecithal and Megaleicithal eggs, where the yolk is in enormous quantity and concentrated in one part of the egg.
- Thus only a disc of cytoplasm called germinal disc remain in the egg which is located at the other pole of egg.

Mosaic Egg

In certain eggs, every portion is predetermined with respect to its potentialities for further development.If a small portion of such an egg is removed, a defective embryo is formed, This is because removal of a portion results in a permanent loss from the egg. The remaining portion of the egg cannot make compensatory development to make good the lost part. Such an egg, in which the future developmental potentialities are predetermined in the form of a mosaic, is called mosaic or determinate egg (e.g annelids, Molluscs and ascidians).

Regulative Egg

In vertebrates and most of the invertebrates, the developmental potentialities are not predetermined in the eggs. Removal of a small portion of the egg, or even one or two early blastomeres will not affect the normal development. This type of egg in which the future developmental potentialities are not predetermined is known as regulative or indeterminate egg.

Egg Membranes

- The Oocytes is surrounded by a membrane is termed as egg membrane. The eggs are well protected by egg membranes.
- The membranes are produced either by the egg itself or by the follicle cells of the ovary or by the genital ducts (oviduct) of the female mother.
- The egg membranes are classified into three types.

I. Primary membranes
II. Secondary membranes
III. Tertiary membrane.

1. **Primary membranes**
    - The membranes secreted by egg cytoplasm (ooplasm) constitute the primary membrane.
    - They are closely attached to the surface of the egg.
    - The primary membranes are named differently in the different animals. They are

a. Plasma Membrane

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

b. Vitelline Membrane

- It is closely attached to the plasma membrane of egg.
- Commonly found in Egg of Amphioxus, Molluscs, Echinoderms, amphibians birds etc.
- It is very thin and transparent.

- It is formed of mucopolysacharide and fibrous protein.
- The space formed between it and the plasma membrane is called Perivitelline space filled with a fluid called Perivitelline fluid.

c. Chorion

- It is found in the eggs of lower chordates like fishes (styela).
- It is a product of surface ooplasm

d. **Zona Radiata**

- The egg of the shark Scyllium canicula has two primary membrane produced by the surface ooplasm. The outer membrane is the vitetline membrane and the inner membrane has a radiating appearance and hence called zona radinta.
- The eggs of teleost fishes are also covered by zona radiate.

e. **Zona Pellucida**

- All mammalian eggs are surrounded by a membrane called zona pellucida is also named as zone 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 (desmosomes) in this zone. The microvilli are produced by the surface of the egg which are produced by Follicle cells. They protrude into the zona pellucida

II. Secondary Membranes

- The secondary membranes are produced by the follicle cells (cells found around the developing oocytes) of the ovary. These membranes are usually tough and impermeable.
- The secondary membranes are as follows

a. Chorion

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

b. Corona Radiata

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

III. Tertiary Membranes

- The tertiary membranes are produced by the oviduct.

White Albumen

- It is found in the egg of hen.
- It is found outside the vitelline membrane.

- It is formed of three layers-an inner less dense albumen, a middle dense albumen and an outer less dense albumen.
- The albumen is formed of water and protein

Shell Membrane

- The shell membrane is formed around the albumen in the egg of hen.
- It is a double membrane.
- The two membranes adhere closely and are separated by an air space are the blunt end of the egg.
- This membrane is formed of keratin-

Shell

- The shell is the outer covering of land animal's eggs.
- It is formed of calcium carbonate.
- It is white or brown in colour.
- It contains as many as 7000 minute pores.
- These pores are 0.04 to 0.05 mm in diameter.
- They are filled with a proteinous substance called collagen.

Jelly Coat

- The amphibian eggs are surrounded by a gelatinous covering called jelly coat

Mermaid's Purse

- It is the egg case of some cartilaginous fishes.
- It is a protective hard shell secreted by the shell glands present in the oviduct.
- The shape of the purse varies from group to group.
- Generally it is rectangular in shape.
- The corners of the shell are drawn out into four long twisted elastic filaments which serve to attach the eggs to sea weeds. In dog-fish Chiloscyllium, development is completed within this purse

Effect of yolk take on cleavage

- Yolk is a mechanically inert material, which when present in large quantities, may interfere physically with the subdivisions of an egg during cleavage.
- It retards the progress of the furrow to divide the cytoplasm following nuclear division.
- During cleavage, the chromosomes and the achromatic spindle are generally shifted into the more protoplasmic portions and away from the yolky areas of the egg.
- Consequently, the protoplasmic portions divide into smaller cells than the yolky areas. Besides, they divide more frequently.

- Cleave is mitosis. Mitosis is characterized by the movements of cell components viz., the chromosomes, achromatic figure, mitochondria etc.
- The activity of these components along the equator of the maternal cell leads to the ultimate separation of the daughter cell.
- The yolk granules or platelets are passively distributed between the daughter blastomers during these movements.
- When yolk become abundant, it tends to retard and the process of cleavage slows down.
- The yolk in the uncleaved egg is generally more concentrated toward the vegetal pole of the egg than the animal pole.
- Therefore, the cleavage is most retarded at the vegetal pole of the egg and here the blastomeres are larger in size.
- Frog‟s egg is a good example to explain the effect of yolk on cleavage.
- The first cleavage furrow is meridional but it does not appear simultaneously all stround the circumference of the egg.
- At first it is seen only at the animal pole of the egg where the amount of yolk is less. It then gradually prolongs along the meridian of the egg.
- Passing through the yolk-laden cytoplasm or deutoplasm, it eventually reaches the vegetal pole. This divides the egg into two blastomeres.
- The same process is repeated during the second meridional cleavage which takes place at right angles to the first.
- During the third cleavage, when the plane of division is latitudinal, the cleavage furrow appears simultaneously all over the circumference of the egg because it meets with an equal resistance from yolk at all sites.
- There is a greater accumulation of yolk at the vegetal pole of telolecithal egg. This interferes with the cell division at this pole and as a result the cleavage here become inhibited.
- The pattern of cleavage is determined considerably by the amount of yolk in the egg. Isolecithal and telolecithal eggs undergo complete or holoblastic cleavage. In this type, the cell membranes formed during cleavage cut completely through the egg. Including the yolk.
- In centrolecithal and discoidal eggs, the cleavage is incomplete or meroblastic. Such eggs contain so much yolk that only a small amount of cytoplasm with nucleus undergoes segmentation.

Physico-chemical nature and forms of yolk in animals

- The principal components of yolk are proteins, phospholipids and fats in differ combinations. Depending on the components which predominate, the yolk is distinguished as “protein yolk” or “fatty yolk”. These two kinds of yolk are present side by side in the eggs of many animals.
- The avian yolk as a whole contains 48.7% water, 16.6% proteins, 32.6% phospholipids and fats and 1% carbohydrates. The fatty portion of avian

yolk is mainly neutral fat (50% of the dry weight), the remaining being phosphatides and cholesterol.

- In animals yolk is found in three forms as given here under:
    - Granular Yolk: Protein yolk of many invertebrates like echinoderms and of lower chordates (Amphioxus, Tunicates) consists of fine yolk granules which are fairly evenly distributed in the cytoplasm of the eggs.
    - Yolk Platelets: In amphibian eggs, the yolk is found in the form of large granules called yolk platelets. The yolk platelets are oval and flattened in one plane. They contain two main proteinaceous substances: phosvitin and lipovitellin.
    - Yolk Spheres: The yolk of birds, reptiles and bony fishes lies in a compact mass in the interior of the egg. The cytoplasm is restricted to a thin layer on the surface, with a thickened cap on the upper side. Most of the yolk is liquid, but about 23% is in the form of solid “yolk Spheres.”