# EMBRYOLOGY

# Oogenesis

The **oogenesis** is a period of growth and maturation of the egg occurring in the female gonads (ovaries).

The female gametes is larger than most somatic cells and non-motile, because in all animal egg have many vital roles like; it has a nucleus containing half of the chromosomal content (haploid number of the chromosomes), it has to supply all cytoplasm to the embryo after fertilization, also it has supply food store to the embryo to develop. Primordial germ cells migrate into the developing gonad early in embryogenesis, and differentiate into oogonia. These oogonia proliferate by mitosis

**It is divisible into following three phases:**

**1. Multiplication Phase:**

The primary germinal cells of the ovary with diploid number of chromosomes (46,2n, 2c) divide several times mitotically so as to form a large number of daughter cells known as oogonia found in the cortex of ovary

**2. Growth Phase:**

The oogonium will differentiate to increases in size to form a primary oocyte, diploid number of chromosomes This process is called oocytogenesis (46,2n,4c) The growth is associated with both nuclear and cytoplasmic growth. The nuclear growth is due to accumulation of large amount of nuclear materials and is termed as germinal vesicle. The cytoplasmic growth is associated with increase in number of mitochondria, endoplasmic reticulum and Golgi complex and accumulation of reserve food material called yolk, Oocytogenesis is complete either before or shortly after birth. When oocytogenesis is complete, no additional primary oocytes are created, in contrast to the male process of spermatogenesis, where gametocytes are continuously created. In other words, primary oocytes reach their maximum development at ~20 weeks of gestational age, when approximately seven million primary oocytes have been created; however, at birth, this number has already been reduced to approximately 1-2 million.

**3. Maturation phase:**

The primary oocyte undergoes two successive divisions by meiosis. The first division is meiosis-I and two unequal daughter cells are produced during embryonic period, the large cell is called secondary oocyte containing haploid (n) set of chromosomes (due to reduction division) and entire amount of cytoplasm. Haploid (23,1n, 2c) The smaller cell is called first polar body or polocyte containing ‘n’ number of chromosomes and practically no cytoplasm.

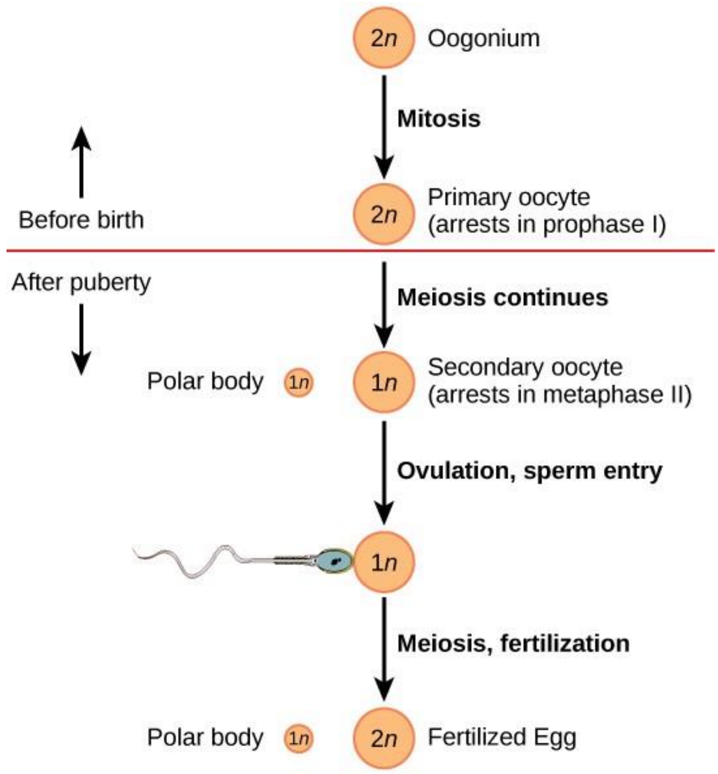
it stops at diplotene stage of prophase I until puberty. In late fetal life, all oocytes, still primary oocytes, have arrested at this stage of development. **This called the first stop point.** These cells then continue to develop, only a few do so every menstrual cycle. synapses occurs and tetrads form, enabling chromosomal crossover to occur. As a result of meiosis I, the primary oocyte has now developed into the secondary oocyte and the first polar body.

- At the ovulation during puberty :

immediately after meiosis I, the haploid secondary oocyte initiates meiosis II. However, this process is also stop again at the metaphase II stage until fertilization,**This called the second stop point**.

When fertilization is occur meiosis II has completed to form mature ovum and another polar body have now been created.

the first polar body may divide into two polar bodies or may not divide at all. Thus only one functional ovum is formed and the two or three polar bodies soon degenerate. In vertebrates the first polar body is formed after the primary oocyte is released from ovary and has entered into the oviduct. The second polar body is formed only when the sperm enters into ovum during fertilization.



# Development of the ovarian follicles

## 1- Primordial follicle

Primordial germ cells migrate into the developing gonad early in embryogenesis, and differentiate into oogonia. These oogonia proliferate by mitosis. Some of these enlarge and develop into larger cells called primary oocytes and enter the first meiotic division on the pathway to making gametes by meiosis. This happens between 3 and 8 months of gestation in the human embryo.

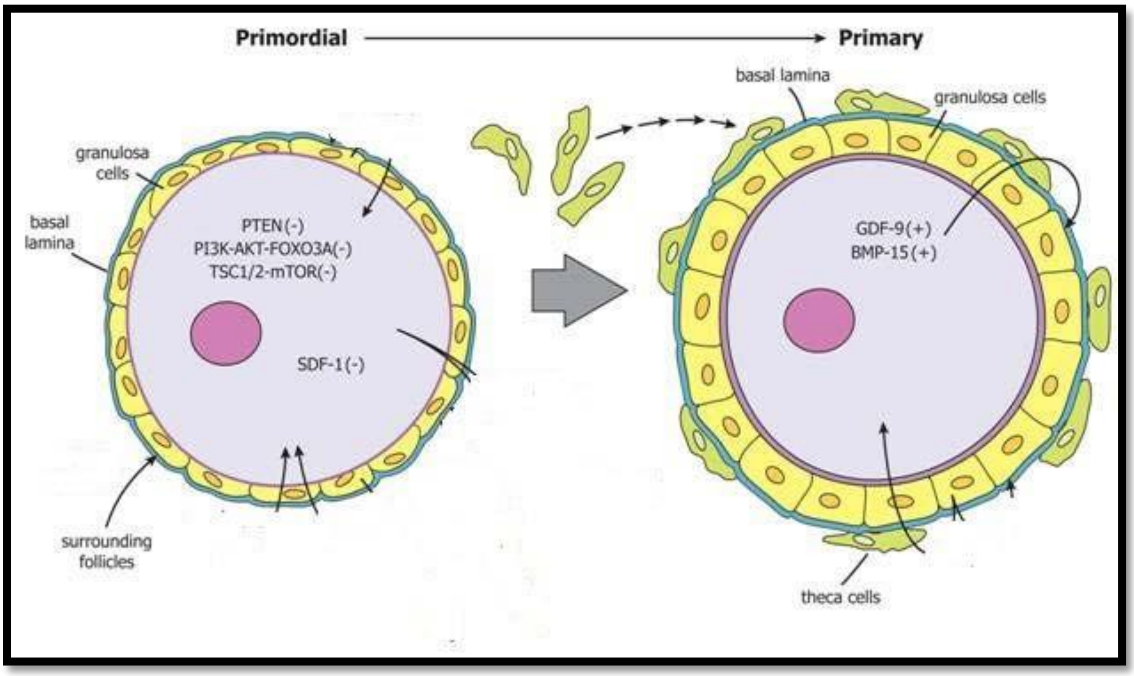
These 'primary' oocytes become arrested in prophase of the first meiotic division until the female becomes sexually mature. At sexual maturity, a small number of primary oocytes (20-50) mature each month and complete the fist meiotic division to become secondary oocytes, under the influence of **follicle stimulating hormone**. The oocytes synthesize a coat and cortical granules - this glycoprotein coat is called the 'zona pellucida'. They also accumulate ribosome, yolk, glycogen, lipid and the mRNA that will be used later on after fertilization to direct early development of the embryo.

After a second mitotic division, ova are formed.

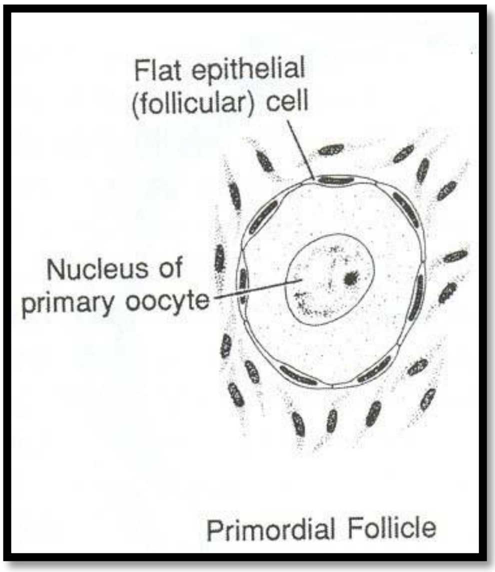
In primordial follicles, the oocyte is arrested in the last stage of prophase at this stage, it is surrounded by a single layer of flattened **ovarian follicular epithelial cells**. (These cells are also known as granulosa cells). They are small, and usually found close to the outer edge of the cortex.

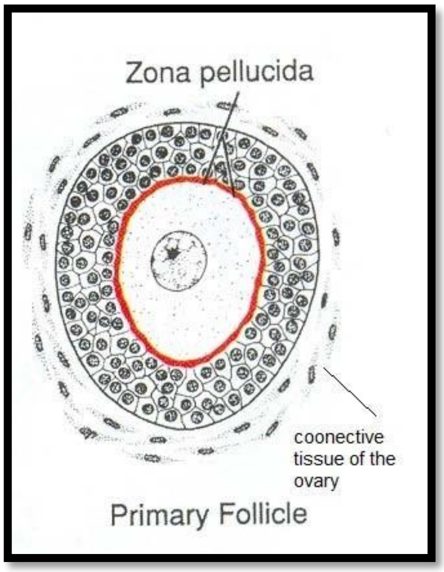
## 2- Primary follicle

When the primordial follicle is stimulated, it becomes a **primary follicle**. The oocyte enlarges, and the **follicular cells** divide called the granulose cells with two layers of granulose cells is called a primary follicle. These cells continue to hypertrophy and proliferate to form many layers surrounding the oocyte. Eventually these cells become known as 'granulosa' cells. The granulosa cells will secrete progesterone after ovulation. A thick glycoprotein layer develops between the oocyte and the zona granulosa, called the **zona pellucida**.Finally, the **stroma** around the follicle develops to form a capsule like 'theca'. (Theca is greek for 'box'). Only one of the maturing follicles completes the maturation process each month. The rest degenerate into **atretic** follicles. Follicular maturation takes about 3 months.




Development of the primordial follicle to primary follicle in the ovary of the female embryo

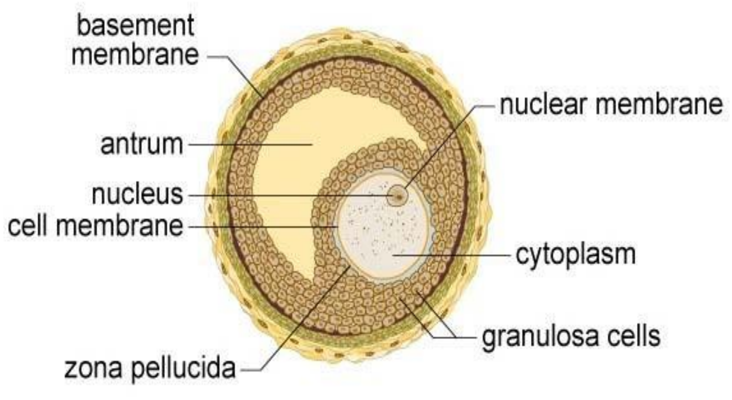



### 3- Secondary Follicle

The primary follicle develops into a **secondary follicle**. The secondary follicles look very similar to primary follicles, except that they are larger, there are more follicular cells, and there are small accumulations of fluid in the intracellular spaces called **follicular fluid** (nutritive fluid for the oocyte) to form an **antrum**. The surrounding granulosa cells is called the **cumulus oophorus** (greek for 'egg bearing heap').

The surrounding theca differentiates into two layers: the **Theca interna** (rounded cells that secrete androgens and follicular fluid) and a more fibrous **Theca externa** - spindle shaped cells. The androgens are converted into oestrogen by the granulosa cells.




secondary follicle

## 4- Graffian follicle

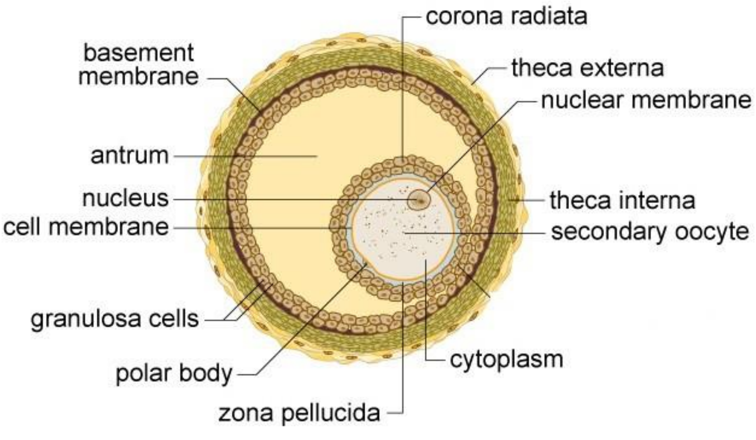
The secondary follicle develops into a **Graffian follicle**.

The first meiotic division is now completed, and the oocyte is now a secondary oocyte, and starts its second meiotic division. After the first meiotic division, most of the cytoplasm goes into one of the two daughter cells. The other becomes the polar body (hard to see).

The folicular fluid fills a single space, called the **antrum**, which is surrounded by the follicular cells - called the **membrana granulosa**. The granulosa cells that surround the oocyte, and project into the antrum are called as the **cumulus oophorus**. There is a basement membrane between the granulosa cells and the **theca interna**. The fibrous **theca externa** merges with the surrounding stroma.

The **oocyte**, **zona pellucida** and the follicular cells surrounding the ooctye (known as the **corona radiata**) are all expelled at ovulation, and enter the fallopian tube**.**

Once released, the oocyte begins its second meiotic division, as far as metaphase II. Division only carries on if the ovum is fertilized.



Mature Follicle

## Fate of the degenerated follicles

**Corpus Luteum**

After ovulation, the ruptured follicle collapses and fills with a blood clot (corpus haemorrhagicum) which then forms the corpus luteum. The **granulosa cells** enlarge, and become vesicular, and are now called the **granulosa lutein** cells. these become folded, as you can see here.

The spaces between the folds are filled with **theca interna** cells, which also enlarge and become **glandular**, and are now known as the **theca lutein** cells.

The **zona granulosa** cells begin to secrete progesterone (granulosa lutein cells). The corpus luteum also secretes estrogen (which inhibits FSH) and relaxin (which relaxed the fibro cartilage of the pubic symphysis).

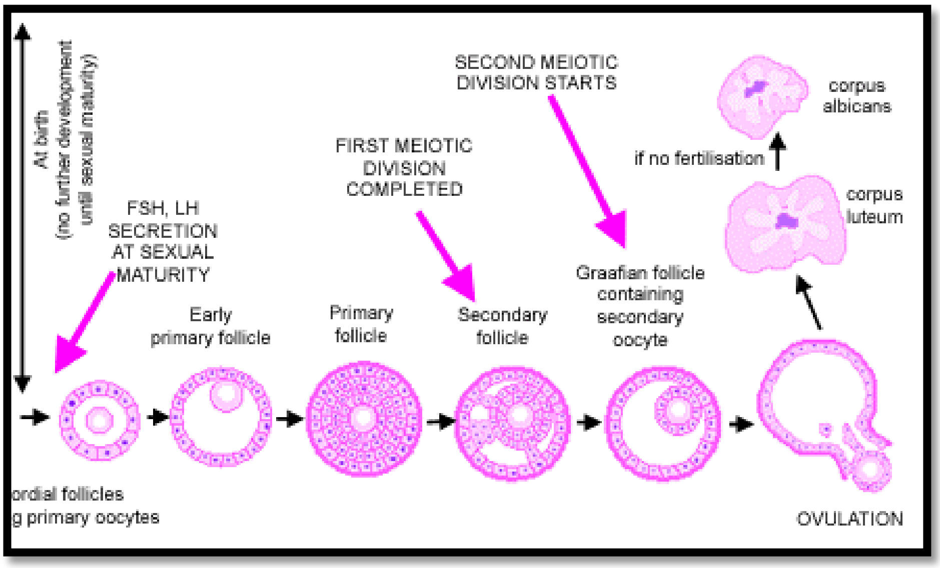
If pregnancy does not occur, then the corpus luteum degenerates into the **corpus albicans**, and levels of estrogen and progesterone fall, allowing release of FSH and LH.

If pregnancy does occur, then the syncytiotrophoblasts of the placenta release **human chorionic gonadotrophin**, and the corpus luteum persists.

About 20 primordial follicles start developing in each cycle, but only ONE makes it!

## Corpus albicans

This image shows an atretic corpus luteum or corpus albicans. The cellular elements have degenerated, and macrophages phagocytose the dead cells. Fibrous tissue is left behind. The corpus albicans looks pale. It will continue to shrink, eventually forming a small scar on the side of the ovary.



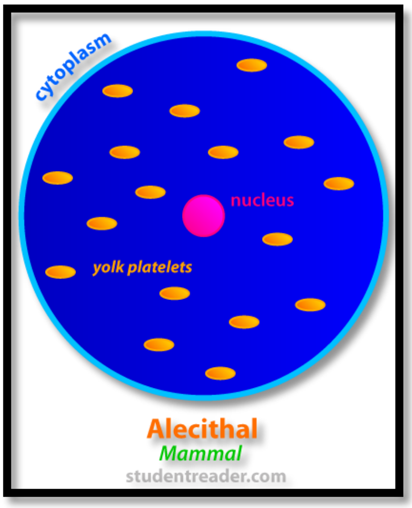

## Classification of eggs

Yolk, the major nutritional reserve of the oocytes during the growth and development and after the fertilization to provide the embryo with nutrition, the yolk varies greatly in amount and distribution in different animals groups.

- ❖ **Based on the amount of the yolk, the eggs can be classified into the following:-**
- ❖

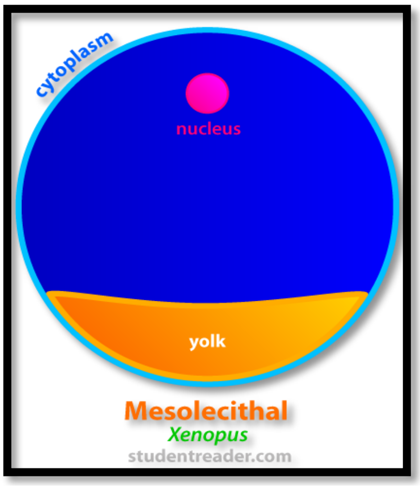
**1- Microlecithal (oligolecital ) eggs**

These are small-sized eggs which contain a very small amount of yolk distributed in the cytoplasm (ooplasm), this type found in certain marine invertebrates, ex: *Hydra*, and some chordates like *Amphioxus*, cephalochordates, tunicates, and the eutherian mammals, in the mammals this type of egg called also **Alecithal egg.**



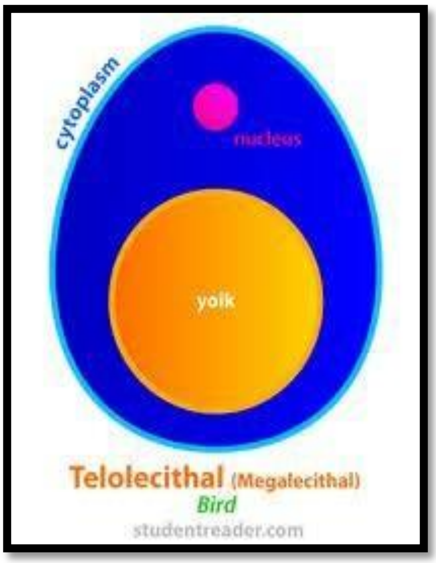

## 2- Mesolecithal eggs

This type of eggs contain moderate amount of yolk, found in annelid worms, molluscus, *Petromyzon*, lung fish and amphibian.




## 3- Macrolecithal (megalecithal ) eggs

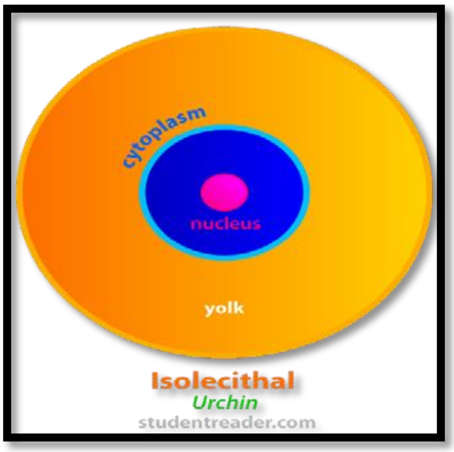
These eggs contain enormous amount of yolk, found in insects, chondrichthyes, reptiles, birds and monotrems.




## ❖ Based on the distribution of the yolk

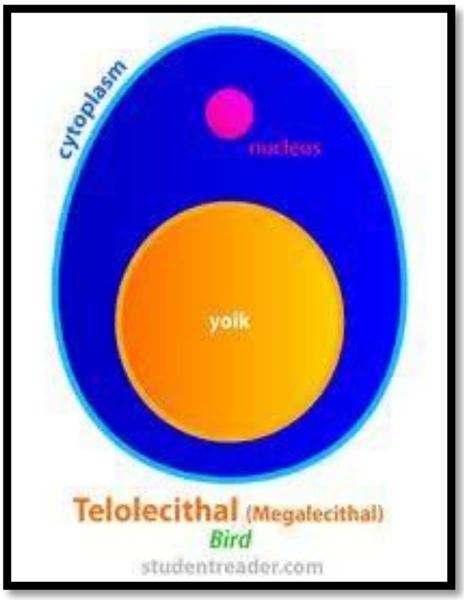
### 1- Homoelcithal or isolecithal eggs

In Microlecithal eggs, the amount of yolk is little, therefore it is found almost scattered through all the cytoplasm of the egg.



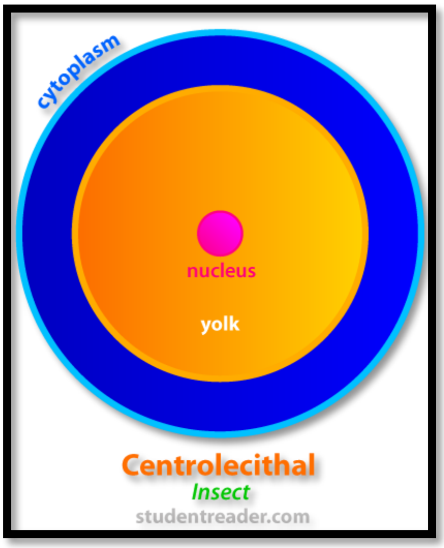

### 2- Telolecithal eggs

This type of egg has a **polarized** distribution of yolk in the ooplasm due to the gravity of the yolk; it concentrated more in one side than in the other. The side that contain no or very small amounts of yolk is called the **animal pole**, while the side where the yolk concentrated more called the **vegetal pole**. This type found in the amphibian, *Petromyzon*, cartilaginous and bony fishes, reptiles, and birds.




### 3- Centrolecithal eggs

In insects and some hydrozoa, the yolk is concentrated in the center of the egg and the active ooplasm and nucleus form a thin peripheral layer around the yolk.



**Homework**

| | item | Spermatogenesis | Oogenesis |
|---|---|---|---|
| 1 | location | | |
| 2 | Start of process | | |
| 3 | End of process | | |
| 4 | No. of gametes per germ cell | | |
| 5 | Start of meiosis I | | |
| 6 | stop of meiosis I | | |
| 7 | Need to differentiation (yes/ no) | | |
| 8 | Stop of meiosis II | | |
| 9 | Source of nutrition | | |

# Formation of egg membranes

In most animals, except the sponges and coelenterates, oocyte maturation is not completed until additional structures, called egg membranes, egg membranes are added outside the plasma membranes of egg and vary in different animal groups and sometimes reflect the adaptations by the animals, protect eggs from predators, disease, and many environmental effects like PH , There are several ways of classifying the egg membranes, but the simplest way is according to their origin as follow:-

**1- Primary egg membranes**

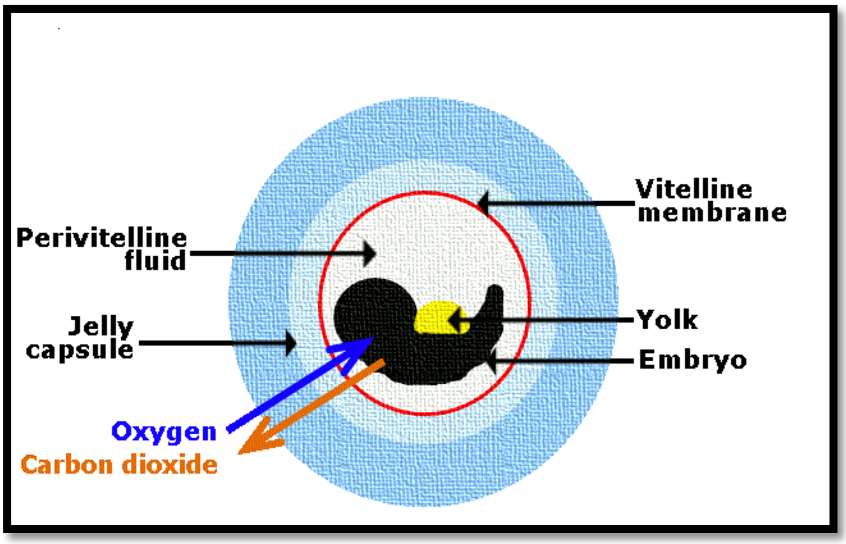
These membranes are formed in the ovary between the egg plasma membrane and follicle cells, they are formed either by ovum and follicle cells, this type of egg membranes includes:-

**a- Vitelline membrane**

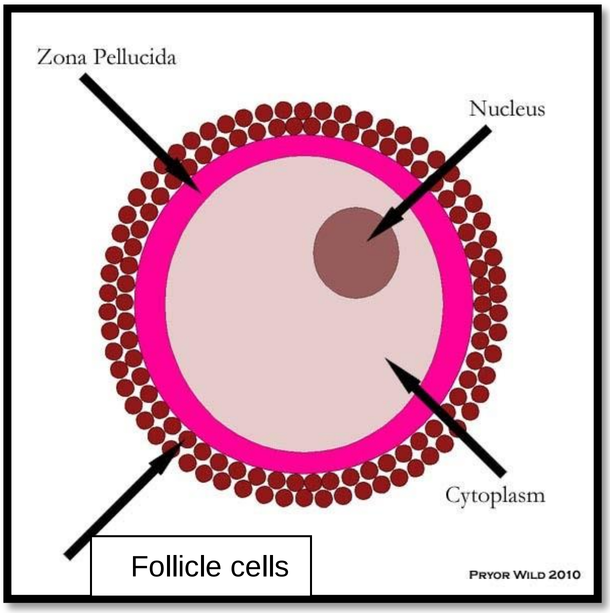
In fact it is not a membrane, but a non-cellular transparent layer of mucoprotein out of egg give the physical support and elasticity.

**The Vitelline membrane** is a structure directly adjacent to the outer surface of the plasma membrane of an ovum

Vitelline membrane has different names for example, in birds it contact to the ooplasm until the fertilization then will separate therefore it's called the fertilized membrane, in fish called the chorion, and in the reptiles and mammals called zona pellucida.



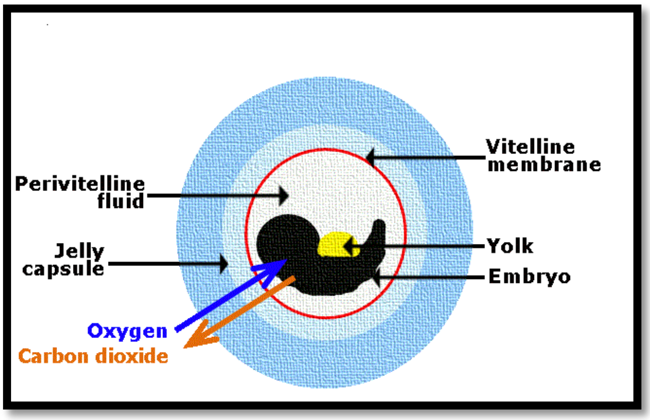

Vitelline membrane in amphibians




Zona pellucida

**b- Jelly envelope**

In echinoderms and many eggs of the marine invertebrates, the primary egg envelope is much thicker structure like jelly coat.




2- **Secondary egg membrane**

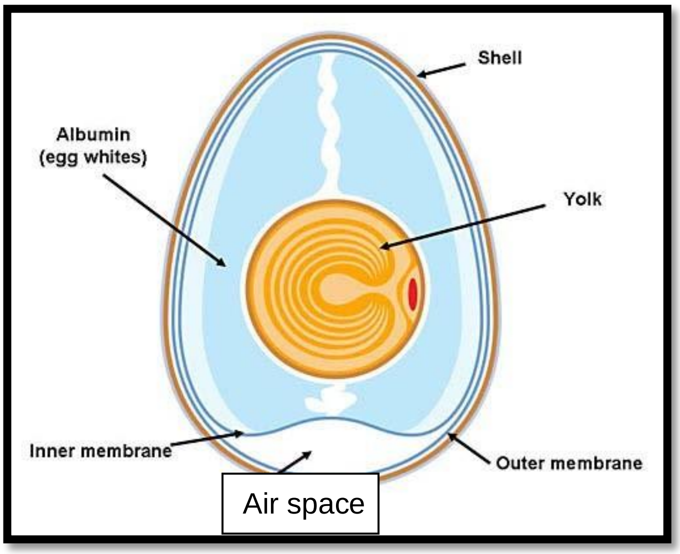
The secondary egg membrane is secreted outside the primary egg membrane by the follicle cells. It occurs in the form of chitinous shell around egg in insects and cyclostomes and called the chorion, this chorion is different from the chorion in fish that is formed by the oocyte and contains proteins and polysaccharides.

No secondary membranes are found in the amphibians, reptiles, birds and even mammals eggs.

3- **Tertiary egg membrane**

The tertiary membrane secreted through passage the egg in the oviduct or during the presence of the egg in the uterus secreted by the cells of the oviduct itself. This membrane is found in:

- In oviparous sharks the eggs are surrounded by albumin and hard capsule secreted by shell glands of the oviduct.
- In amphibians, three layers of albumin (jelly) are deposited around egg, during the amphibian's eggs down in water; the jelly membranes absorbed the water and swells. These jelly membrane protect the eggs from infection and predators.
- In reptiles, bird's five tertiary membranes make up the envelopes of the egg out of the vitelline membrane.




Anatomy of chick egg