

Insight of Embryology and Development Biology

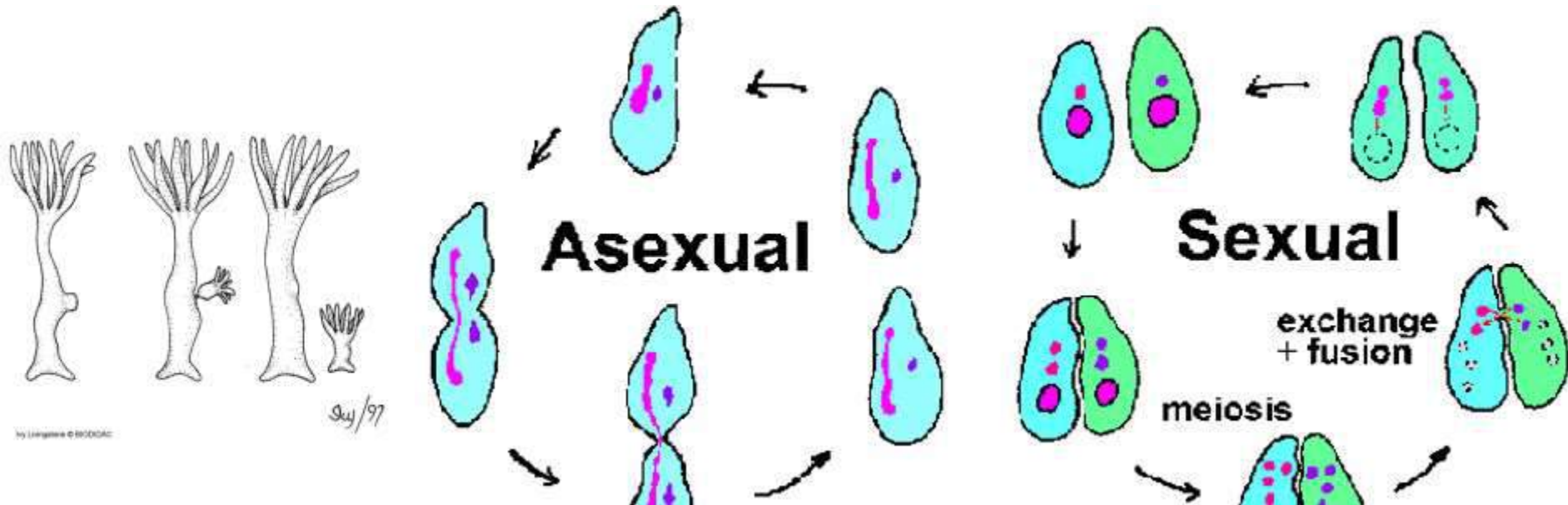


Lec. Dr.Ruwaidah F. Khaleel

- The study of the early development called the **Embryology**.
- So the simplest **definition of embryology** is: -
- **(The study of development of an organism from fertilization to birth)**
- The survival of each species of **viruses, bacteria, fungi, plants** or animals requires that its individual members multiply to produce new individuals to replace that one killed by the natural death in old age or by **predators, parasites, environmental pollutions or others factors**.
- The multiplication of new species is achieved by two basic process, called **asexual reproduction**, and **sexual reproduction**



- **In the asexual reproduction**, the progeny arises from single existing organism which **splits, buds or fragments** from the body of the organism, to give rise to two or more off springs, all of which **have** hereditary traits identical to those of the parental organisms.
- **In the sexual reproduction**, the progeny arises from the **fusion of the two genetically identical gametes (sperms & eggs)** in the multicellular animals; each of them is derived from different sex of the organisms with genome different from the parent, the resultant cell called **fertilized egg or zygote**.

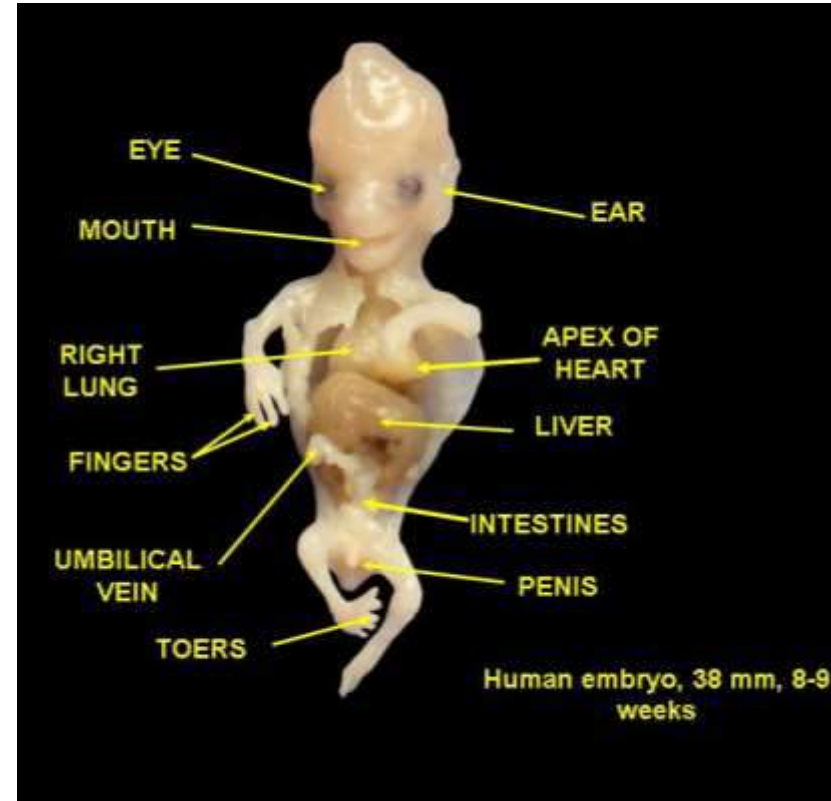


- Both the asexual and sexual reproduction which constitute two different aspects of development are :

- ❖ **Ontogenetic development**

- ❖ **Phylogenetic development**

- The **Ontogenetic development**: - is the historical or evolutionary development of species, which includes the **embryogenesis** period, can be defined as **Embryogenesis**, that mean, development of a new individual from the zygote and the **blastogenesis**, that mean, development of a new individual from an asexual reproduction.
- The different in the concept between the embryogenesis and the development is that the development is a wider term than the embryogenesis, because its include all the changes that undergo in the organism from the fertilized egg until death. (In another meaning = the life history' of the organism).



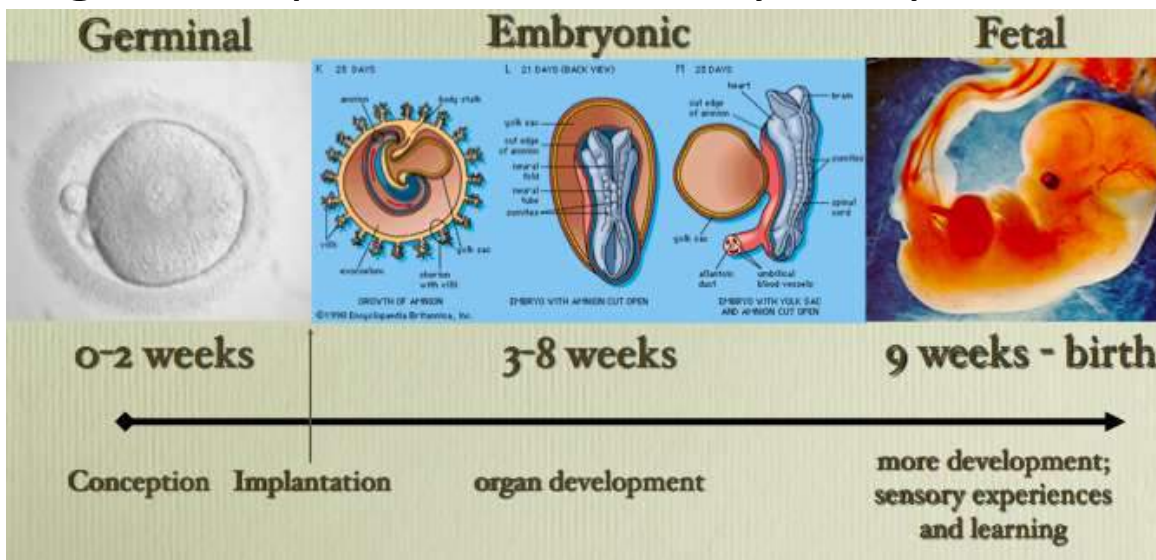
Most animals have two distinct periods in their life history (development):-

1. Embryonic period or called Pre-natal period

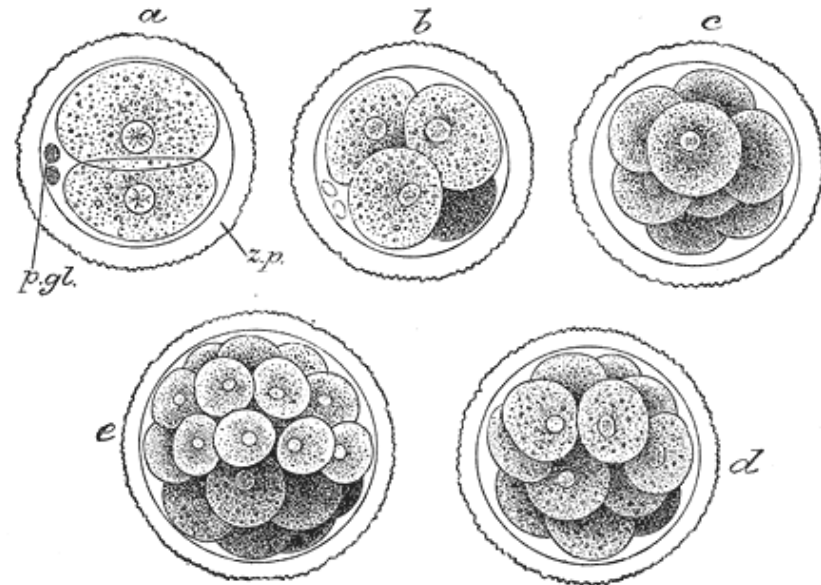
This represents the period in the egg or inside the body of the mother.

2. Postembryonic period or called Post-natal period

This period extend from hatching or birth up to the natural death of the organism due to aging. Thus, all the developmental events and changes which occur from the time of fertilization of the egg through Formation of the embryo or fetus until the hatching or birth belong to the prenatal or embryonic period



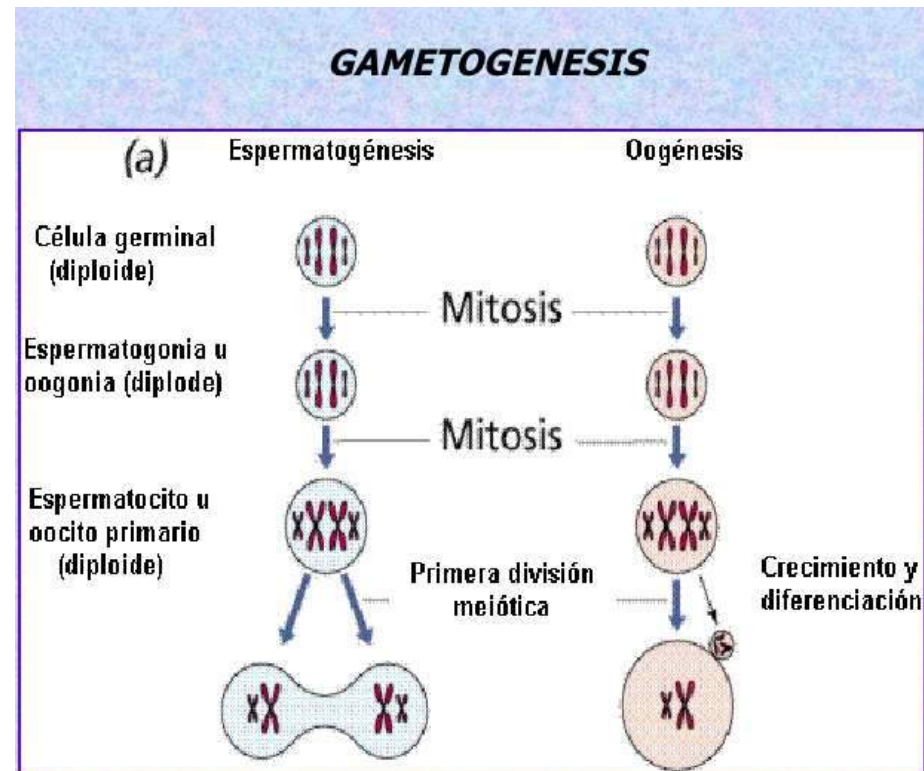
- These events are included in embryogenesis and the science which studies the **embryogenesis** is called **Embryology**.
- The field of biology which deals with the study of those **embryogenetic** and **blastogenetic** process by which organism undergoes progressive and orderly changes in structure and function during their entire life history, unlike embryology, does not restricted itself to the study of the development of embryo (i.e., embryogenesis) but deals with all aspects (**genetic, biochemical, physiological and morphological**) of the entire developmental period of the individual organism.



The embryogenesis of an animal species includes the following stages or phases:

1. Gametogenesis

- This stage is started from the time of development and specialization of haploid male & female sex cells, from diploid somatic cells of each parent during a process called **gametogenesis**. Gametogenesis includes **spermatogenesis** in male testes and **oogenesis** in female ovaries.



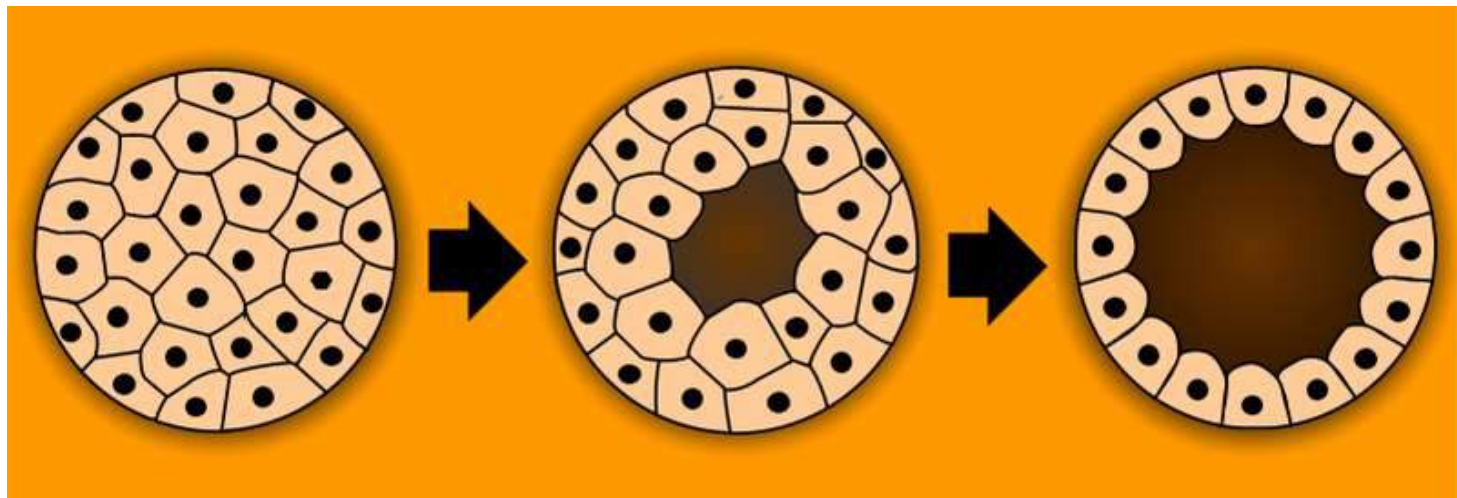
2. Fertilization

- This second phase of embryogenesis is fertilization, which is the union of spermatozoon (sperm) and the **ovum** and then activation of egg to begin the embryogenesis of a new individual.



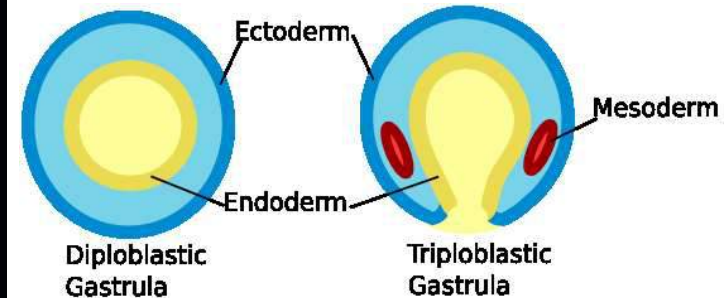
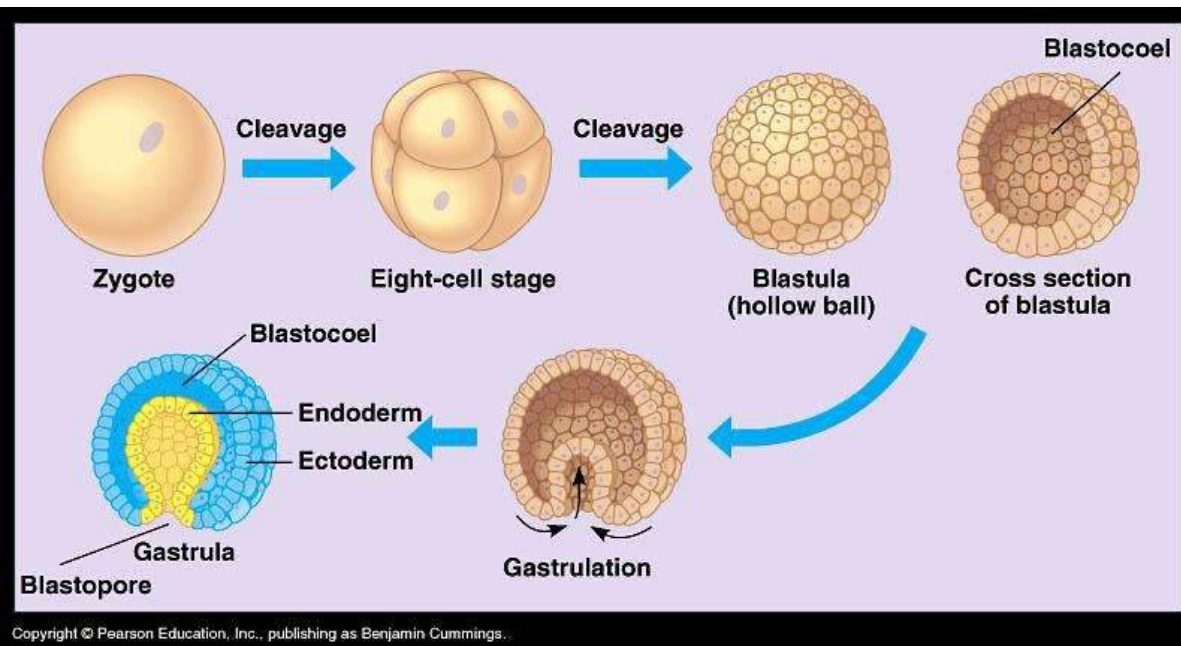
3. Cleavage

- During third phase of embryogenesis, the cleavage, **no growth** of egg occur, but rate of **synthesis of some macromolecule such as DNA, protein, glycogen, fats and yolk**, so the fertilized egg undergoes repeated mitotic cell divisions and produces a compact mass of cell, called **morula**.
- **The morula** soon get arranged in hollow spherical mass, called **blastula**, with a layer of **blastocysts** called **blastomeres** surrounding a fluid-filled central space or cavity, and called the **blastocoel**. The process of conversion of a fertilized egg into multicellular blastula called **blastulation**.

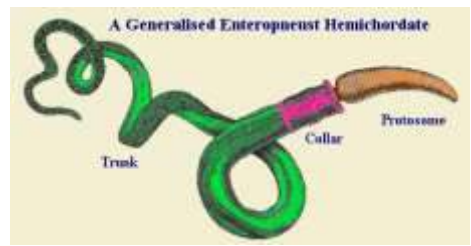
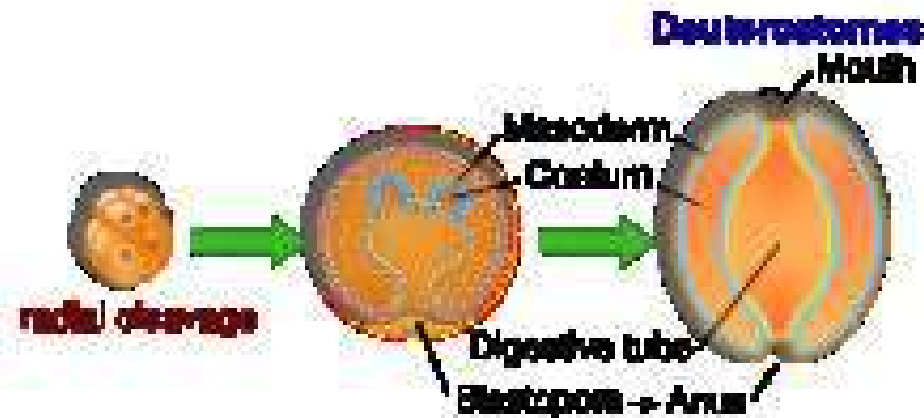
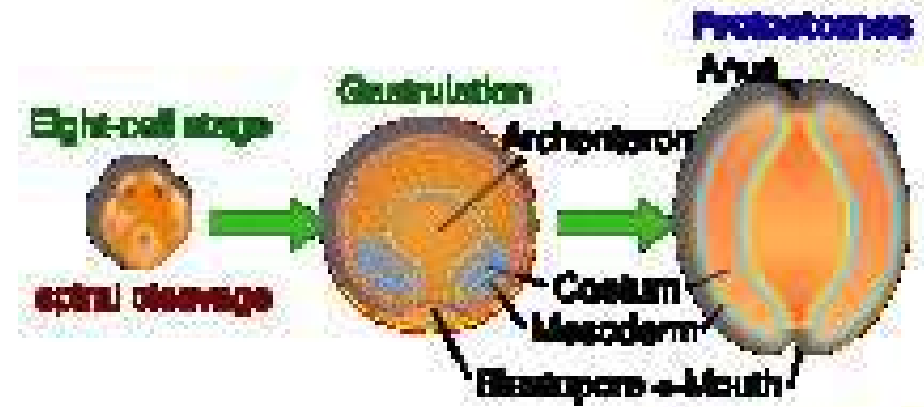
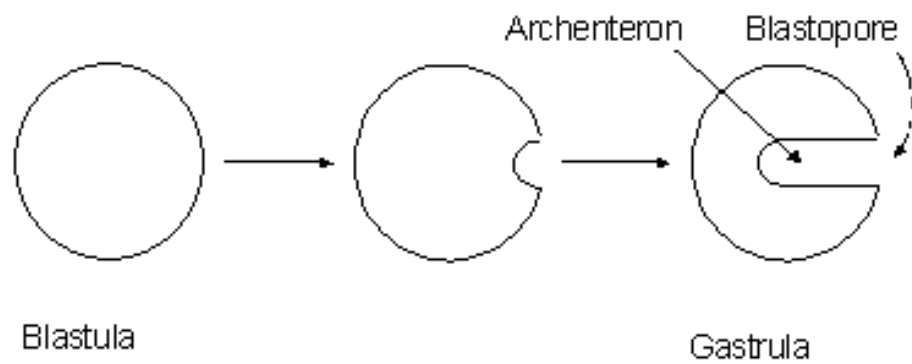


4. Gastrulation

- In this phase, there are an extensive movements and rearrangements of cells of blastula, transforming the one-layered thick embryo (blastula) into a two or three-layered thick embryo, called **Gastrula**.
- From the gastrula the **three primary germ layers** are formed, the outer layer called **ectoderm**, the middle layer called **mesoderm**, and the inner layer called **endoderm**; from these three germ layers various organs of animal body are formed.

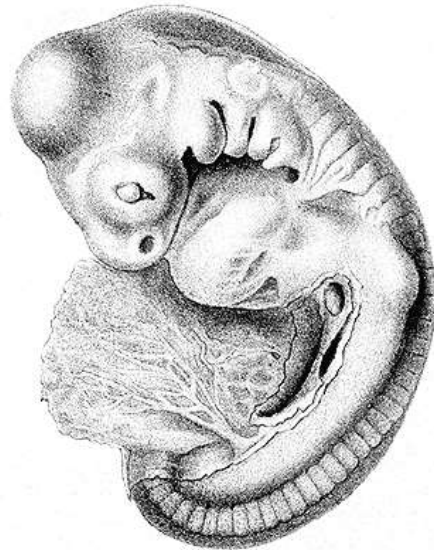


- In the middle center of the gastrula found a central cavity called the **archenteron**, which is lined by endoderm and communicates to the outer environment by an opening called **blastopore**.
- During later stages of the development, the archenteron becomes the cavity of the alimentary canal, while the blastopore becomes **mouth opening in all invertebrates, except echinoderms and hemichordates**, therefore these animals in embryology called **protostomia**.
- But in the other groups of animals includes echinoderms, hemichordates and all vertebrates the blastopore becomes the anal opening '(anus)', therefore called **deuterostomia**.

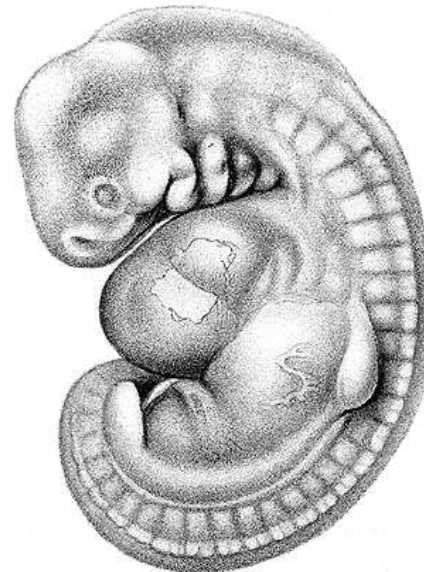


5. Organogenesis

- During the fifth phase of embryogenesis, the organogenesis or named the formation of the organs.
- The continuous growing of the masses of the three germ layers will split up into smaller groups of cells, called primary organ rudiments, each of which is destined to produce a certain organ or part of the adult body.



A



B

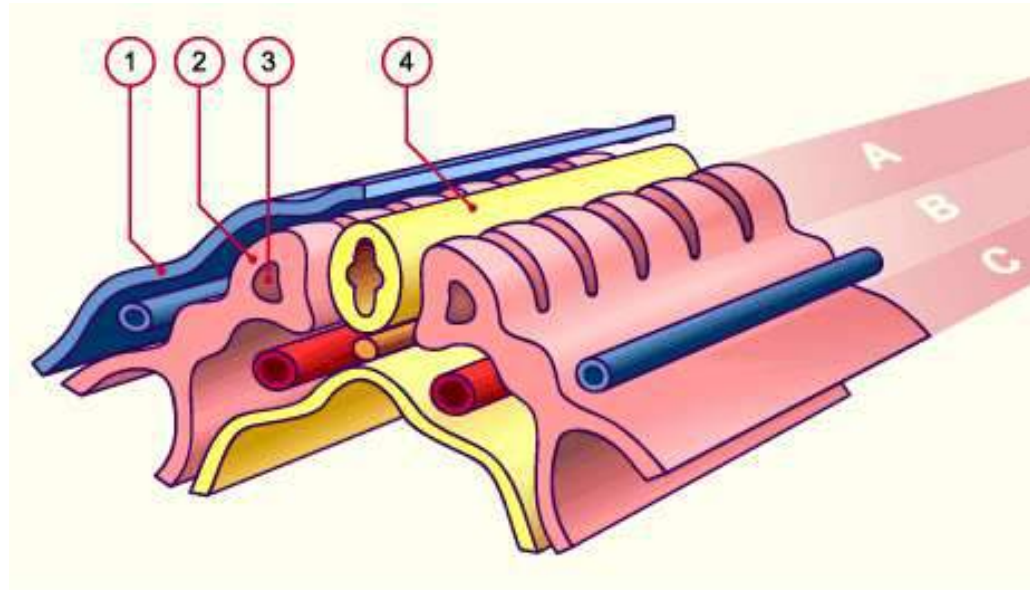
6. Growth

- The simplest definition of the growth in embryology is the **increase in the body mass of the animal.**
- This increase in the body mass is achieved by **synthesis of new nuclear material and cytoplasm and cell multiplication**, thus during growth period the organ rudiments of the embryo begin to grow and greatly increase their volume.



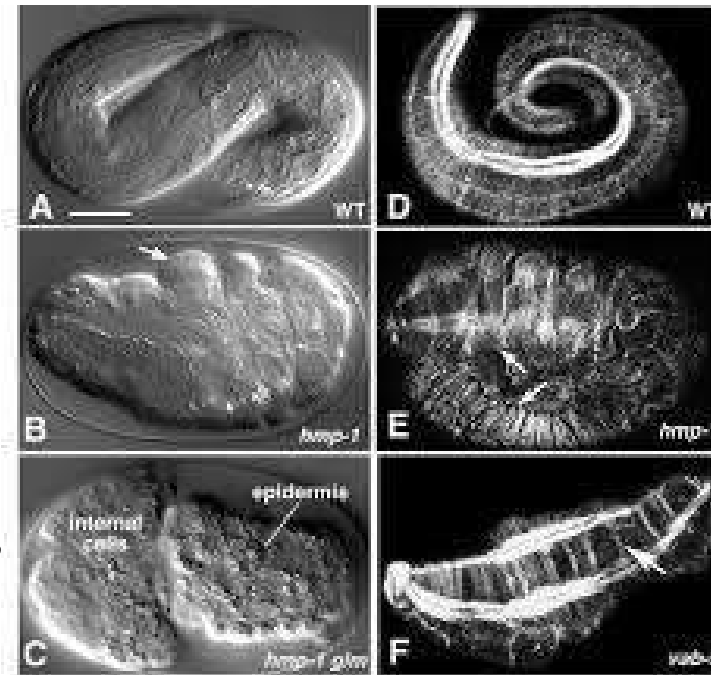
7. Differentiation

- The differentiation refers to the events by which parts become different from one another and also different from their origin.



8. Morphogenesis

- The morphogenesis refers to that tissues and organs are take a special shape and size that make the special form of the organism body.
- **The form of an organism depends on two main factors:-**
 - ❖ The form of the cells (differentiation)
 - ❖ The position of the different cells
- Communicates between the growing cells physically and chemically are the important factors in the morphogenesis process, **morphogens** are chemicals produced during development to determine the morphogenesis and differentiation of cells, tissues or organs.
- The morphogens become active when the embryo become multicellular (**2-cell stage of egg**) these morphogens like **the hormones chemically**.



9. Metamorphosis

- The growth, differentiation and morphogenesis transform the embryo into a young animal.
- After hatching from the egg morphological features are similar to the adult animal **except in being of sexually immature**, so this will be called **juvenile stage** or may find different types of organs which serve the young animal during certain period and disappear later, this is called **larval stage**.
- **The young larva later passes through an important development process. So the Metamorphosis means:**
 - ❖ **A change in the form and often habits of an animal during normal development after the embryonic stage.**
 - ❖ The metamorphosis causes morphological and physiological changes in feature under hormone control the transforms into an animal similar to the adult.



Branches of Embryology

- Modern embryology is truly a scientific cross road, a meeting place of many sciences as **physics, chemistry, zoology, botany, microbiology, genetics, etc.** however modern embryology has following branches:

1. Descriptive embryology

For centuries observation and descriptive of different embryonic stages of the ontogenetic development of a species depend on notices.

2. Comparative embryology

Comparative study is made between the embryology of most animals types.

3. Experimental embryology'

This is youngest and most modern field in embryology, study the fertilization, cleavage, and gastrulation in the vivo.

4. Chemical embryology

Study the embryology phases in molecular terms.

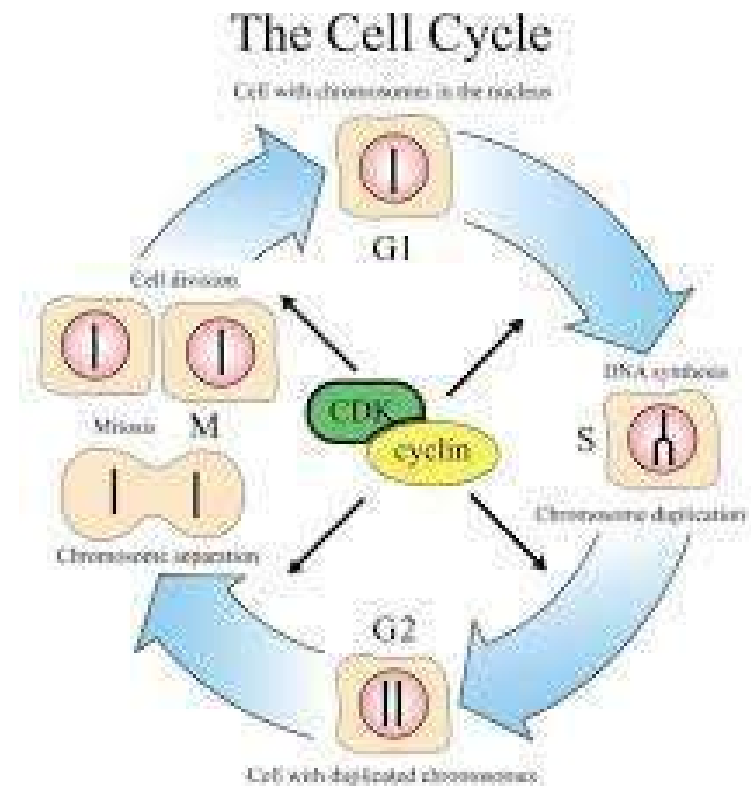


Cell cycle and Cell division

- **Cell Cycle**

each cell capable of division passes through a cycle called interphase **cycle** or **cell cycle** which can be defined as a **sequence of events happening from the one nuclear division to the beginning of the next.**

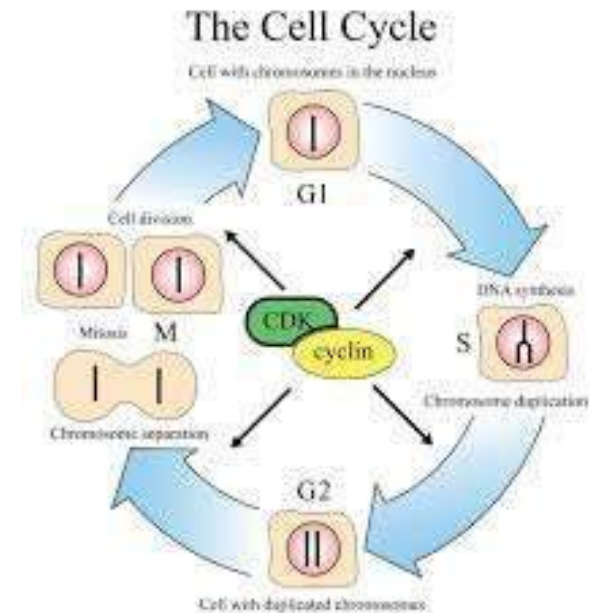
- The total time of the cell cycle in the animal cells varies with the species and many physical conditions like **temperature**, and **the type of the cell.**



The cell cycle divided into 4 phases:-

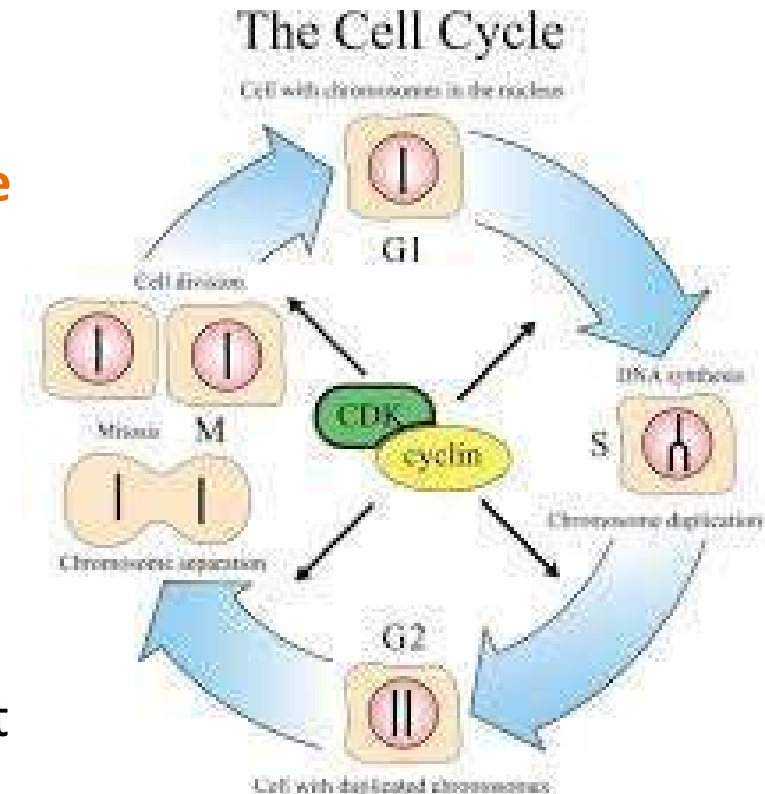
1- G1 phase

- Is the first gap or **growth stage** of the cycle begins immediately following cell division, in which the
 - ✓ **Nucleus and cytoplasm are enlarged.**
 - ✓ **Chromatin is fully extended not recognized as chromosomes.**
 - ✓ **This time is considered the time of the active synthesis of RNA and protein and reactive all the metabolic pathways that slowed during the cell division.**
- **G1** is very variable in its duration; it may occupy **30-50%** of the total time of the cell cycle or may be lacking because the rapid cell division like in the mammalian embryos, differentiated somatic cells that no longer divide like in neurons are arrested usually in the G1 stage is often referred to as **G0 phase**.



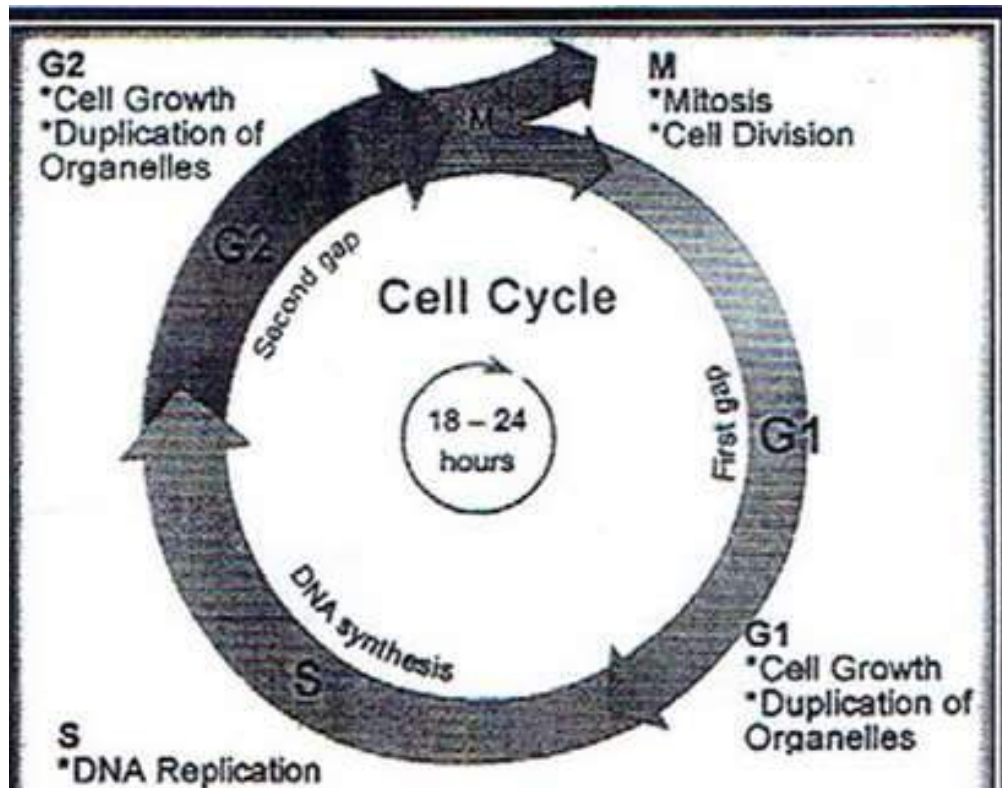
2. S phase

- Called the **synthetic phase**,
- ✓ **Replication of DNA and synthesis of histones occur.**
- ✓ **DNA molecule of each chromosome becomes doubled in the amount.**
- ✓ **So that each chromosome will carry double set of the genes or two DNA molecules (2n).**
- ✓ **At the end of this phase each chromosome is composed of two sister chromatids with one centromere.**
- Cells in early embryos are completely located in **S phase** because the short generation time have, and these cells have **no G1 and G2** like the prokaryotic cells, this means that total genome DNA is replicated 100 times faster in early embryos than in late embryos or in adults tissues.



3- G2 phase

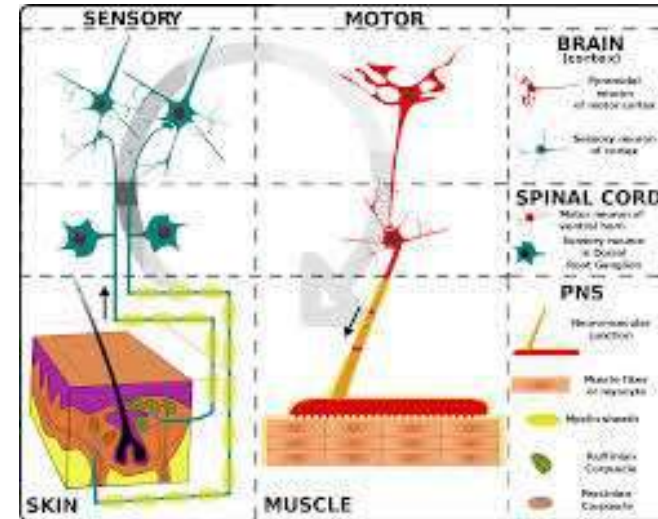
- This is the second gap, or called **the growth phase** represent the less time of the cell cycle, the previous process continues in this time.
- At the end the cell now is ready to enter the **mitotic division or M phase**.



The cell cycle in mature cell

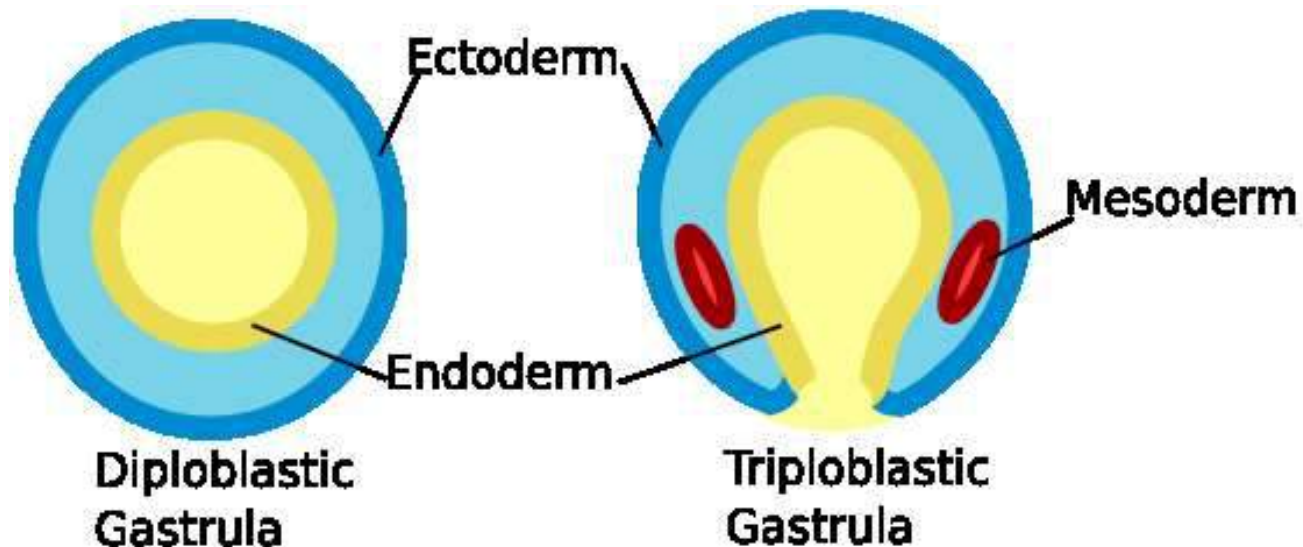
Induction

- The embryonic development is regulated by signals of many types in many ways, one of the most important embryonic signals is **the process of induction**, and the **simple meaning of induction is an effect of one embryonic tissue on another**.
- Inductive interaction occurs throughout much of embryonic development and even into postnatal life.
- In vertebrates, the first major inductive event involves the induction of mesoderm in the embryo, the **mesoderm** induce the nervous system during gastrulation so it's called **primary induction**, shortly after gastrulation the nervous system itself induce other structures (sensory organs) this induction is called **secondary induction** and the tissues produced from the secondary inductions sometimes induce the formation of other structures therefore this called **tertiary induction**.



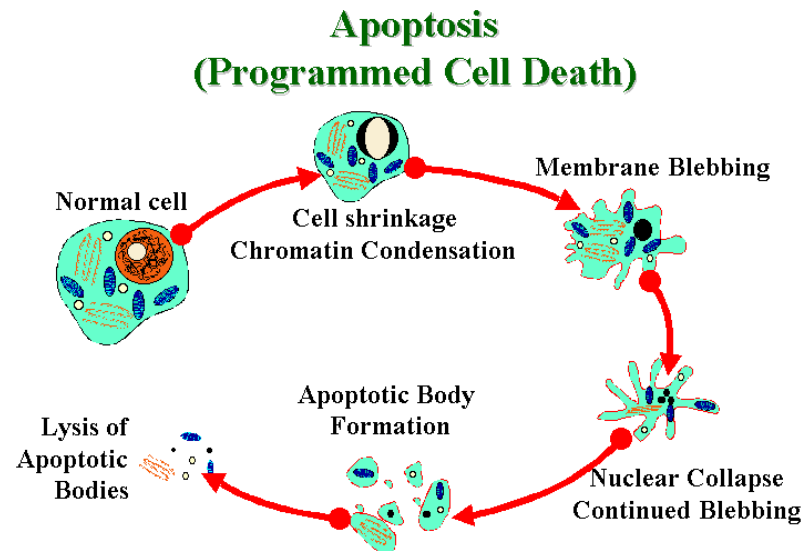
Differentiation

- **Differentiation** is the process by which a cell becomes specialized and the final product is called a differential cell.
- **There are many ways of differentiation:**
 1. **Biochemical**, ways, the differentiated cells choose one or more specialized synthetic pathways, for example, the synthesis of hemoglobin by erythrocytes.
 2. **Functional ways**, the development may progress towards certain function, like the ability of the muscle fibers to contraction.

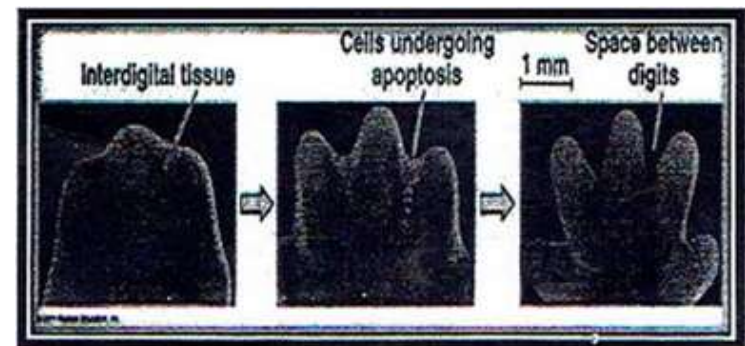
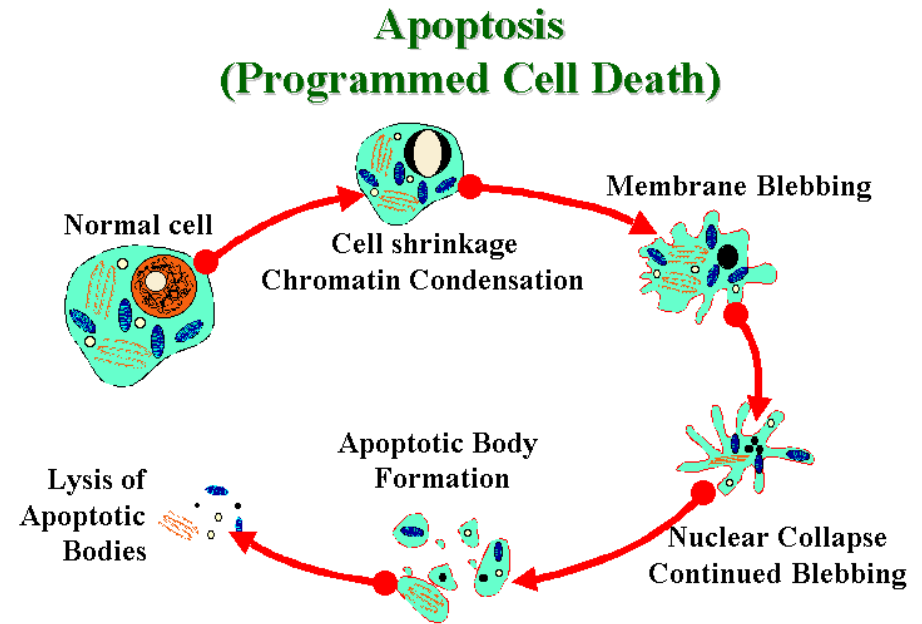


Cell death (programmed cell death - apoptosis)

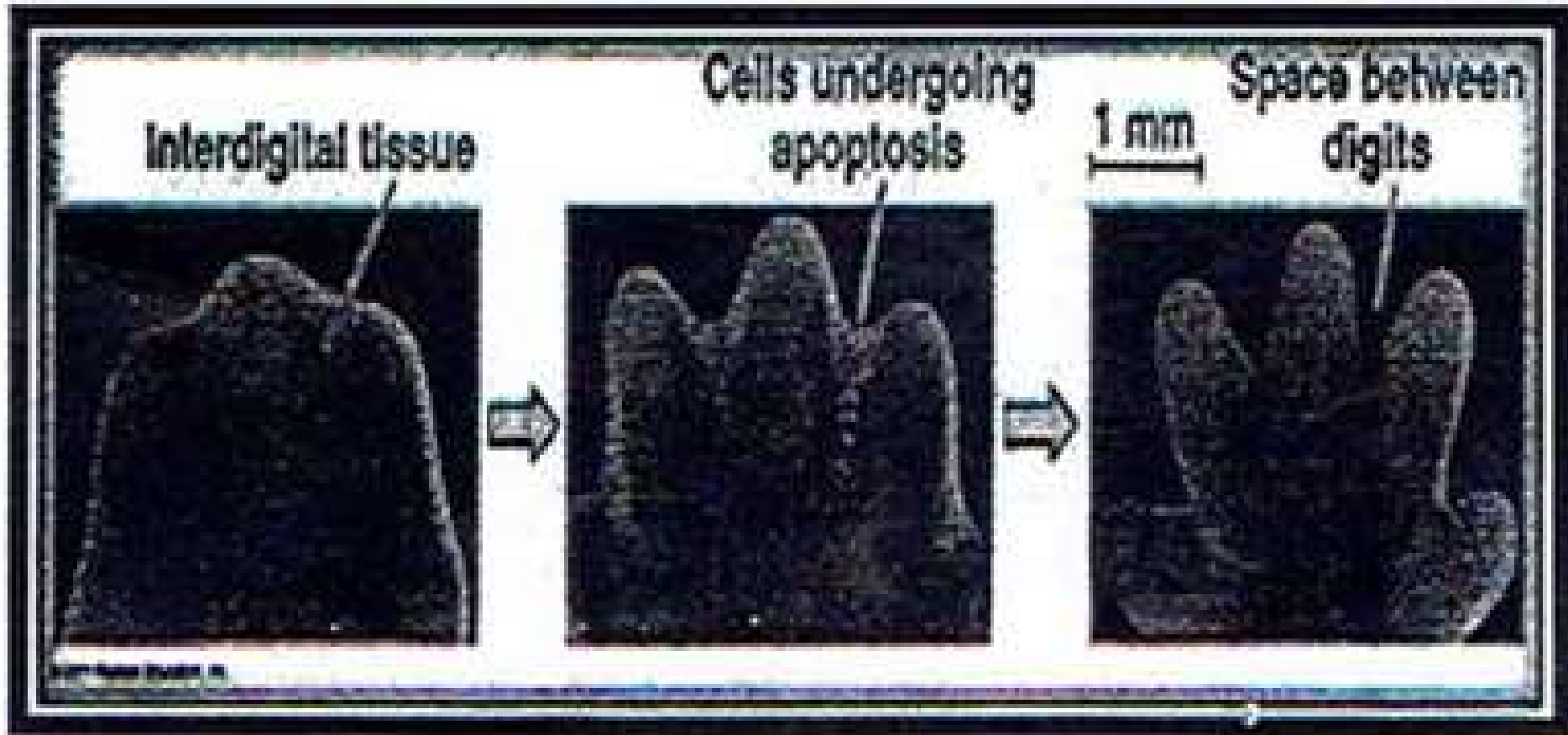
- The death of the cells, play a vital role in the development of the embryos the cell death is one of the components of the development although many findings refer to its role during postembryonic events, **such as the desorption of the tail in the tadpoles, separation of digits of the hands and foot in the avian and mammalian embryos.**



- The mechanism of the apoptosis appears to be genetically, **hormones** sometimes play an important role in stimulating the death of the cells.
- **The primitive female genital ducts (Mullerian)** regress in the presence of the male gonad and its secretions, also the motor nerve cells that fail to make functional contact with the muscle fiber the death is the fate.

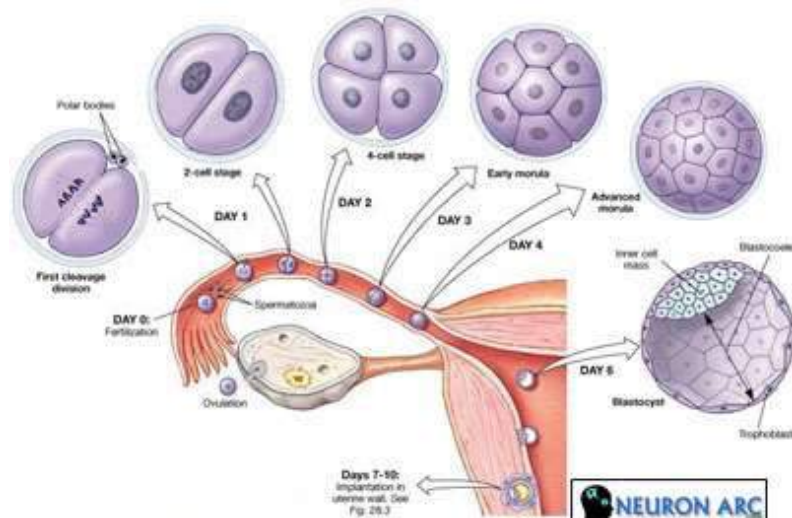


Appoptosis

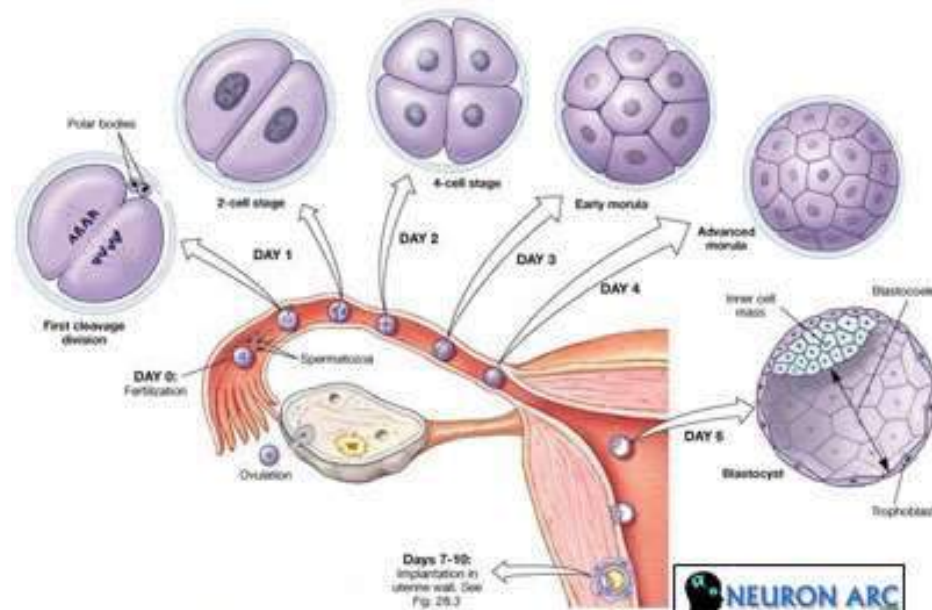


Regulation & Regeneration

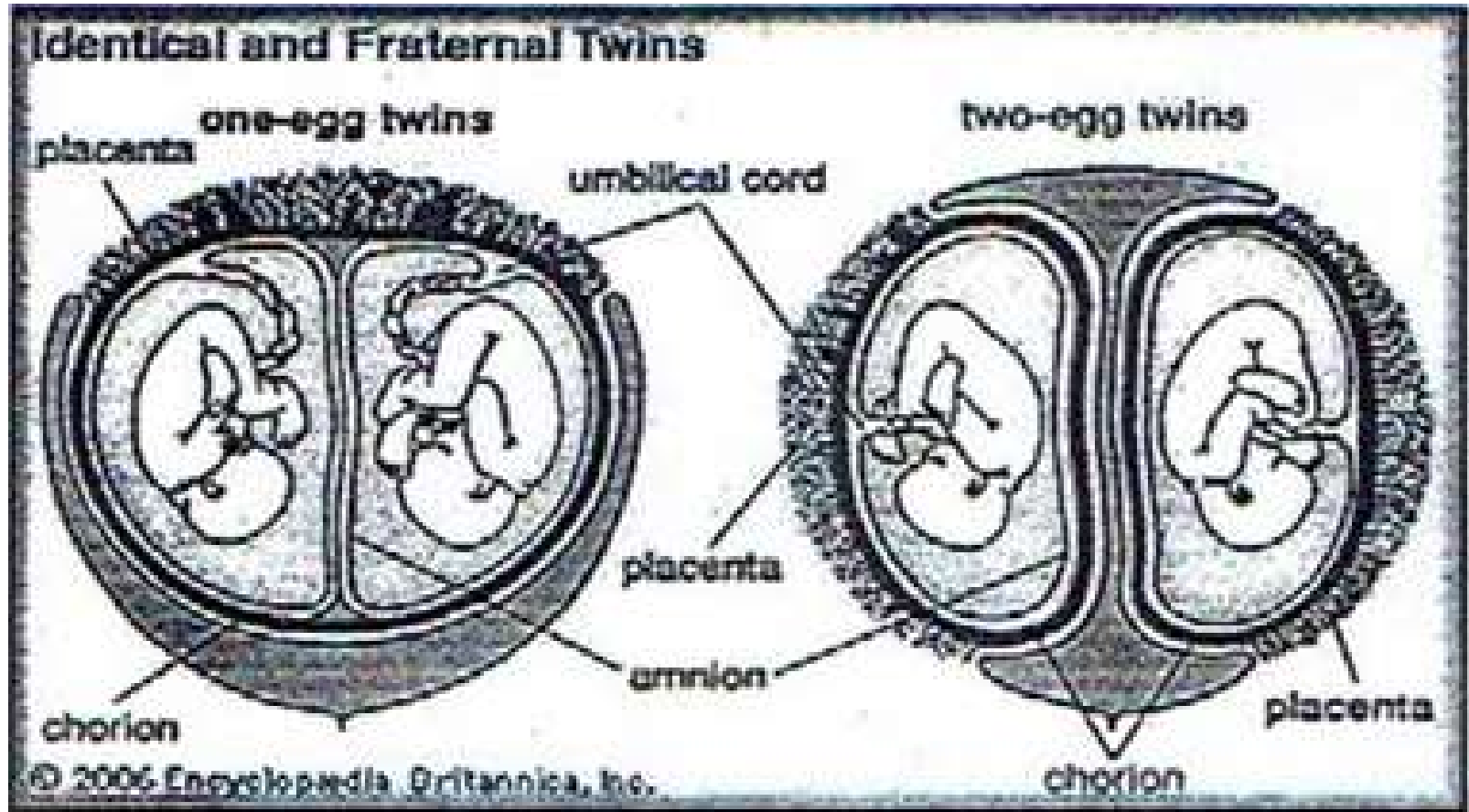
- During early development of the entire organs of specific systems,
- Most vertebrate's embryos have supernatural ability to recognize whether the structure is intact,
- If part is lost or damaged by accident the loss is recognized and stimulate the repetitive process,
- If this occurs **before differentiation** of the structure the restoration of the missing material is called **regulation**.



- Regulation is the basis for the development of the identical twins. In mammals, twinning usually results from the subdivision of the embryos during early stages of cleavage, each half of the embryo is able to compensate the lost tissues and develop into normal individual, in some cases the separation of the two embryos is incomplete, this result in the formation of **conjoined twins**.
- In the late embryo or in the postnatal life a missing structure can be replaced, if differentiation of this structure has occurred, the process of the replacement is called **regeneration**



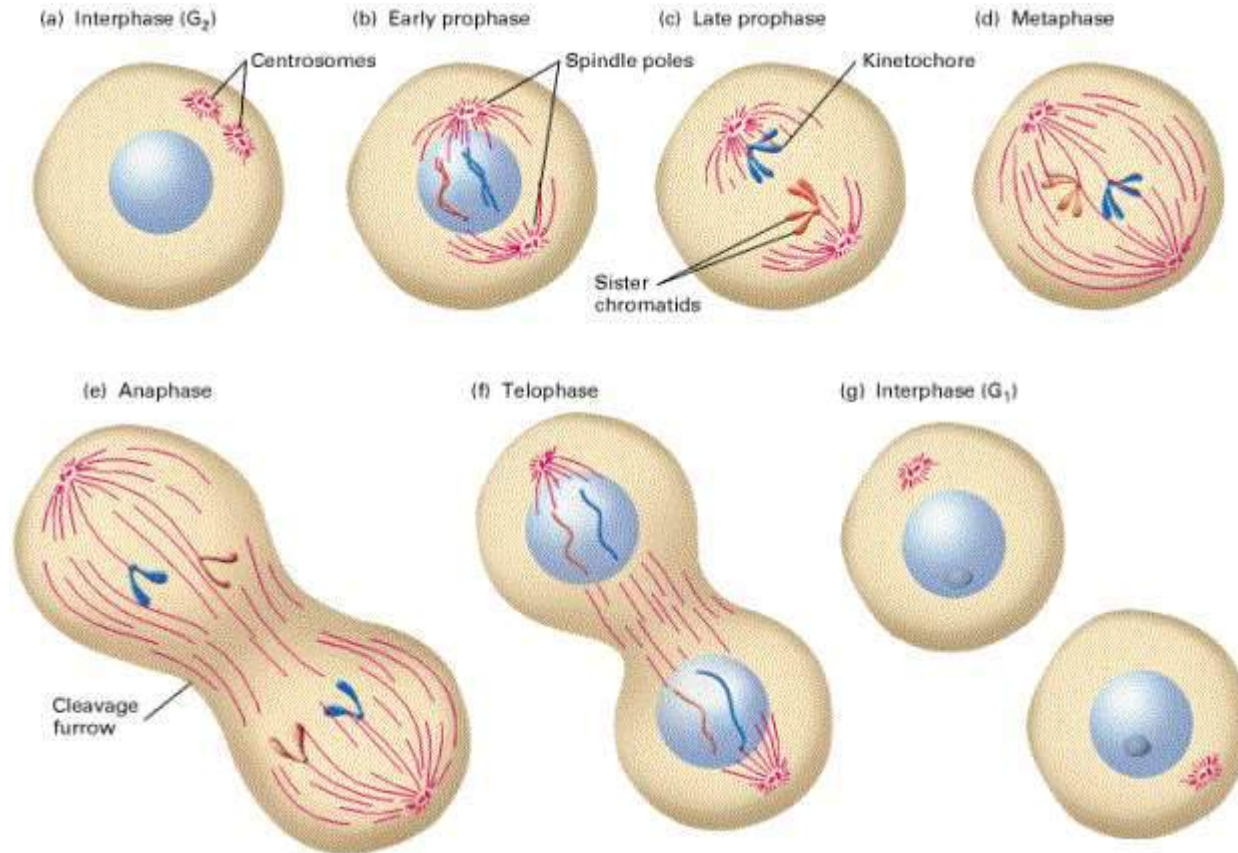
Twin in human





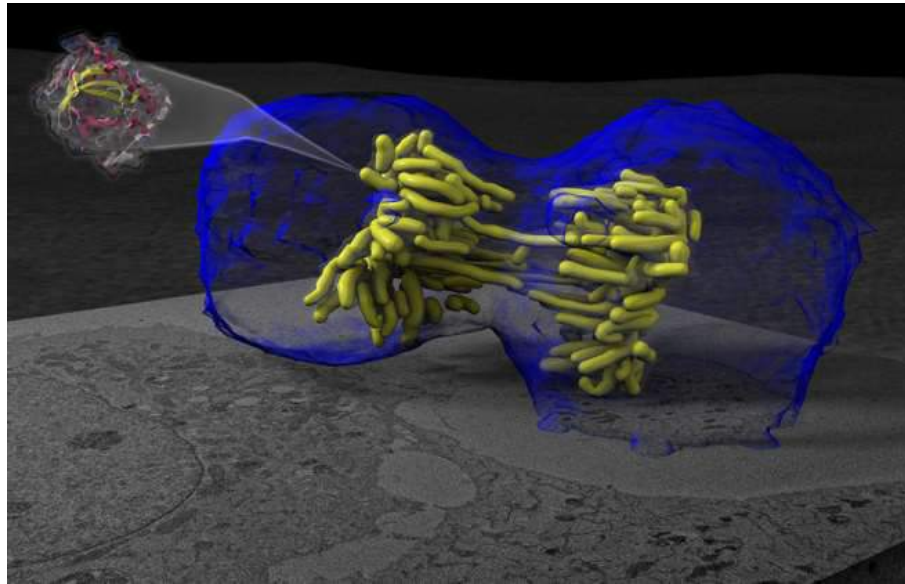
Thank you

Cell Division



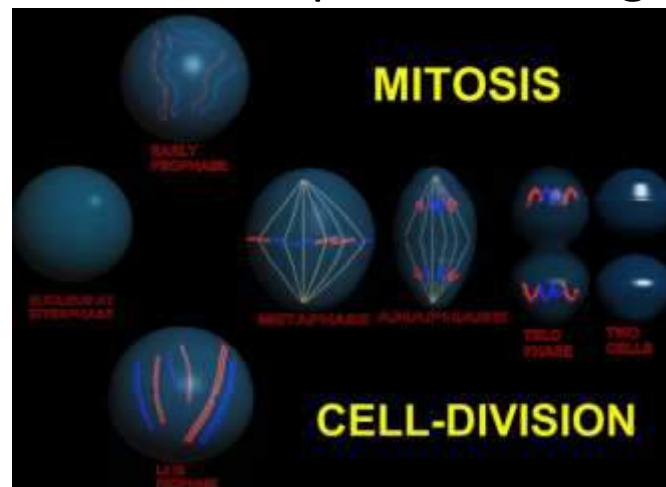
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- **Growth and development of any organism depend in large part on:**
 - ✓ Multiplication,
 - ✓ Enlargement
 - ✓ Differentiation of its cells beginning with the zygote.
- **Division of nucleated cells consists of two division,**
 - ❖ Nuclear division (karyokinesis)
 - ❖ Cytoplasmic division (cytokinesis).
- **The nuclear division in turn consists of two types:**
 - **Mitosis** , mitosis is associated with nuclear division of the somatic cells
 - **Meiosis**, the meiosis occurs in the gametes.



• Mitosis

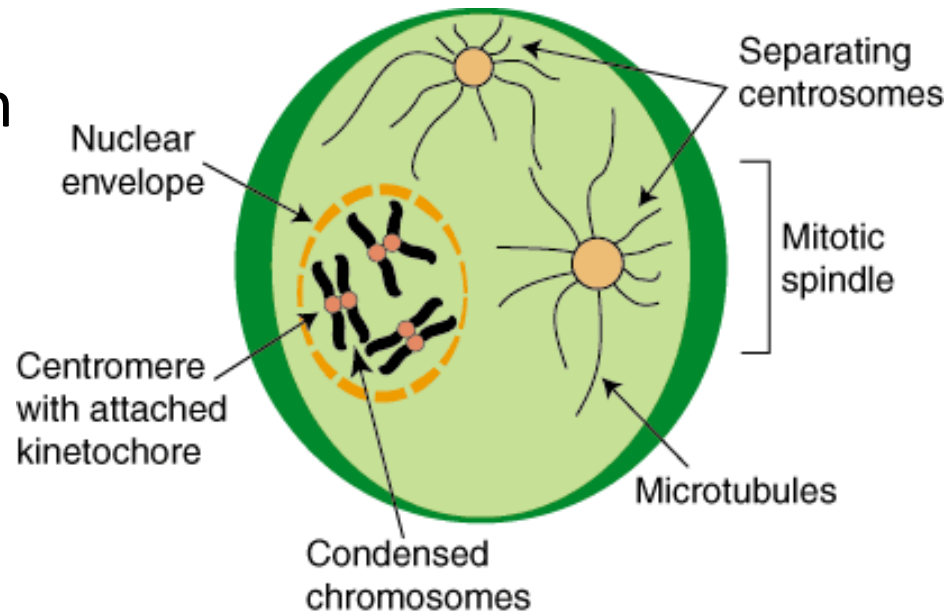
- Mitosis (mitos=fiber) begins at the end point of the interphase, it is important for growth, replacement of cells lost during normal development or under certain cases like wounds healing.
- The mitosis is rapid during the early development but it slows down with age because all cells divide but later as the embryo grows
- DNA replication slows down to allow the cells to become differentiate, irreversibly some cells lose the ability to divide after stop the genes shut off as in the nerve cells and skeletal muscles,
- ❖ Some cells are functionally differentiated and non-dividing but never lose mitotic potential, like the liver cells can resume the mitosis when they are isolated in nutrient culture medium or exposed to strong stimuli as wounds or some cuts in the organ, also there are some cells like the bone marrow cells and epithelium cells in skin or in the digestive system remains mitotically active all life span of the organism.



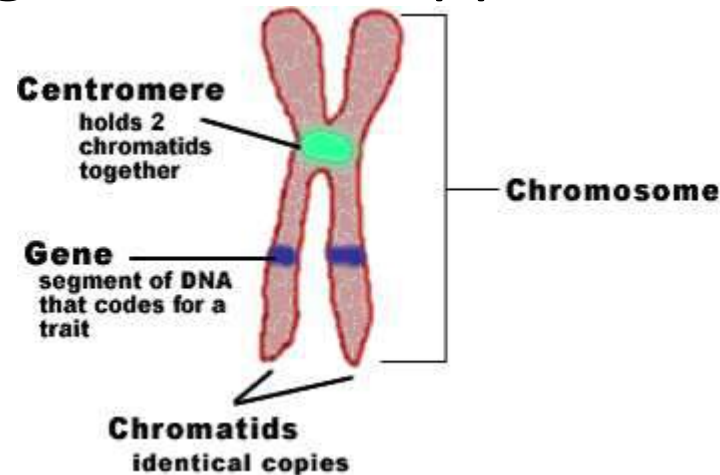
There are 4 steps of mitosis:-

1. Prophase (*pro*= before)

- Appearance of chromosomes like the thin thread-like
- Cells become spherical
- Regress the nucleolus
- Appear the spindle fibers (mitotic apparatus)
- Regress the nuclear membrane

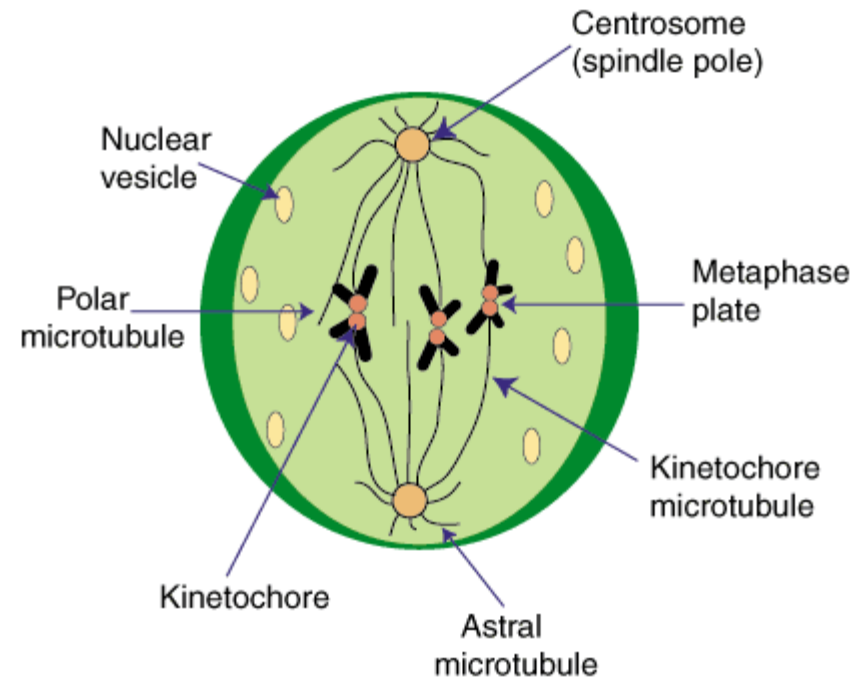


- The chromosomes composed of 2 coiled filaments called the chromatids result from the replication of the DNA during-the **S phase** in the cell_cycle, bind together by the centromere (each chromosome have 4 thread-chromatids with one centromere) therefore they are called the **sister chromatids**, and the chromosomes called the **daughter chromosomes**, these chromatids become shorter and thicker.
- The cells have **2 pairs** of centrioles (duplicated in the interphase) migrate to the opposite site of the cell



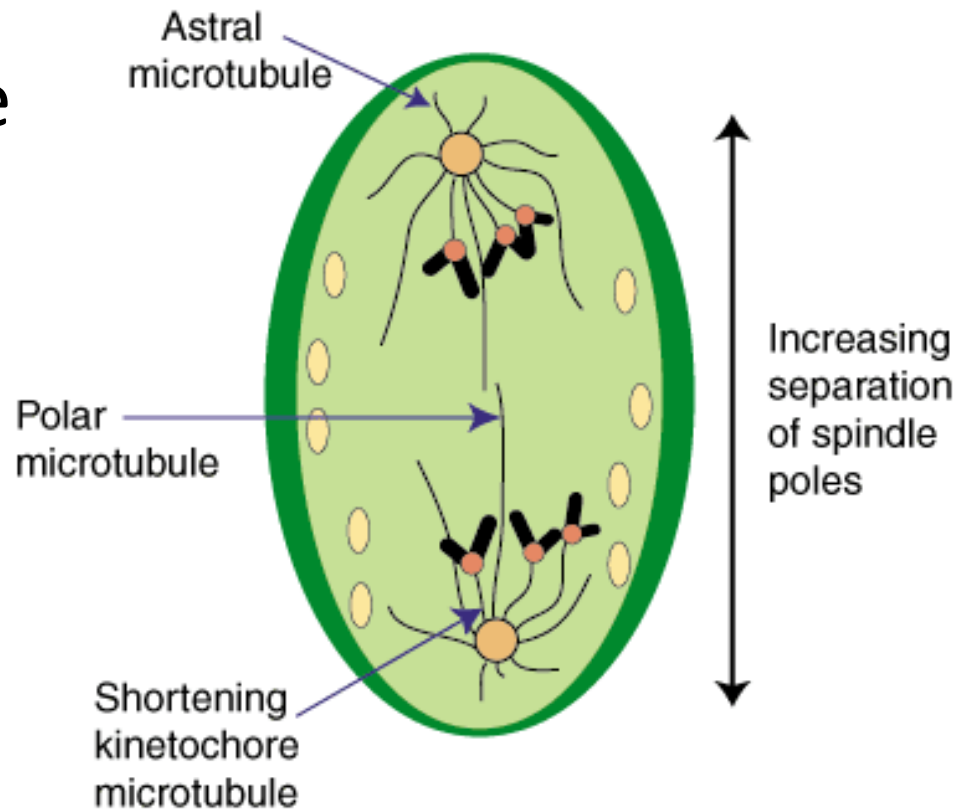
2. Metaphase (*meta*= between)

- The centromeres occupy the middle plane of the cytoplasm (metaphase plate)
- the sister chromatids are still held together by connecting chromatin fibers at the centromere



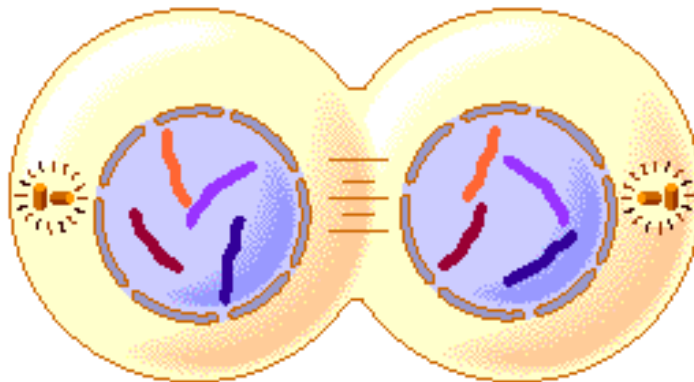
3. Anaphase (*ana*= back)

- The chromatids separate and migrate towards poles
- The centromere divide



4. Telophase (telo=end)

- The end of the daughter chromosomes migration marks the beginning of the Telophase and the Telophase is terminated after reorganization of the two new nuclei and their entry into G1
- ❖ The events here are reverse to the prophase
- ❖ New nuclear membrane are formed
- ❖ Reform the nucleoli
- ❖ Long, thick and slender chromosomes **Cytokinesis (cytoplasmic division)**

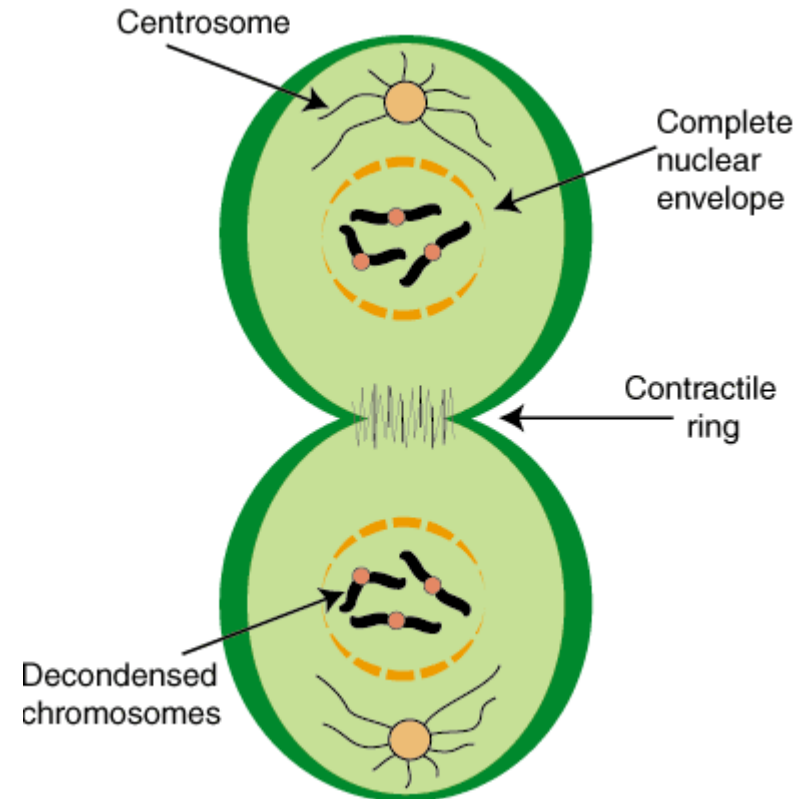


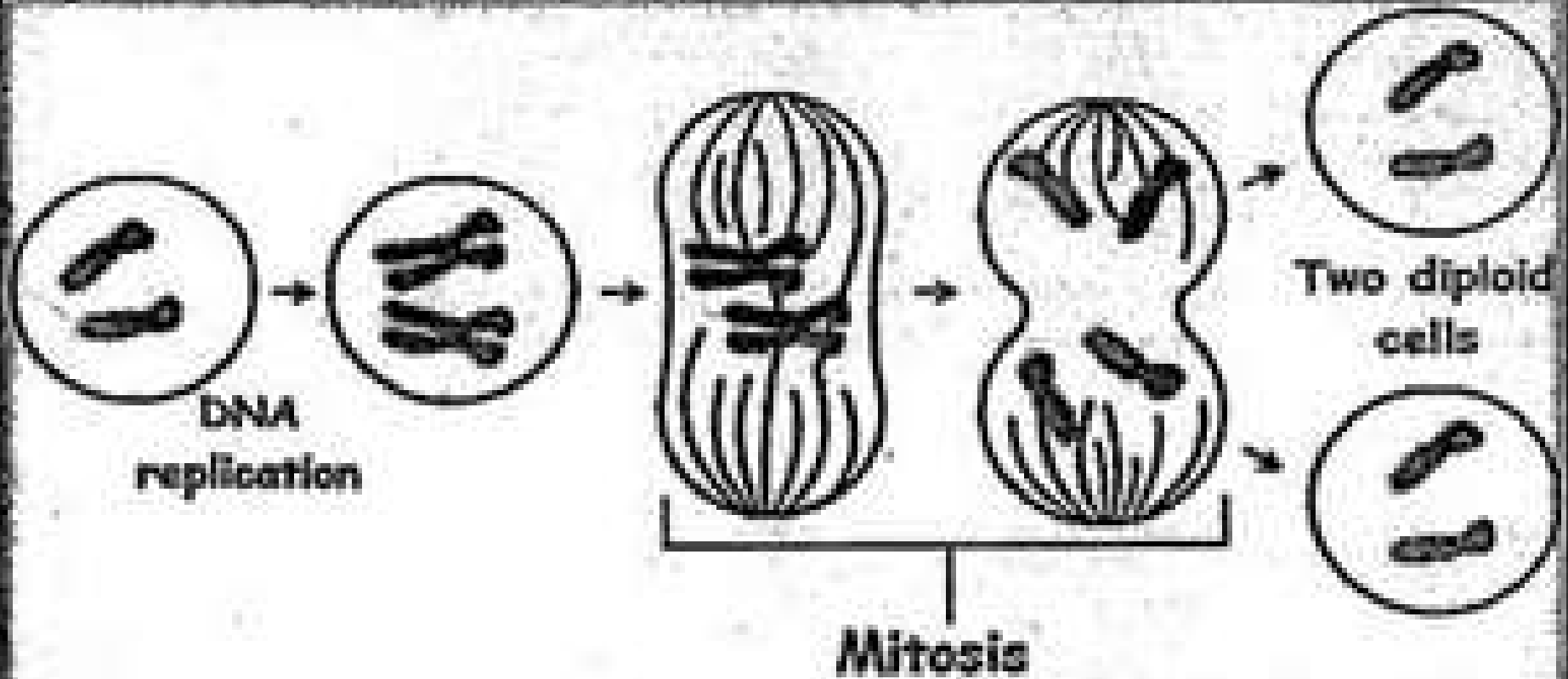
Telophase

The chromosomes are at the poles, and are becoming more diffuse. The nuclear envelope is reforming. The cytoplasm may be dividing.

Cytokinesis (cytoplasmic divisions)

- A furrow will appear in the surface of the cell.
- Slowly cutting the cell into 2 daughter cells.



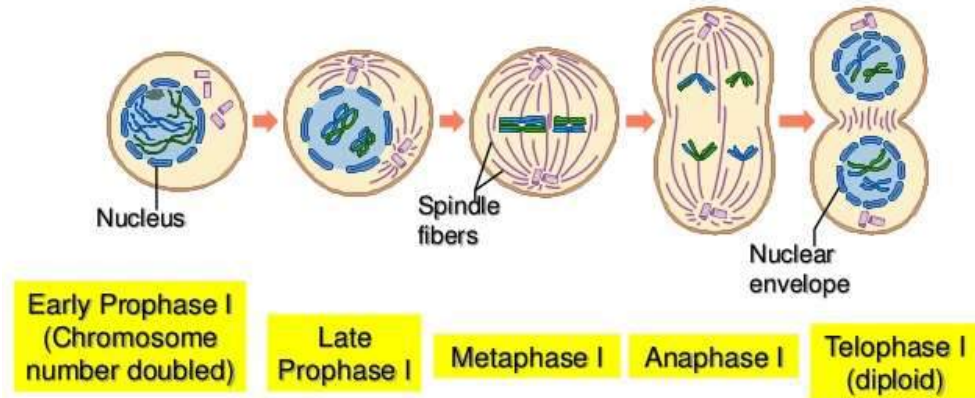


Mitosis

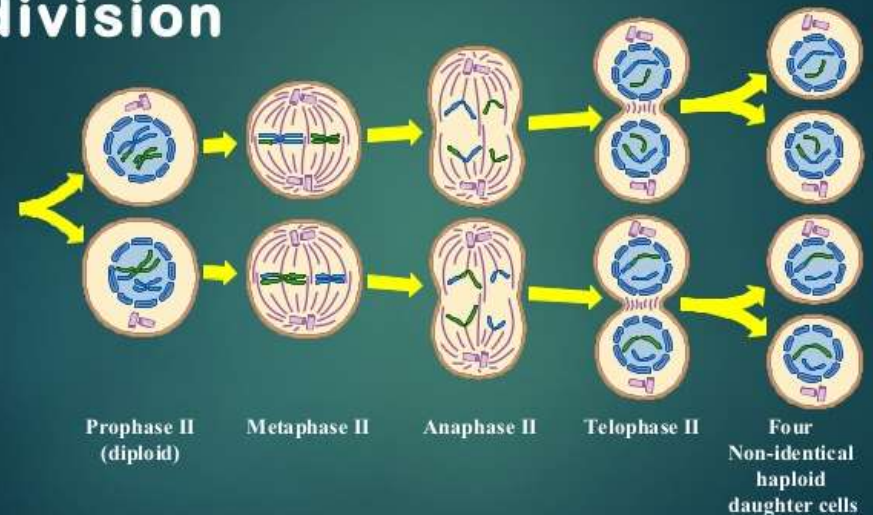
Meiosis

- Meiosis (*meioun*=to diminish) is a universal process restricted in sexual reproduction of animals, the numbers of the chromosomes is reduced by half, and one cell will give 4 haploid cells,
- **So the meiosis consists of two divisions:**
 - ❖ Reduction division
 - ❖ Equational division

Meiosis I: Reduction Division



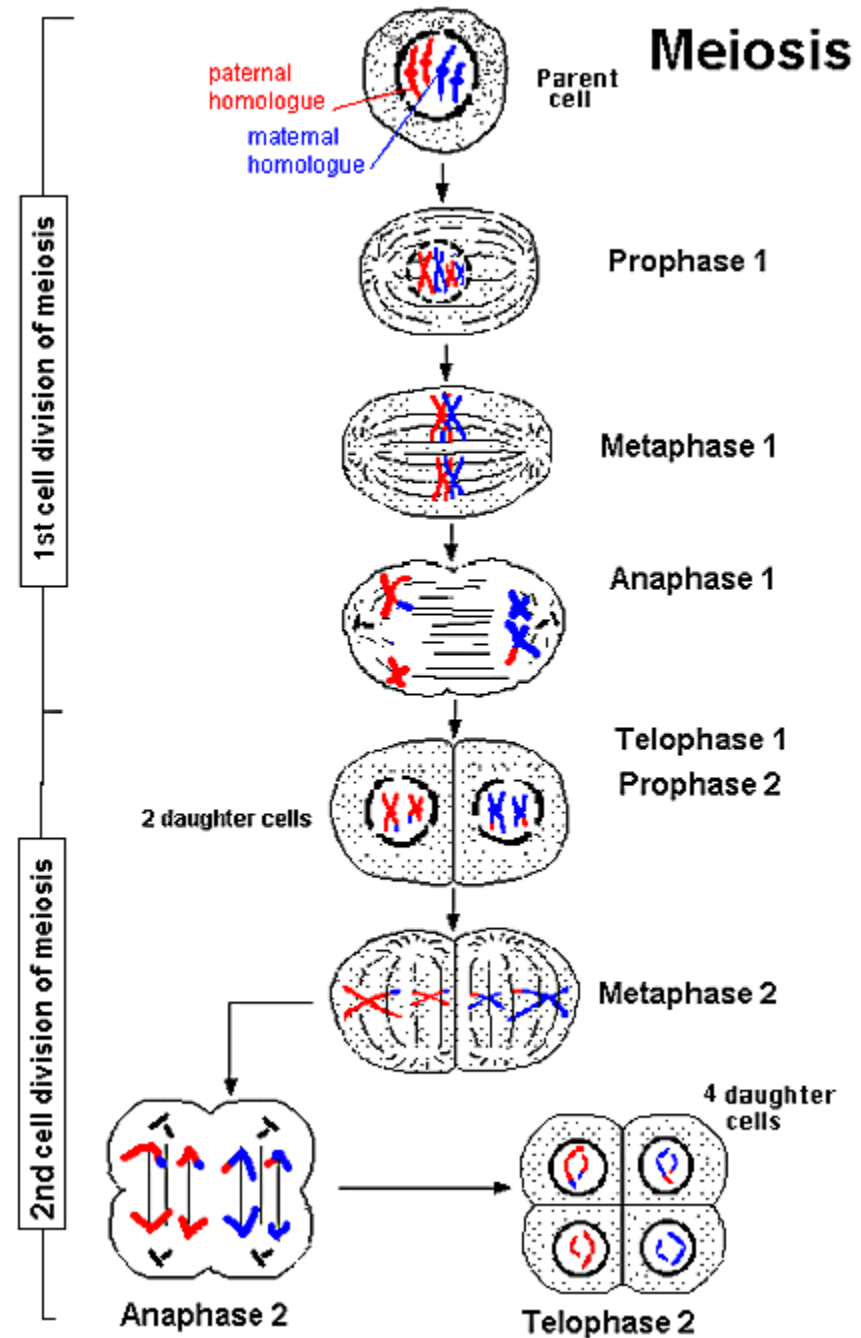
Meiosis II: the equational division



- **The meiosis includes 3 minor processes:-**

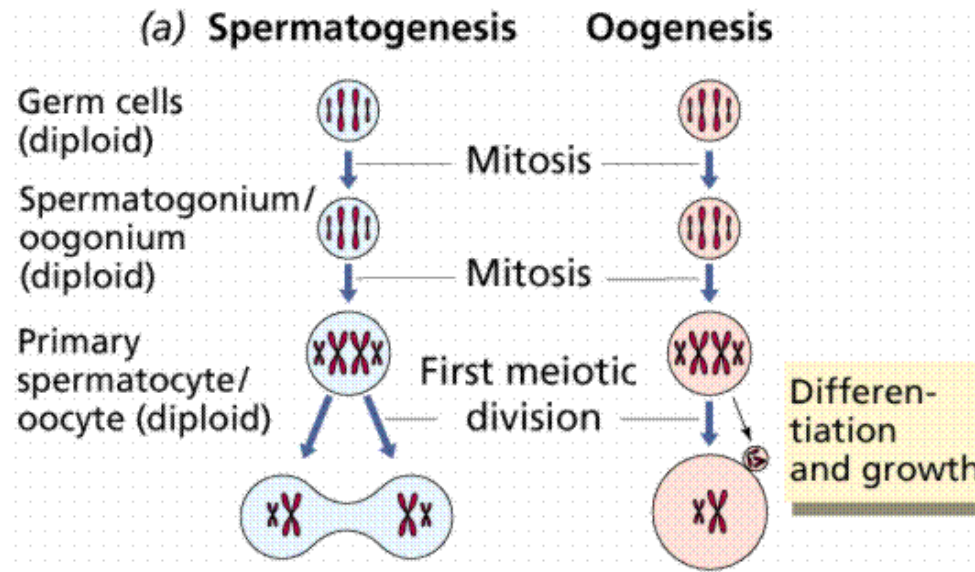
1. Reduction the number
 2. Crossing over or called recombination
 3. Random arrangement of the homologous chromosomes .
- ✓ Although the timing of meiosis is very different between male and female, the basic chromosomal events are the same in the two sexes. Therefore we can put a simple definition of it

☐ **Meiosis:** - is a specialized of cell division that occurs **only** in the germ cells (oogonia & spermatozoa) in which the chromosome number is reduced from diploid (**2n**) to haploid (**n**)



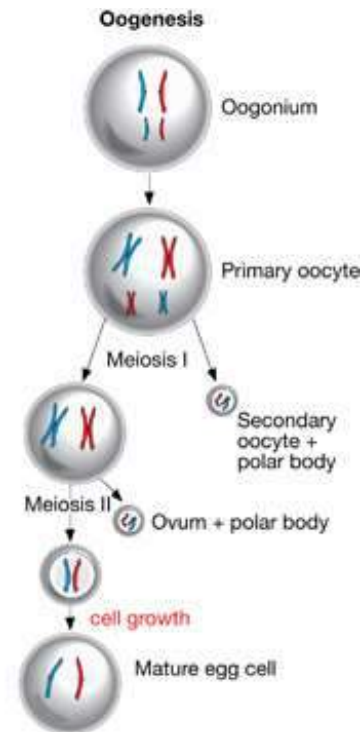
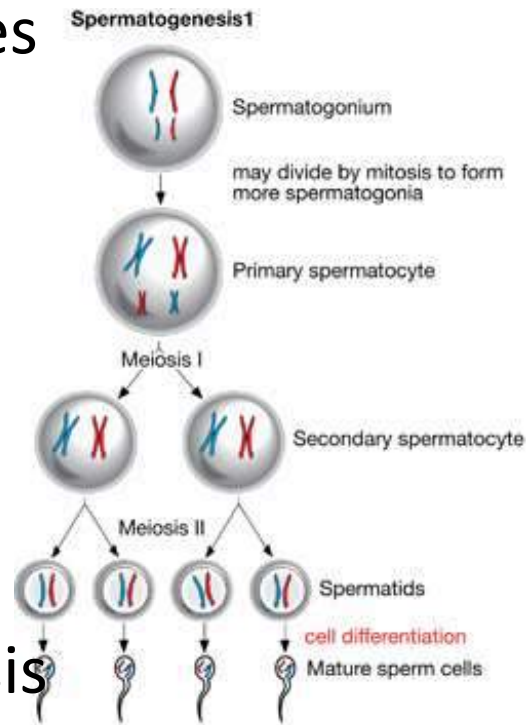
Mechanism of the meiosis

- **A meiocyte** is any diploid cell that undergoes meiosis. In animals the meiocyte such as spermatogonia in males and oogonia in females give rise to gametes, these cells undergo several mitosis to give another type of cells, primary spermatocytes, and primary oocytes respectively, but then will shift from mitosis, to meiosis during G2 phase



- The meicyte before inter the meiosis must have 4 times ($4n$) content of the amount of DNA thus the primary spermatocytes and primary oocytes are tetraploid ($4n$) amount of the DNA, after the meiosis 1 the amount of the DNA become diploid ($2n$), while after the meiosis2 only the haploid (n) amount of DNA is present.

- Thus the meiosis like the mitosis when the cell duplicates the amount of DNA during prophase, but contrast to the mitosis, this duplication is followed by two divisions.

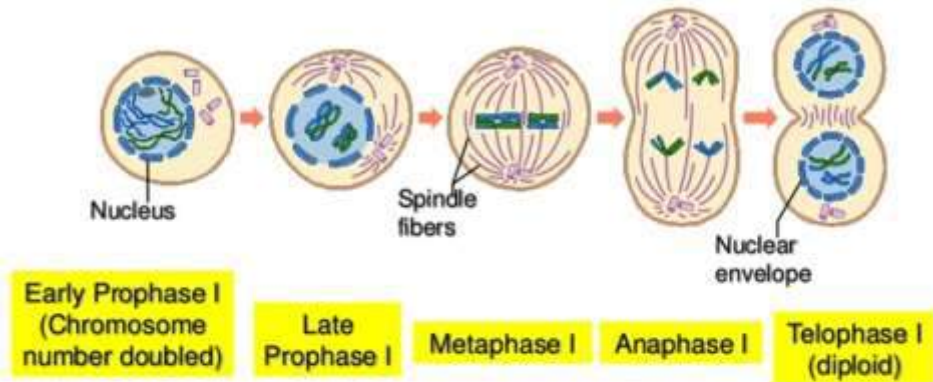


Stages of meiosis

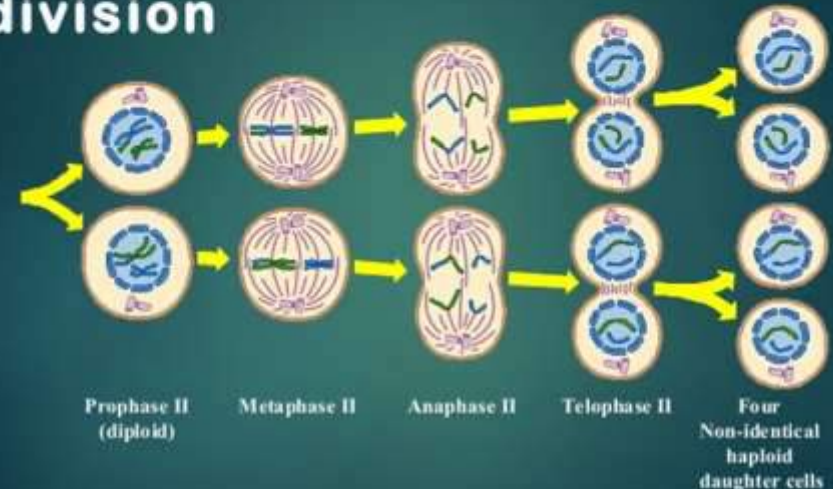
Meiosis requires two cell divisions:

1. Meiosis I (reduction division)
2. Meiosis II (equatorial division)

Meiosis I: Reduction Division



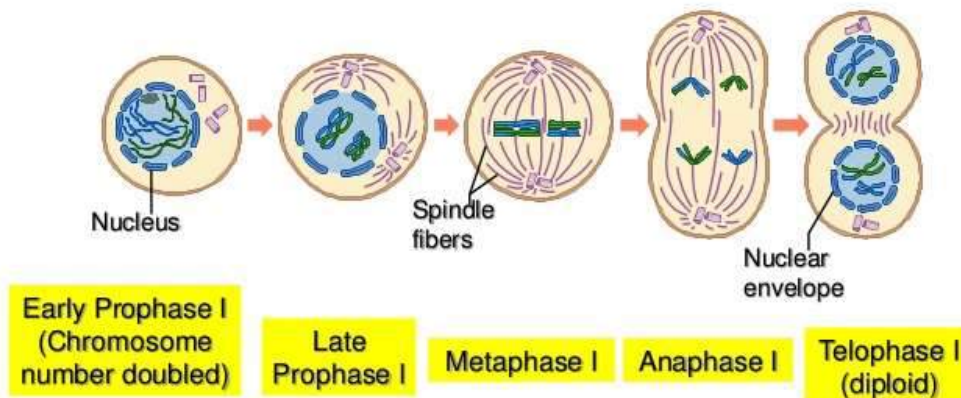
Meiosis II: the equational division



1-Meiosis I (reduction division)

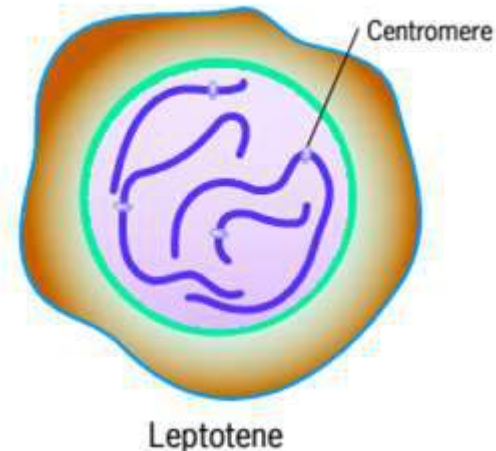
- At the following some important events that occur during this stage:-
- During early development the germ cell is a diploid chromosomes (46) with two copy of **DNA (diploid ,2n)**
- The DNA content is duplicated ($2n \rightarrow 4n$) while the chromosomes number (46) remain unchanged, so the cell is **diploid,4n**, once the DNA replicates, each chromosome consists of two parallel strands of chromatids joined together at a structure called **centromere**. Each chromatid contains a single DNA-molecule (which itself double strand).
- The meiosis I; consists of five phases like the mitosis.

Meiosis I: Reduction Division



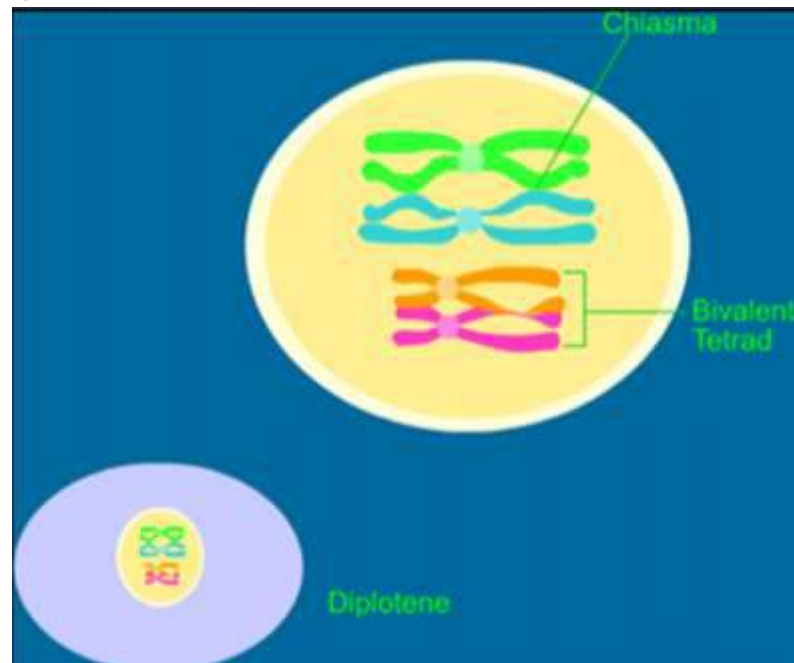
1. Prophase I

- This phase is longest phase of meiosis, in human female it persists in each primary oocyte from a fetal age of **12-16 weeks** until reach ovulation if it reaches. The prophase I divided into five stages:
- **(leptoten, zygoten, pachyten, diploten, Diakinesis)**
- **1- Leptoten (lepto=thin)**
- The nucleus enlarges
- The chromatin material condense
- The centriole duplicate



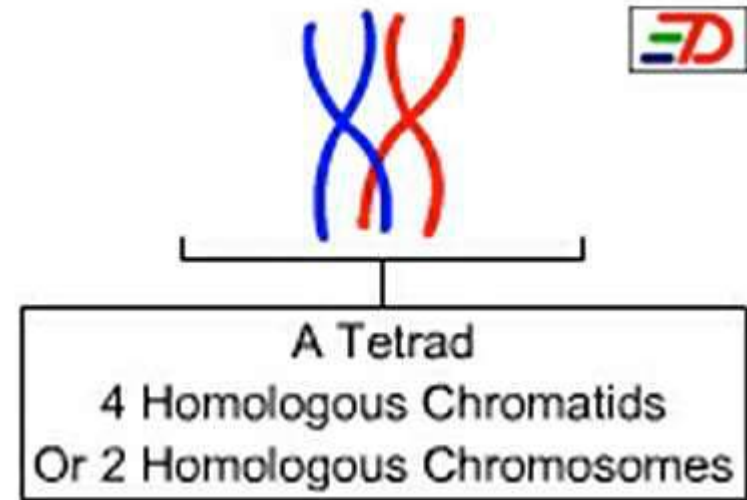
2. Zygote (*zygon*=joining)

- Pair each of the homologous chromosomes nears each other (one comes from mother and the other from the father), this called **the synapse**, and the paired chromosomes are called **bivalent**.



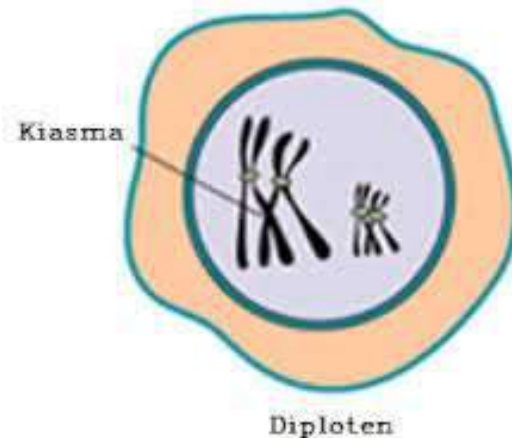
3. Pachyten (pachus = thick)

- Each homologous chromosome of each bivalent splits longitudinally into 2 chromatids attached to the centromere, each bivalent now has 4 strands (4 chromatids) therefore called **tetrad**, and each one of the 4 chromatids called **sister chromatids**, exchange some genes or portions of chromosome between **two non-sister chromatids** by a process called **crossing over or genetic recombination**.
- This result in a genetic diversity of the future gametes and prevents the children from being clones of their parents.



4. Diploten (Diploos=double)

- Beginning the separation of the paired chromosomes but not completely because the homologous chromosomes remain united by their points of will form a joint X- like structure called, **chiasmata (2 chromosomes = 4 chromatids with 2 centromeres)**.
- This stage is taking long time, in human female during fifth week of gestation the oocyte of the embryo, remain in diploten until many years until ovulation occur

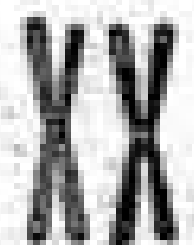


Crossing Over

Paternal Homologue Maternal Homologue *Synapsis: Pairing of Homologous Chromosomes*



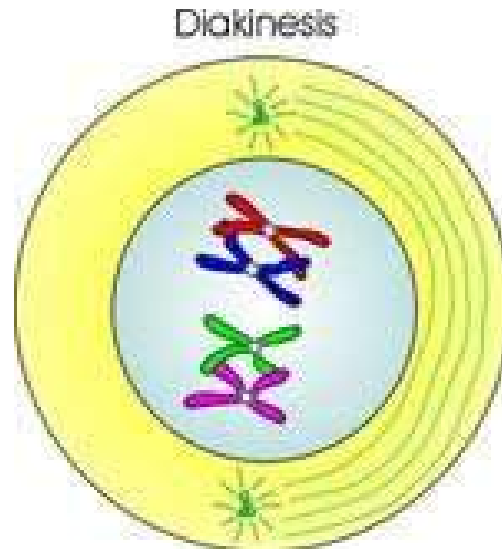
Crossing Over



Synapse

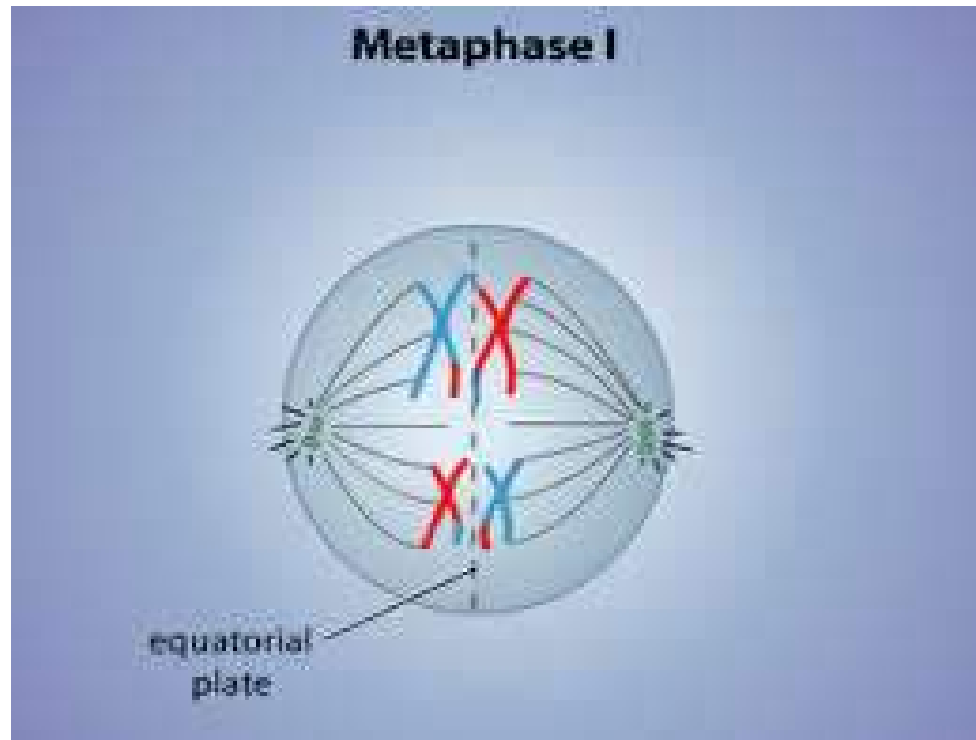
5- Diakinesis (dia=across)

- This is the final stage of the prophase 1
- Chromosomes separate
- Disappear of the nucleolus
- Degenerate the nuclear membrane



b. Metaphase I

- Arrival the synapsed chromosome pairs at the equator of the cell
- Some homologous chromosomes still bind by chiasmata



c. Anaphase I

- This phase is similar to anaphase in mitosis **except** that each chromosome consists of two chromatids that remain held together
- Complete disjunction occur in the homologous chromosomes
- Homologous chromosomes migrate to opposite poles
- The centromere that hold the sister chromatids do not divide as in mitosis, therefore .each two chromatids of one chromosome will move together
- The daughter cells are haploid but $2n$ (1 chromosomes with 2-sister chromatids), **and the important thing here, that these 2 sister chromatids are not genetically identical.** This is unlike in the mitosis)

Meiosis I

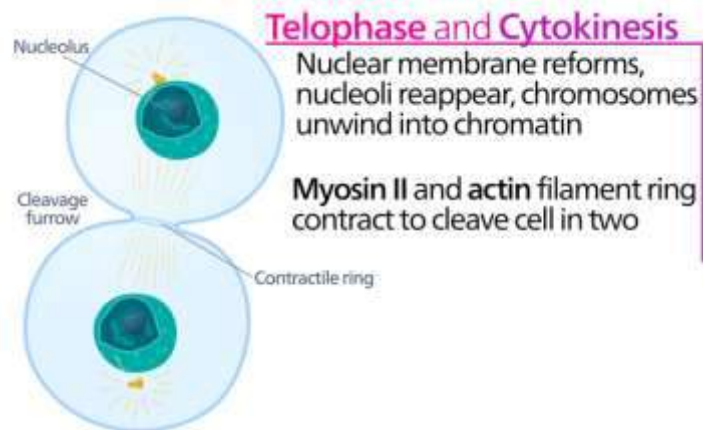
Separation of homologous pairs



Anaphase I

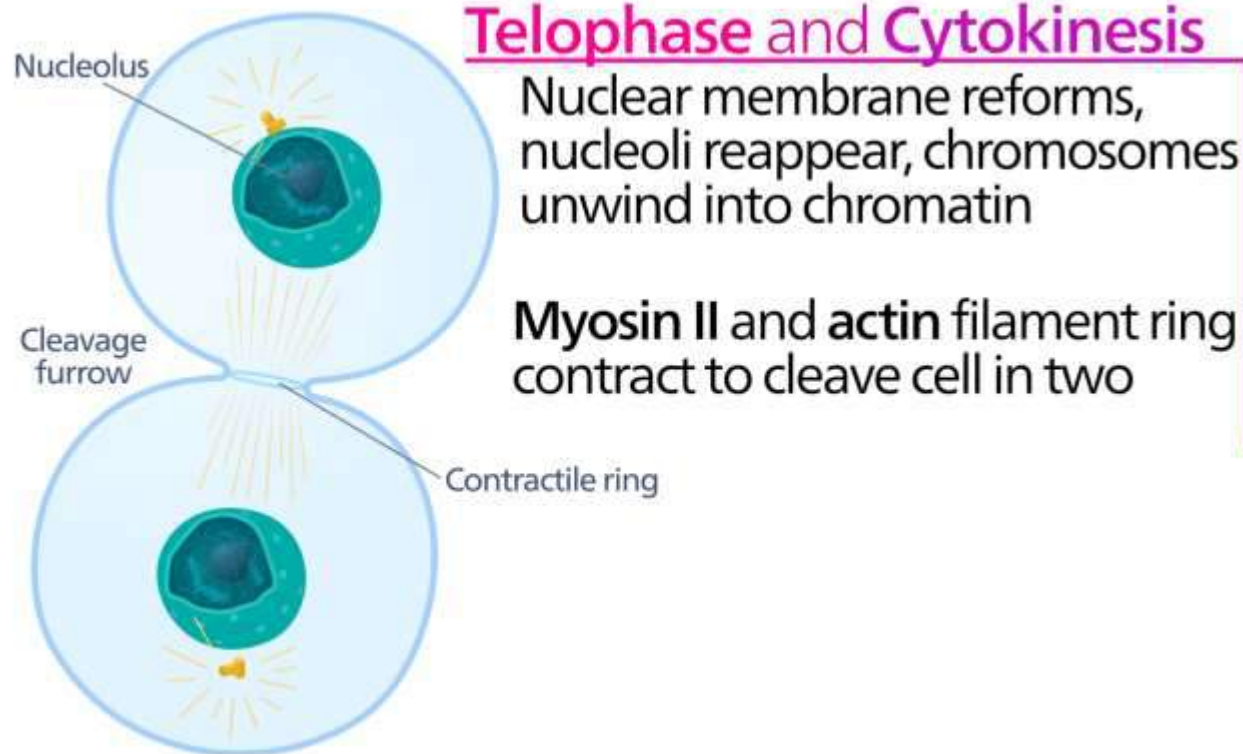
d. Telophase

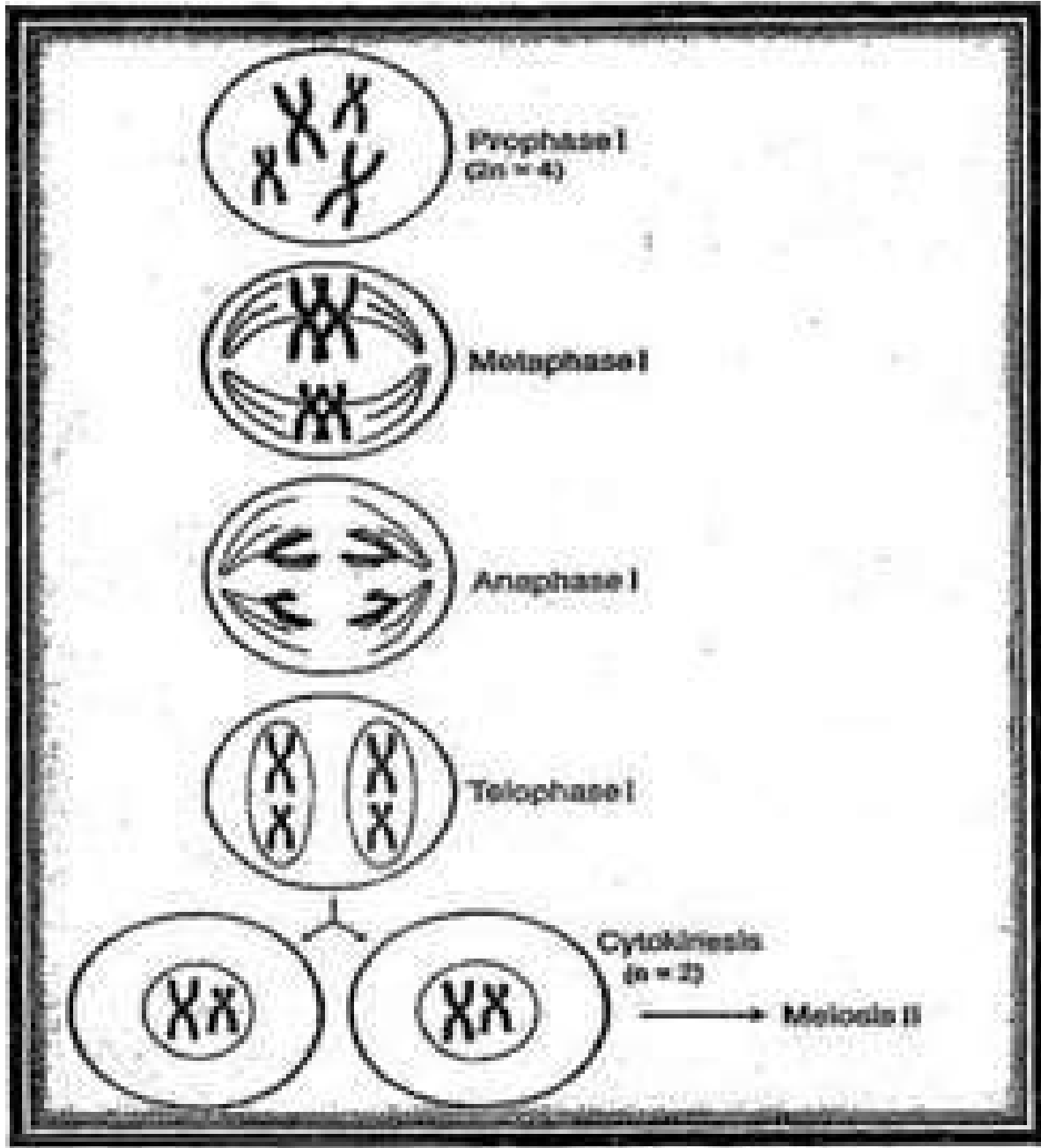
- 1 double-strands chromosomes of each of the homologous chromosomes is distributed to each daughter cell, so the resulting cells contain the same amount of DNA as the parent germ cells but half chromosomes (**haploid with $2n$**)
- Formation of nuclear and nucleolus membrane
- The resultant cells are 2 daughter cells, each nucleus is haploid (double amount of DNA but one chromosome from each homologous chromosome).



e. Cytokinesis (division of the cytoplasm)

- The cytoplasm of the 2 daughter cells undergoes division to result 2 cells

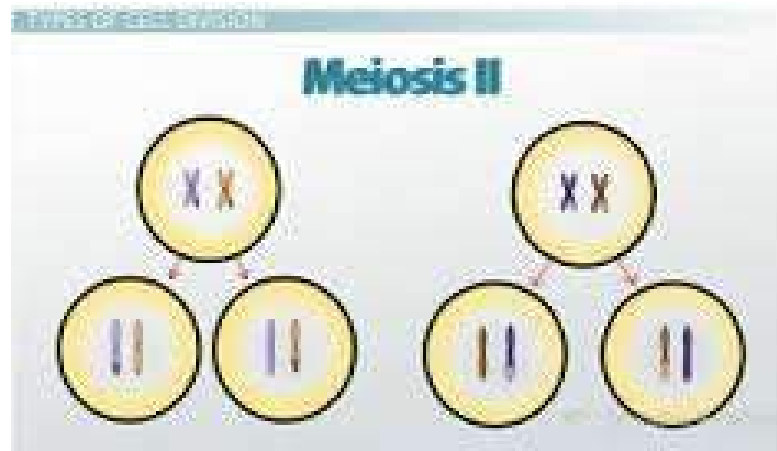


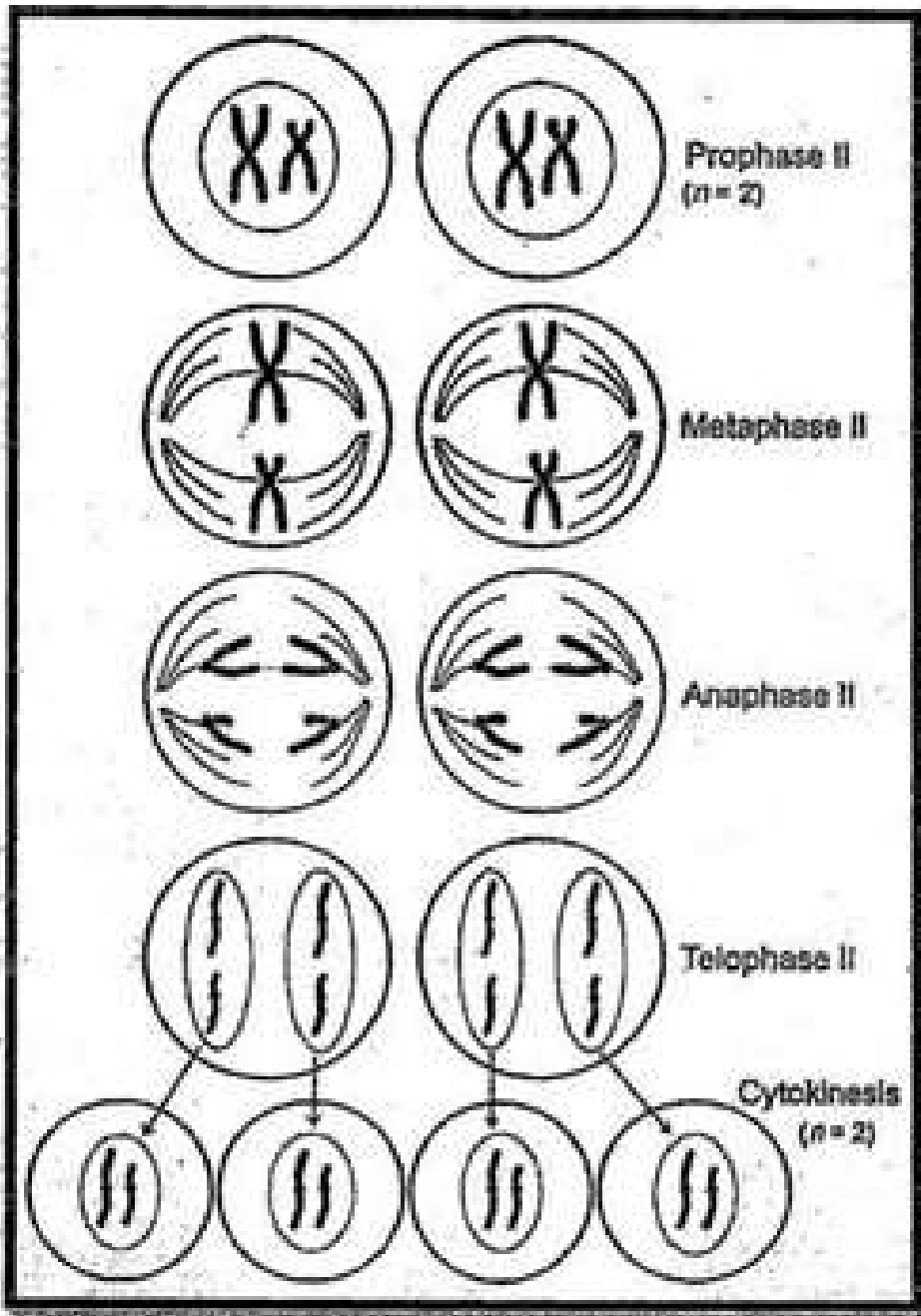


Meiosis I

2-Meiosis II (equatorial division)

- ❖ At the following some important events that occur during this stage:-
 - No DNA replication will happen.
 - The Meiosis II is similar to those in the mitosis and consists of 5 phases also. (**Prophase, Metaphase, Anaphase, Telophase, and Cytokinesis**).
 - The centromeres replicate in the prophase II
 - Each double-stranded chromosome condenses during prophase II and line up during the metaphase II.
 - In the anaphase the double-stranded chromosome pull a part into a side of the cell
 - The cytoplasm division (cytokinesis) occurs and the 2 daughter cell will form with-one-strand chromosome and half copy of DNA (**i.e., haploid, $1n$**)
 - The final result of one germ cell division those **4** daughter cells with half number of chromosomes and half copy of DNA molecule. So theses **4** cells called **haploid $1n$**)





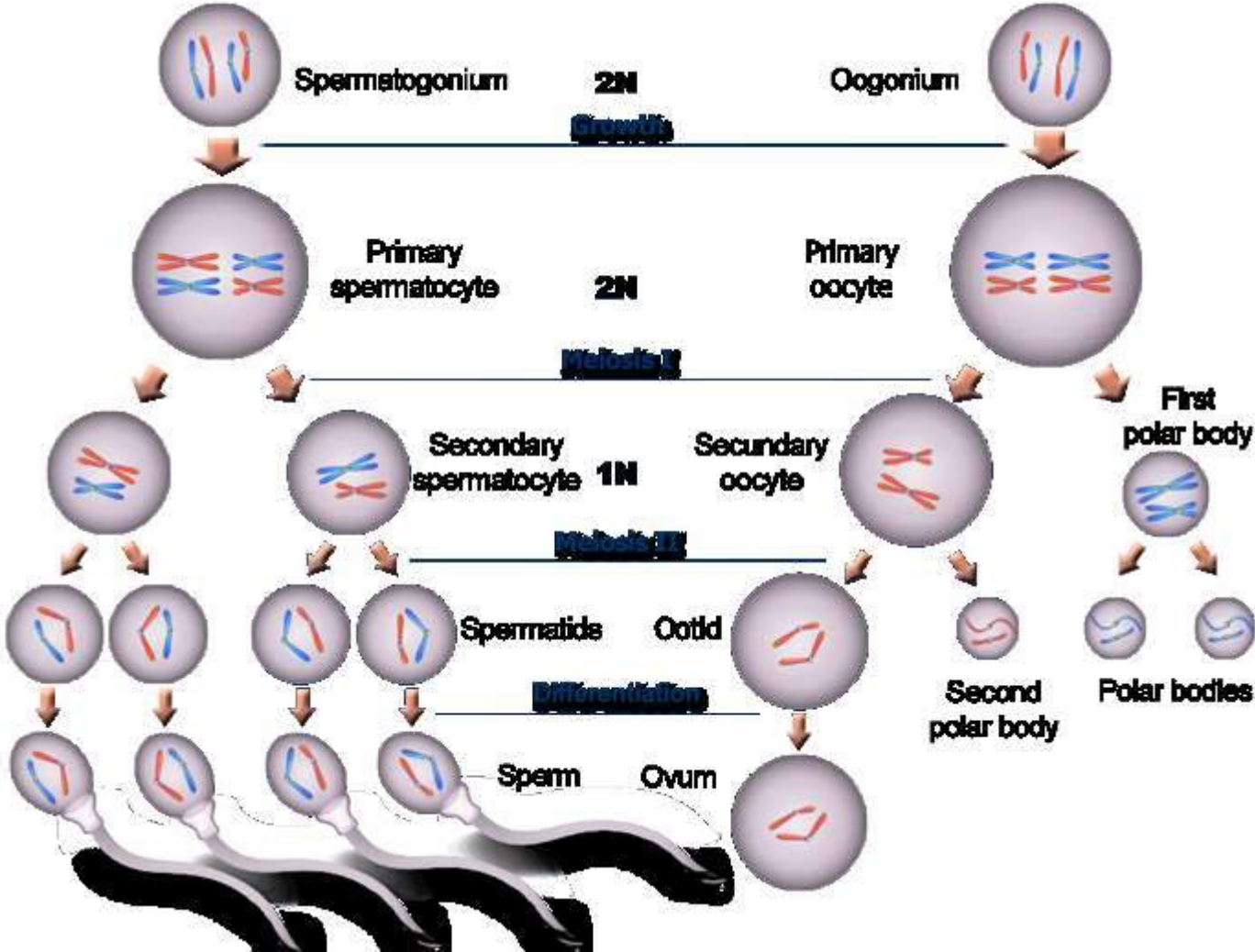
Meiosis II

<u>Item</u>	Mitosis	Miosis
Description	Mitosis is a process of which the cell divides into two daughter cells, with an equal number of chromosomes	Meiosis is a process of which the cell divides into four daughter cells, with an half number of chromosomes
Function	Cellular reproduction and general growth and repair of the body	Sexual reproduction
Takes place in	All organisms	Humans, animals, plants, fungi
Types of cells	Within somatic cells	Takes place within gamete cells (sex cells)
Number of divisions	Mitosis undergoes only one division	Meiosis undergoes two divisions
Produces	Two genetic identical daughter cells	Four daughter gametes genetically non-identical
Crossing over	Mixing of chromosomes cannot occur	Mixing of chromosomes can occur
Number of chromosomes	Same as parent cell	Half of the original gamete cell before meiosis
Pairing of Homologs	no	yes
Centromeres Split	The centromeres split during anaphase.	The centromeres do not separate during anaphase I, but during anaphase II.



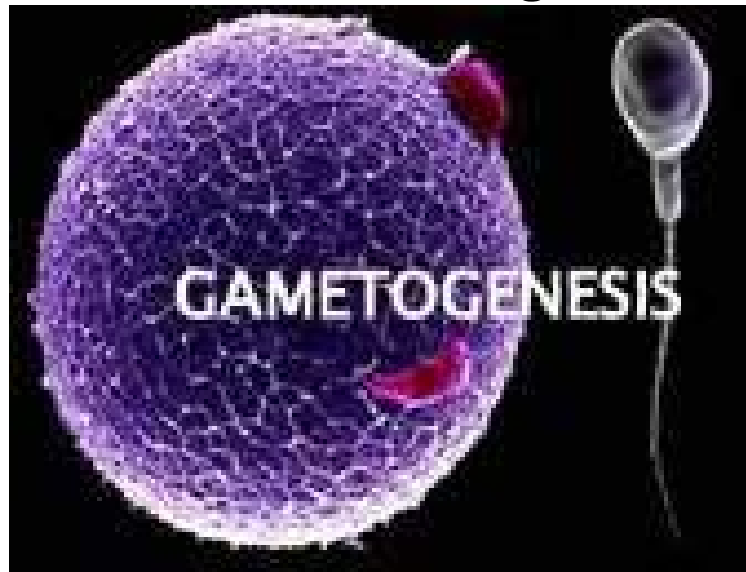
Thank you

Gametogenesis



Gametogenesis

- At fertilization, the maternal and paternal gametes are united forming the zygote.
- The **maternal gamete, the oocyte** is the largest non-motile cell of the body, **while** the **paternal gamete, the spermatozoon** has ability for motion and penetration of the oocyte.
- The cells which produce the gametes during the embryological period are called the **Primordial germ cells (PGCs)**
- **The gametogenesis**: is the process by which the maternal and paternal gametes are produced from the primordial germ cells to form mature sex cells called the gametes.

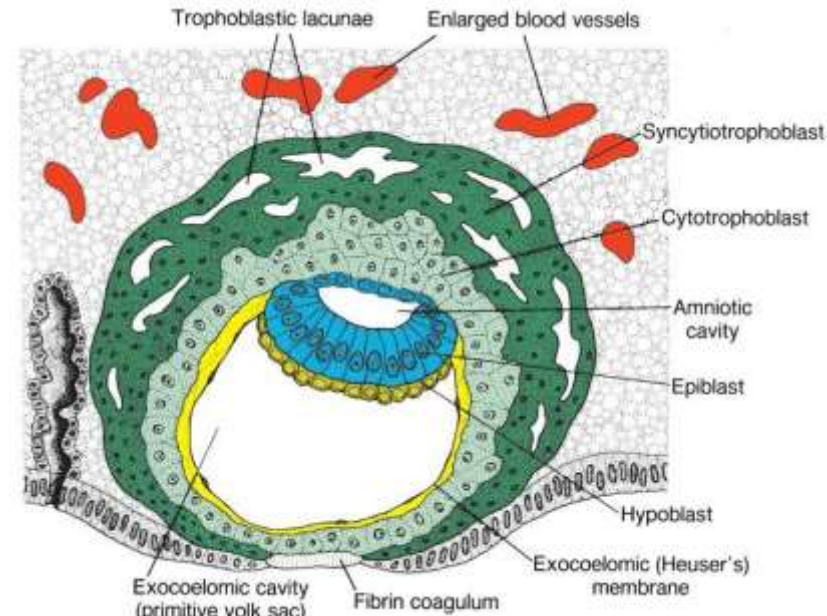
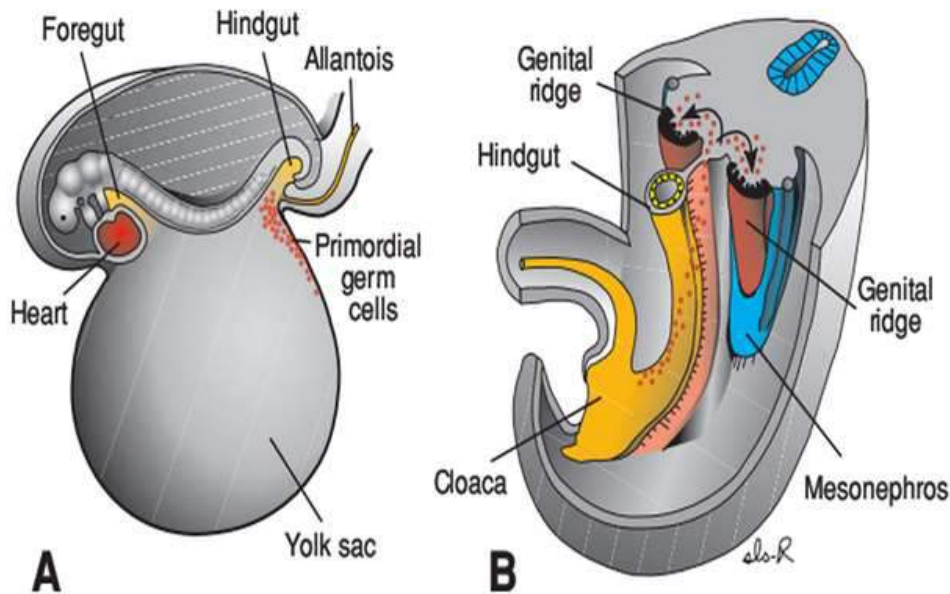


- Gametogenesis includes both mitosis and meiosis to allow for recombination of genetic material and for reduction of the number of chromosomes from diploid to haploid cells.
- **The gametogenesis includes two types of processes differs between male and female:**
- In the male called >>>> **Spermatogenesis,**
- In the female called >>>> **Oogenesis,**
- The two processes are also called **pre-embryonic development.**

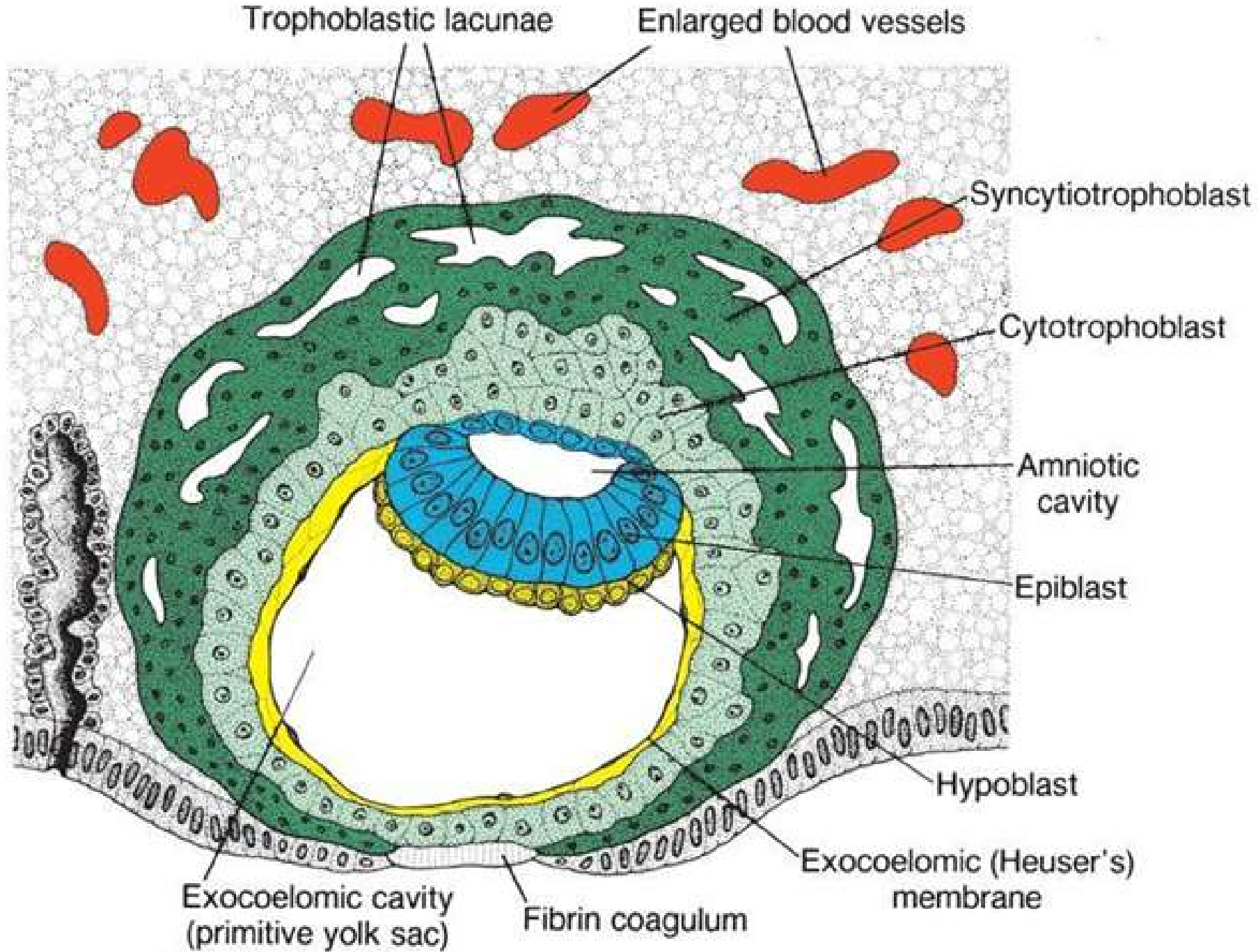


Primordial Germ Cells (PGCs)

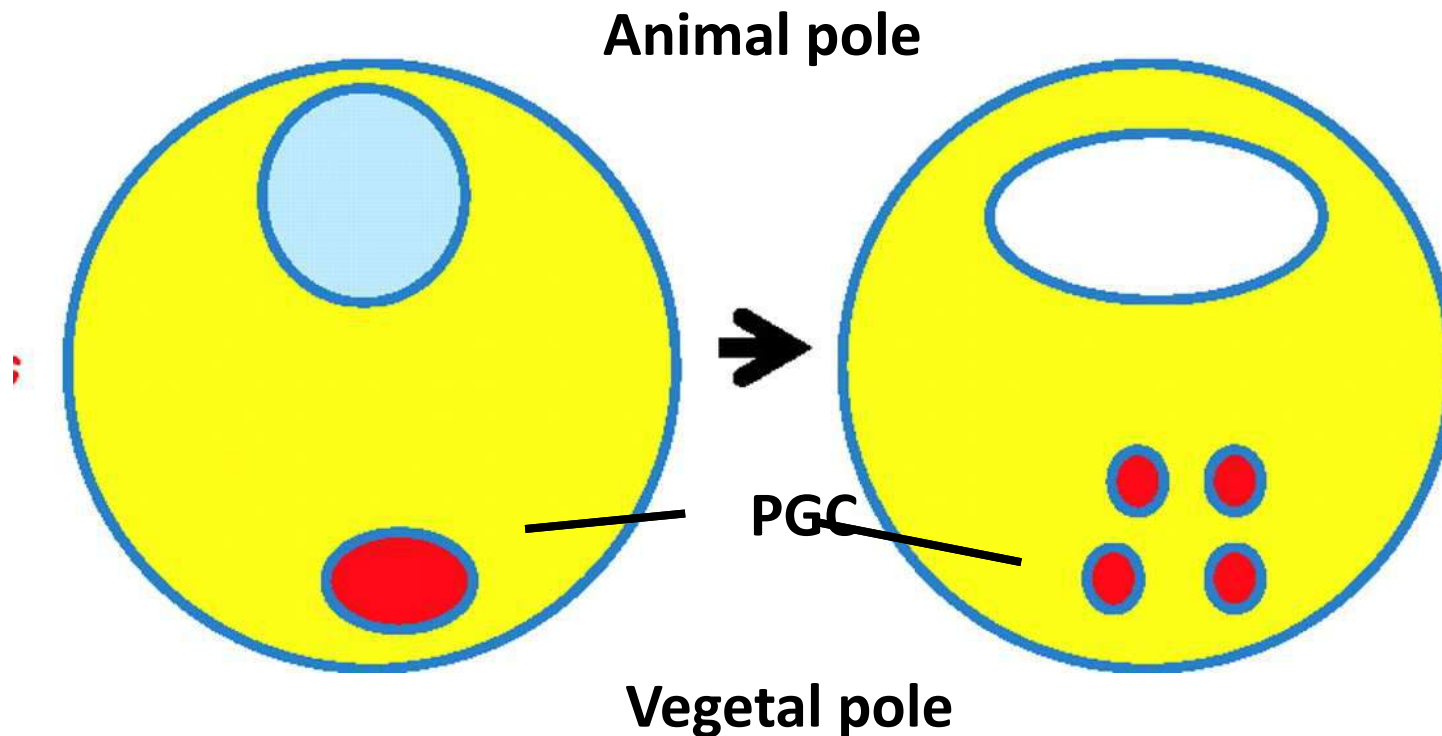
- Although much of the early history of the germ cells is still unknown, the cells that give rise to the gametes are recognized at early stage in development.
- **PGC of birds, reptiles, and mammals** arise in the **epiblast** of the embryo and then go temporary in **extraembryonic tissues** before return to the body of the embryo.



A. A 3-week-old embryo showing the primordial germ cells in the wall of the yolk sac close to the attachment of the allantois. **B.** Migrational path of the primordial germ cells along the wall of the hindgut and the dorsal mesentery into the genital ridge.



- **In frog** and number of invertebrate species, germ cells can be recognized very early in the life of the animal, sometimes in the vegetal pole cytoplasm of the zygote as specific cells during the cleavage stages.



- The PGCs of the **birds** are recognized in the, **germinal crescent** which is located beyond the head region of the embryo,

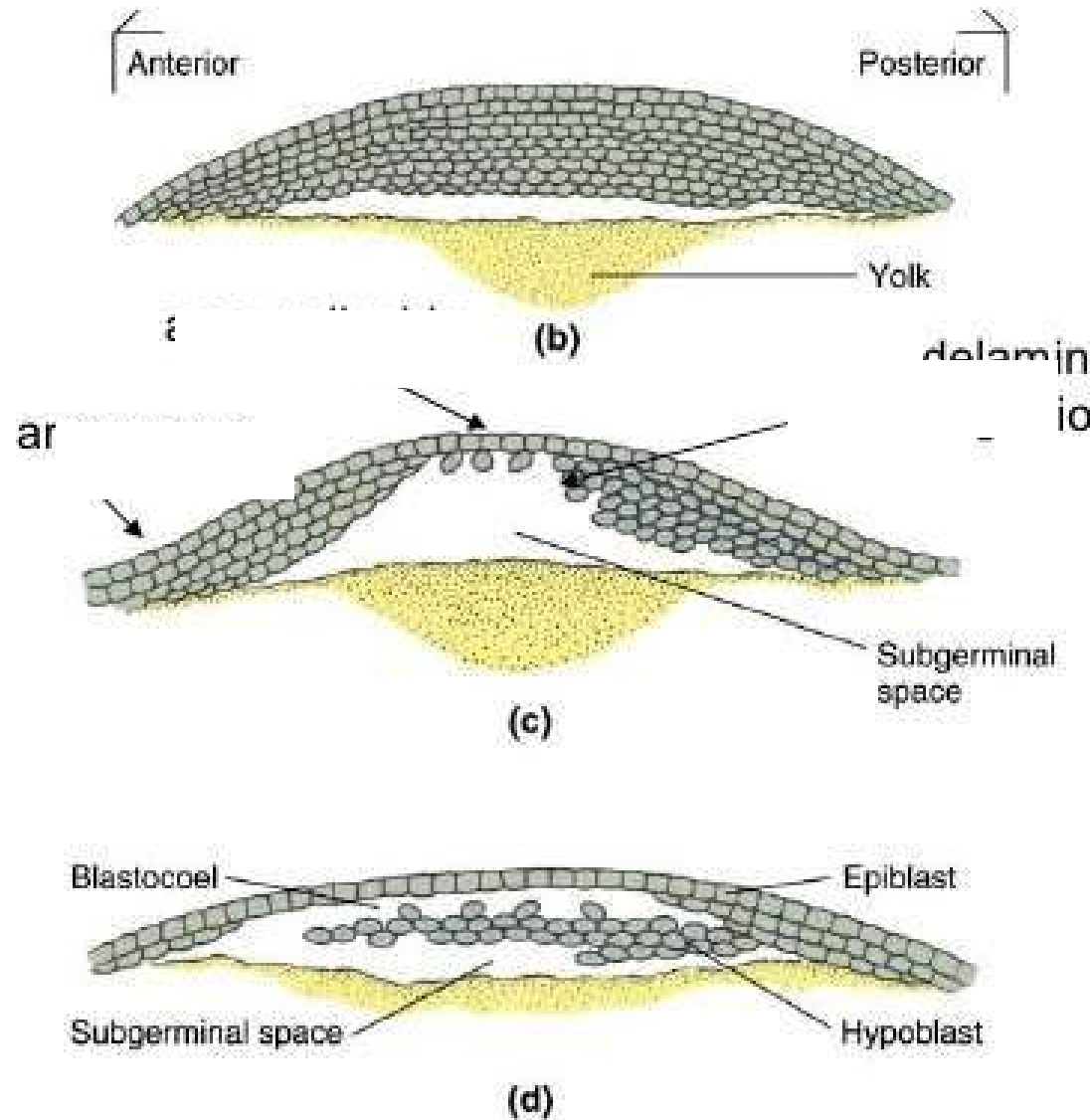
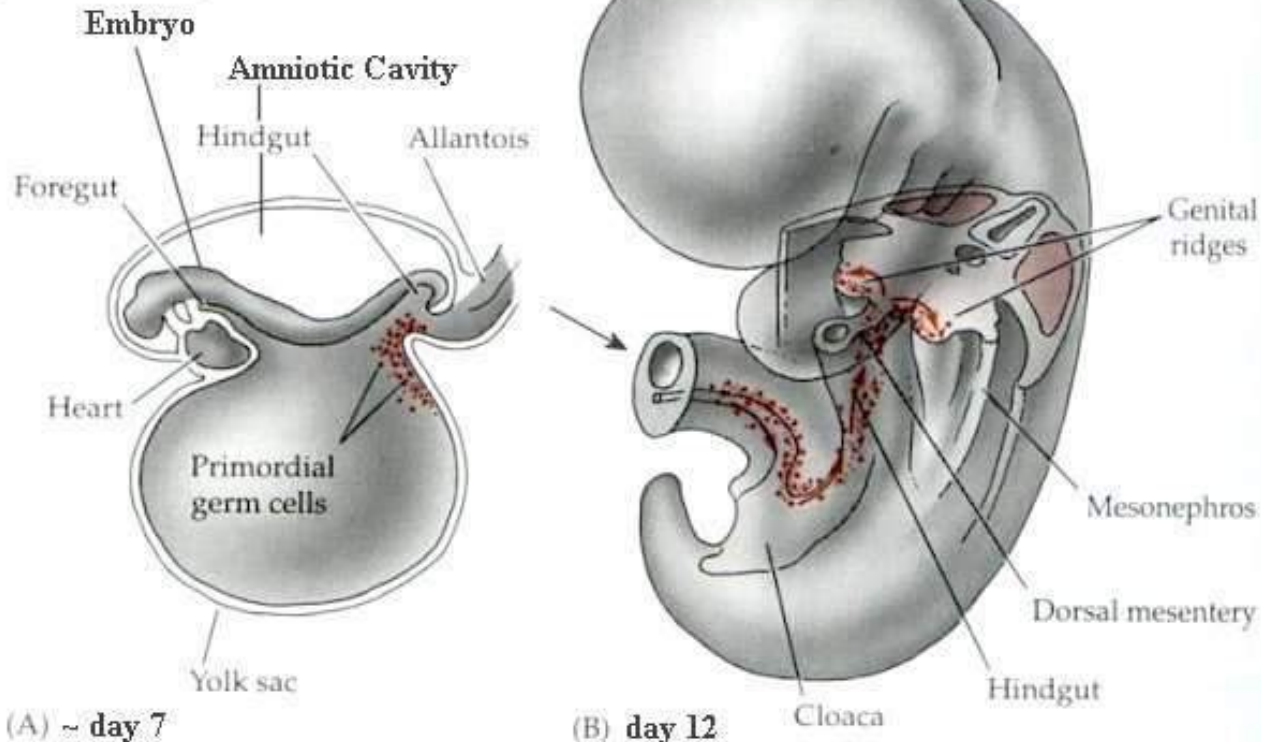


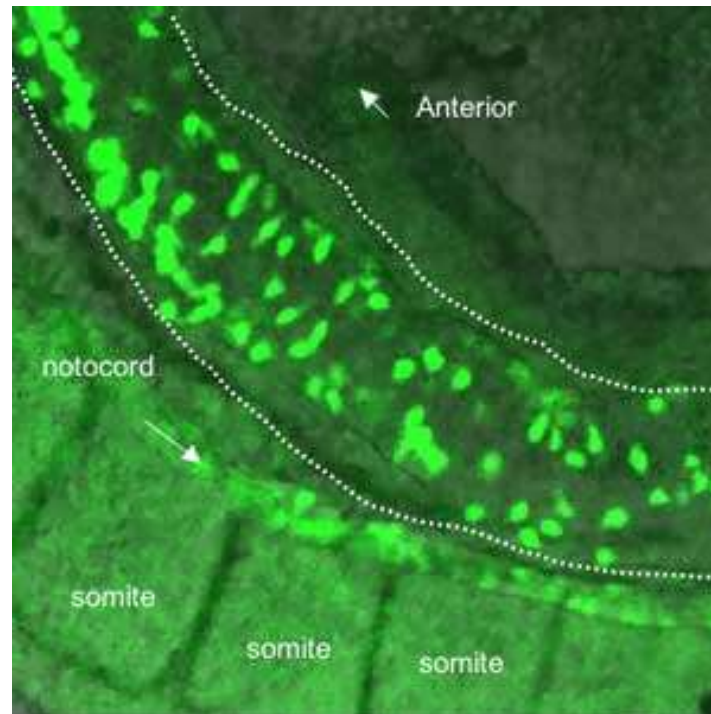
Figure 5.16

- **In the mammals** the_PGCs can be found in the posterior wall of the yolk sac near the origin of the allantois.
- ❖ So many studies proved that the site of the PGCs in various reptiles, birds, and mammals is from an **extra-gonadal origin**.

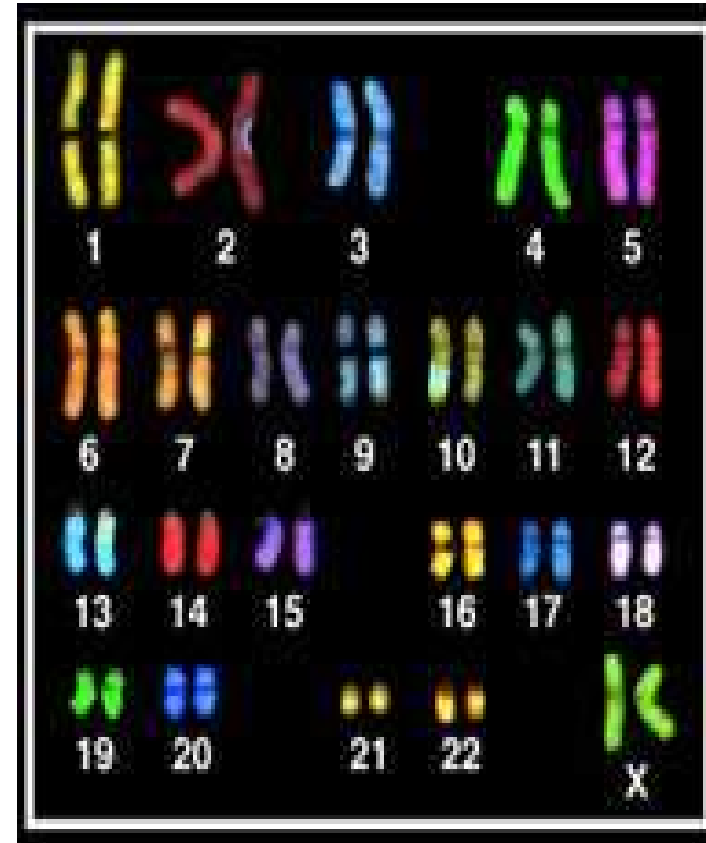
Migration of mammalian primordial germ cells

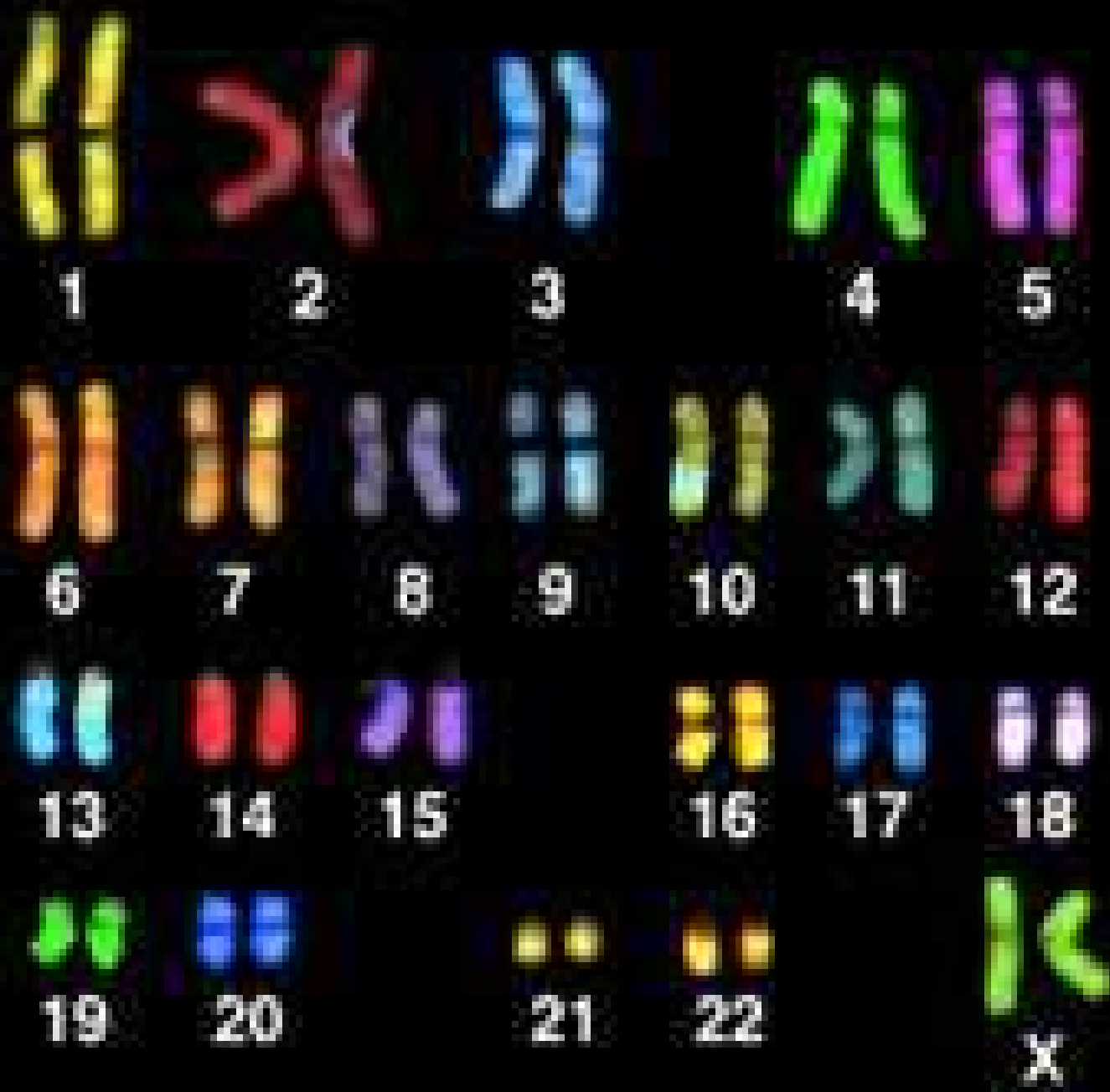


- In most vertebrates, mitosis in the PGC is arrested after their until reach the genital region, but this is differ in the mammals, there is no stop in the mitotic activity of the PGC during migration to the genital area.

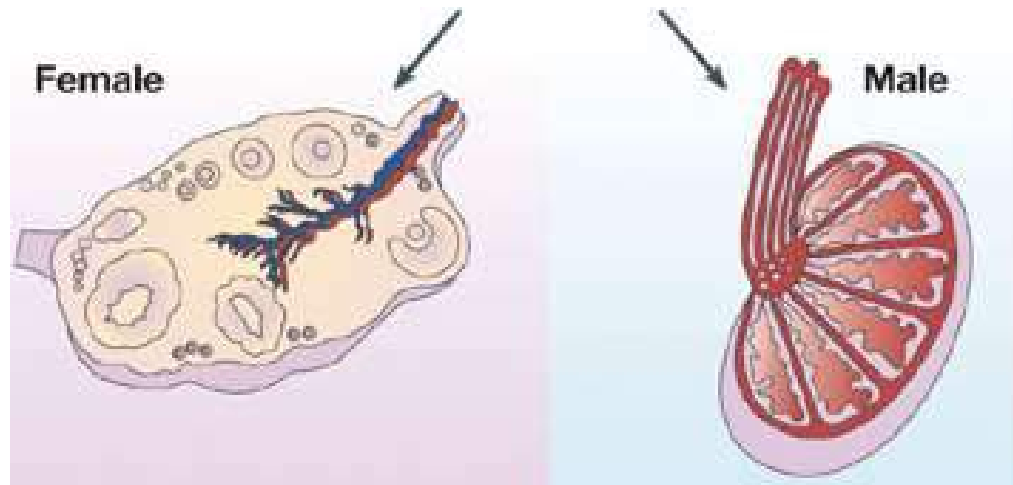


- Like all normal somatic cells (**non-germ cells**) the PGCs contain **23 pairs of chromosomes (46 chromosomes)**. One chromosome of each pair is obtained from the maternal gamete and the other from the paternal gamete, (**22 pair**) consists of homologous chromosomes called **autosomes**, the remaining 2 chromosomes (**1 pair**) are called **sex chromosomes.**
- **In most vertebrates**, mitosis in the PGC is arrested after their until reach the genital region, but this is differ in the mammals, there is no stop in the mitotic activity of the PGC during migration to the genital area.

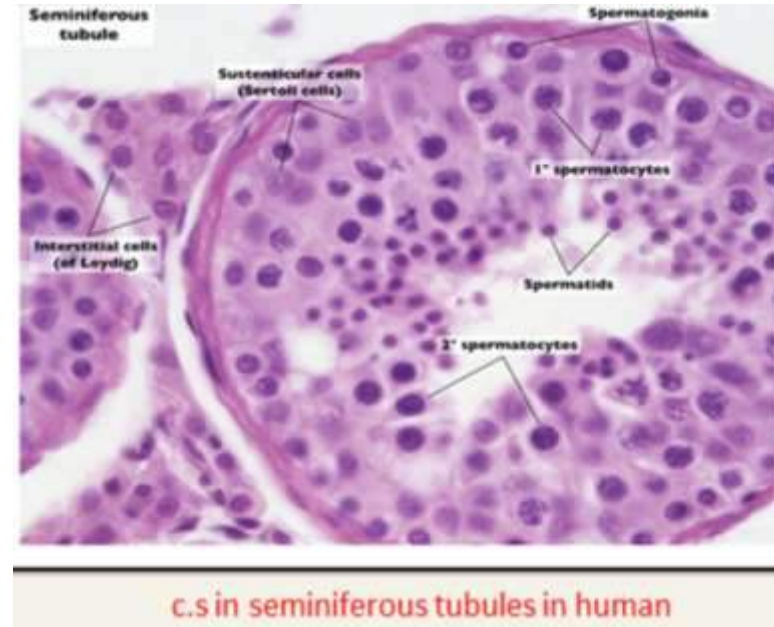




- **In males**, PGCs remain dormant in the testes from 6th Week of human embryonic development until puberty.
- At puberty, seminiferous tubules mature by the **male hormones** that stimulate the differentiation of the PGCs into **spermatogonia** by mitosis.
- **In contrast in the female**, the PGCs, undergo a few more mitotic divisions and invested by some somatic cells from the stroma of the ovaries before 5th Week of the human embryonic development the PGCs transform to the **oogonia**, and by the 5th month of the fetal development all oogonia enter **meiosis I**, they are called **primary oocytes**, the primary oocytes still arrest in the ovaries until **sexual maturity**



- The development of the spermatozoa takes place in the male gonads, the testes, in all vertebrates the testes are mixed gland
- ❖ Exocrine organ, produce sperms
- ❖ Endocrine gland, producing male hormones.
- The spermatogenesis takes place continuously from puberty until death, At birth, the germ cells in the infant male can be recognized in the **sex cords of the testis, as large, pale cells surrounded by supporting cells.**
- The supporting cells called the **Sertoli cells; originate from the surface of epithelium of the seminiferous tubules**, the sertoli cells have physical and chemical support to the spermatocytes.
- **At puberty**, the testes begin to secret greatly increased amounts of the steroid . hormones, **testosterone**, among effects of this hormone; the PGCs will resume the development and divide several times by **mitosis**, and then differentiate into **Spermatogonia**.





c.s in seminiferous tubules in human

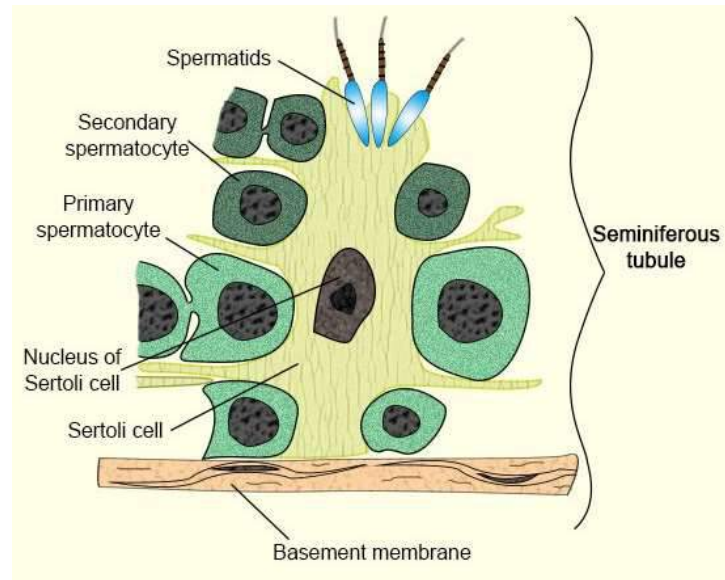
- Spermatogonia locate under the basement membrane of the seminiferous tubule.
- **The spermatogenesis is a continuous process; it can be divided into two stages:**

1- Spermatocytogenesis

1. **Spermatocytogenesis:** - the process which the primordial germ cells (PGCs) produce the spermatozoa during several stages of mitosis.

2. **Spermiogenesis:** - the process which includes the re-structuring of the spermatids to spermatozoa (**sperms**) without any cell division only morphological changes. Because a sperm or spermatozoon is very active and motile, therefore it requires a degree of specialization, head and tail of the sperm are formed in this process.

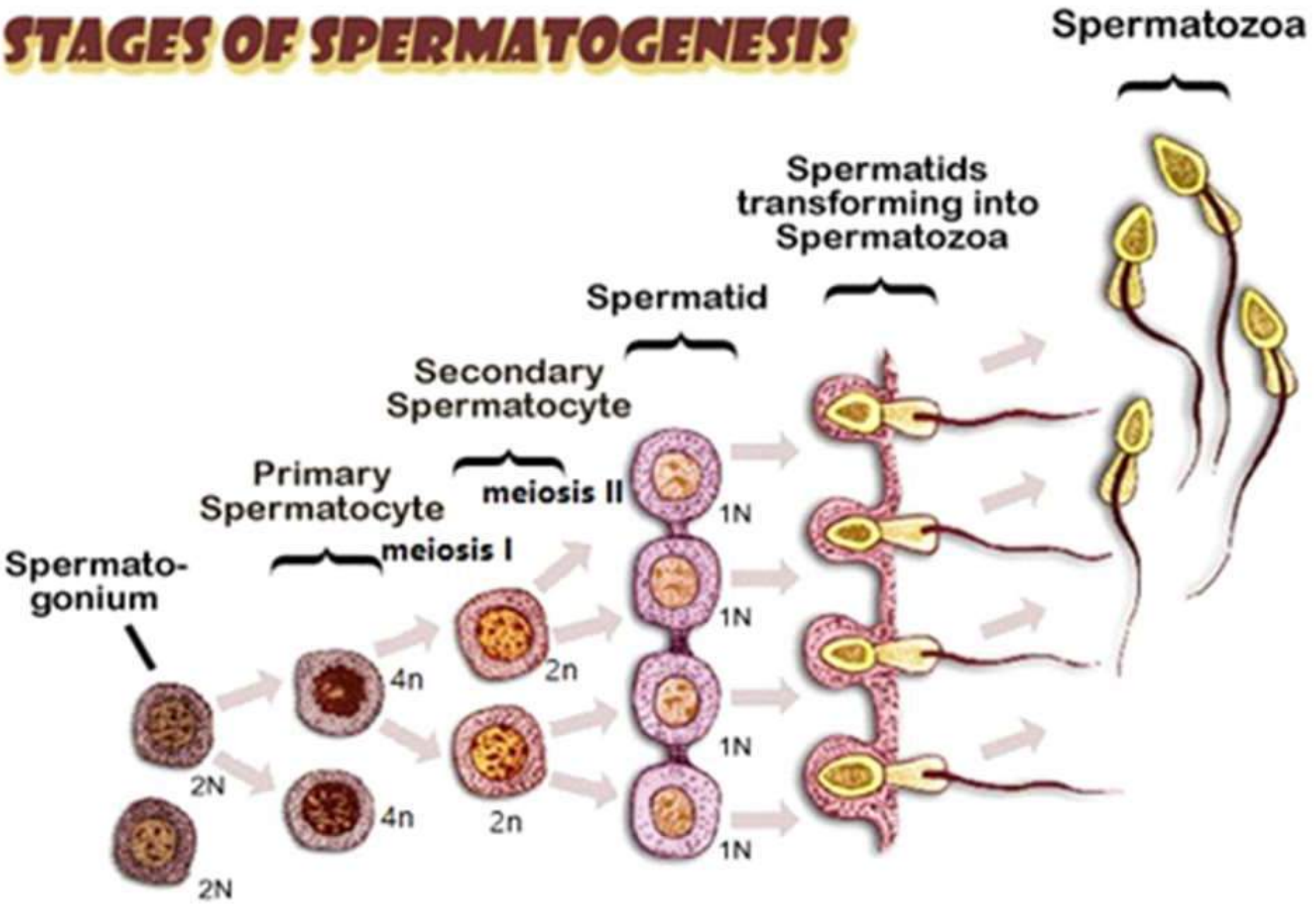
2- Spermiogenesis



Spermatocytogenesis

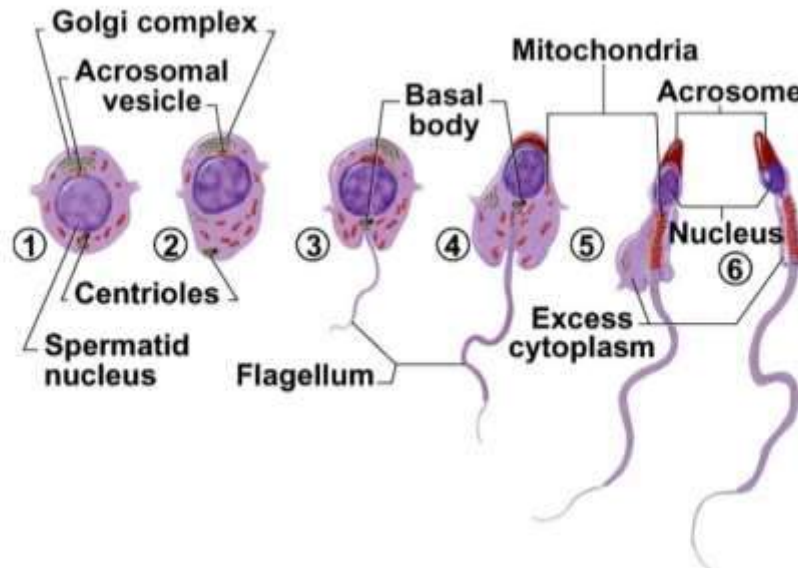
- **PGCs (46,2n)** move from the wall of the yolk sac arrive in the testes and remain dormant until birth,
- **At puberty** the testes differentiate during mitosis into Spermatogonia (46,2n) which are located peripherally in the seminiferous tubules, these cells are active mitotically all the life.
- The DNA replication is occur in mitosis convert the Spermatogonia from **2n** to **4n** the resultant cells called the **Primary spermatocytes (46, 4n)**
- Primary spermatocytes (**46, 4n**) enter the **meiosis I** and divided into two daughter cells called **Secondary spermatocytes (23, 2n)**,
- Each of the secondary , spermatocytes enter the **meiosis II** to form **four haploid spermatids (23,1n)**.
- ❑ Commonly in the human the **meiosis I** last for several weeks, whereas the **meiosis II** is completed in about 8 hours.
- Through this series of division, cytokinesis is incomplete; leaving all cells still connected through thin cytoplasmic bridges, and connects with **Sertoli cells**, which support them physically and metabolically.
- Although the spermatids no longer divide, they undergo a transformation to specialized spermatozoa; this is done by the spermiogenesis process.

STAGES OF SPERMATOGENESIS



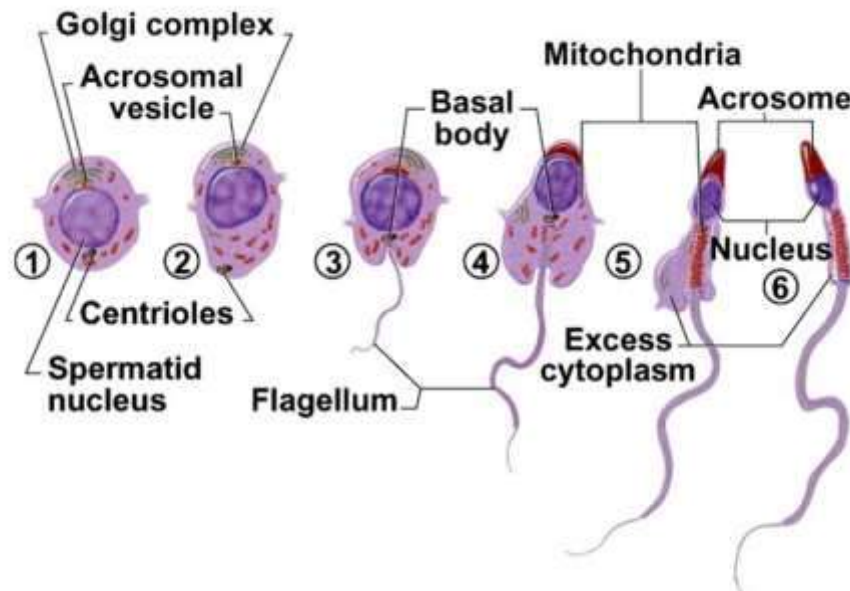
Spermiogenesis

- The Spermiogenesis is the second process of the spermatogenesis mechanisms, it consists of series of morphological changes **that responsible of transformation the spermatids into mature spermatozoa (sperms) (23,In).**
- Because the sperm or spermatozoon is very active and mobile cells, so it must be supported with great amount of energy and activation, therefore there is need to a high degree of specialization must occur in the sperm cells before release from the testes.



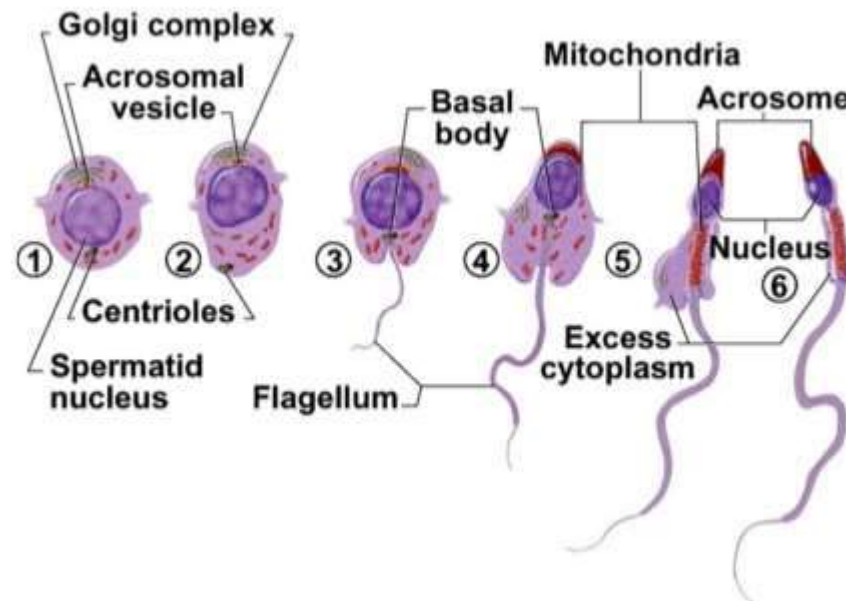
After the end of the meiosis II,

- ❖ The nucleus begins to lose fluid.
- ❖ Decrease its size
- ❖ The nucleus loses its RNA molecules, nucleolus and most proteins,
- ❖ Only the haploid copy
- ❖ The chromatin compress until forming the head of the sperm,
- ❖ At the apical end of the developing sperm head, there is a Golgi complex form the pro-acrosomal granules, contains hydrolytic enzymes that are released; during fertilization.
- ❖ The centriole develop to be a point of the flagellum.



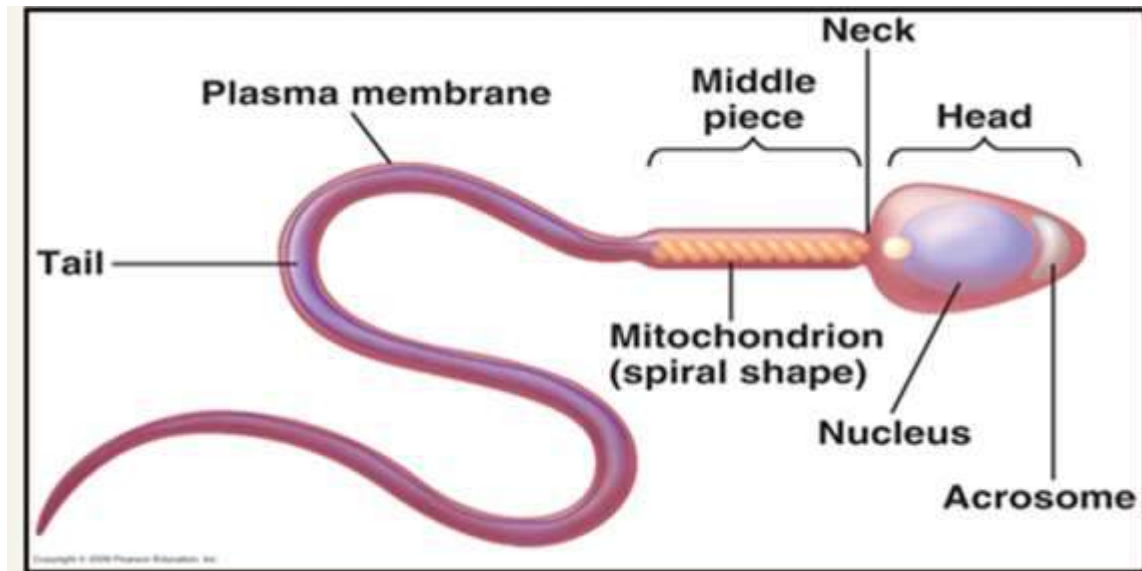
After the meiosis II

- ❖ The two centrioles move through the cytoplasm of the **spermatid** just behind the nucleus,
- ❖ These centrioles give rise to the axial filament of the flagellum of the sperms, which later differentiate into tail,
- ❖ Mitochondria begin to form a spiral form called the mitochondria helix as a source of energy,
- ❖ During development the rest of the cytoplasm will sloughed off and phagocytized by the sertoli cells

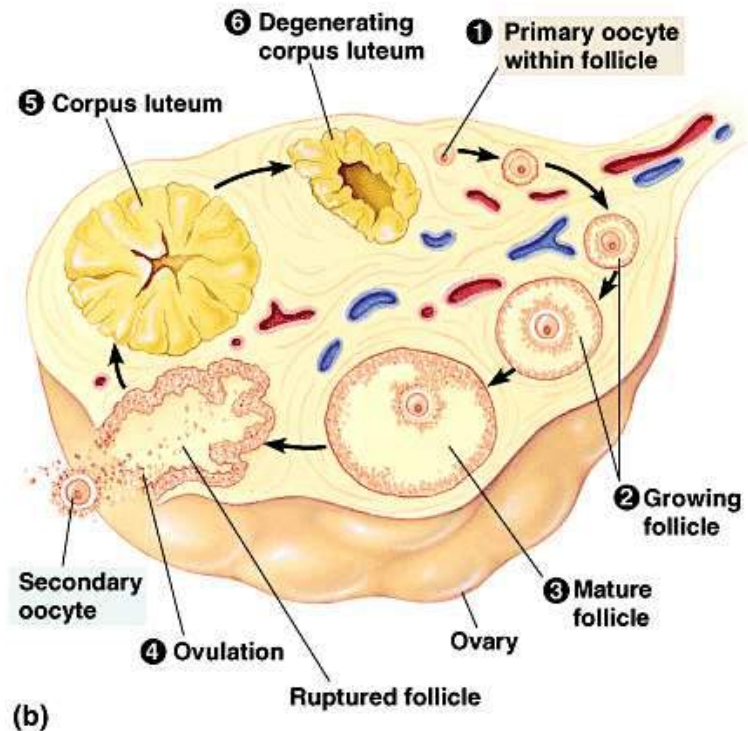
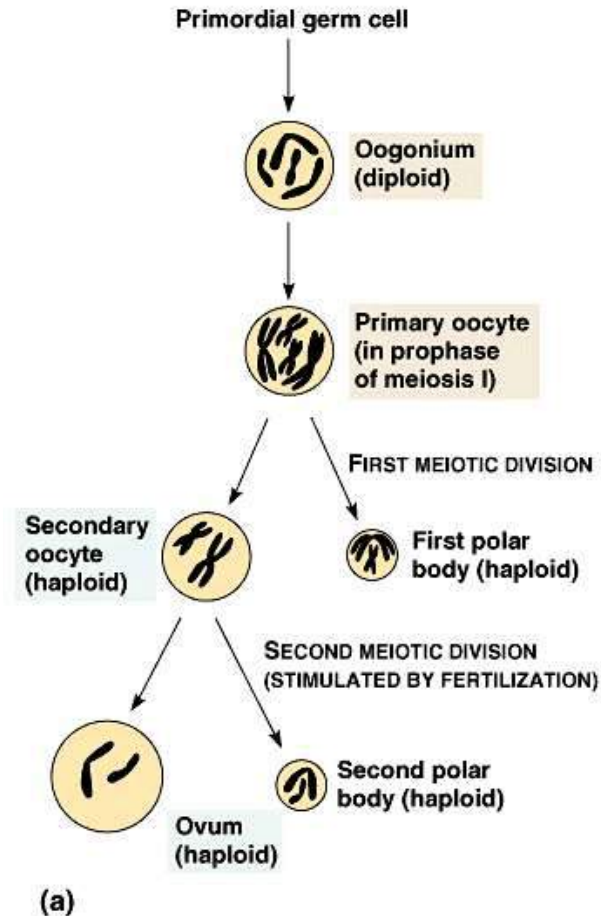


All these events make the mature spermatozoa leaves all the non-essential parts, at the end the mature spermatozoa will consists of

1. **Head:** containing nucleus and acrosome
2. **A neck:** containing the centriole
3. **A middle piece:** containing the proximal part of the flagellum and mitochondria helix
4. **The tail:** highly specialized flagellum



Oogenesis

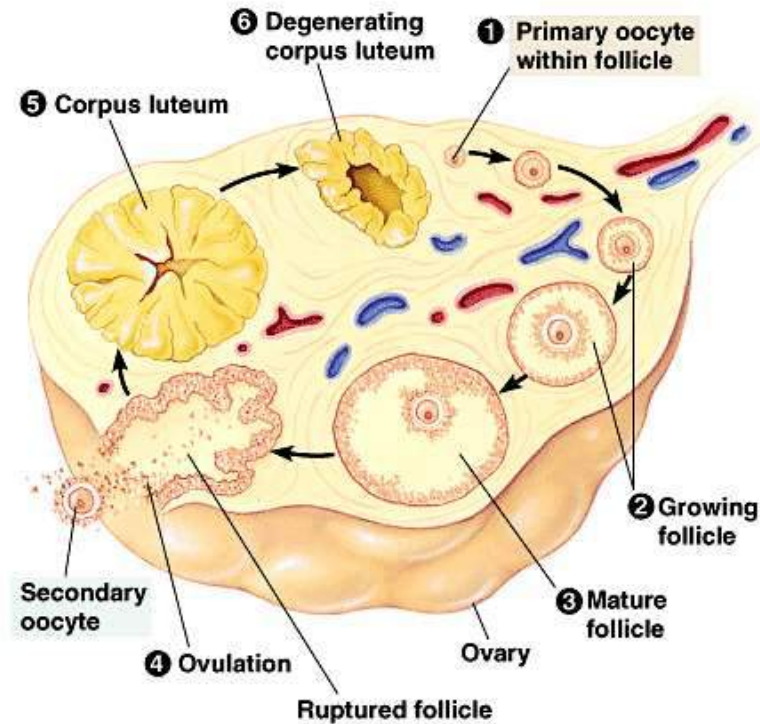


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Dr. Ruwaidah F. Khaleel

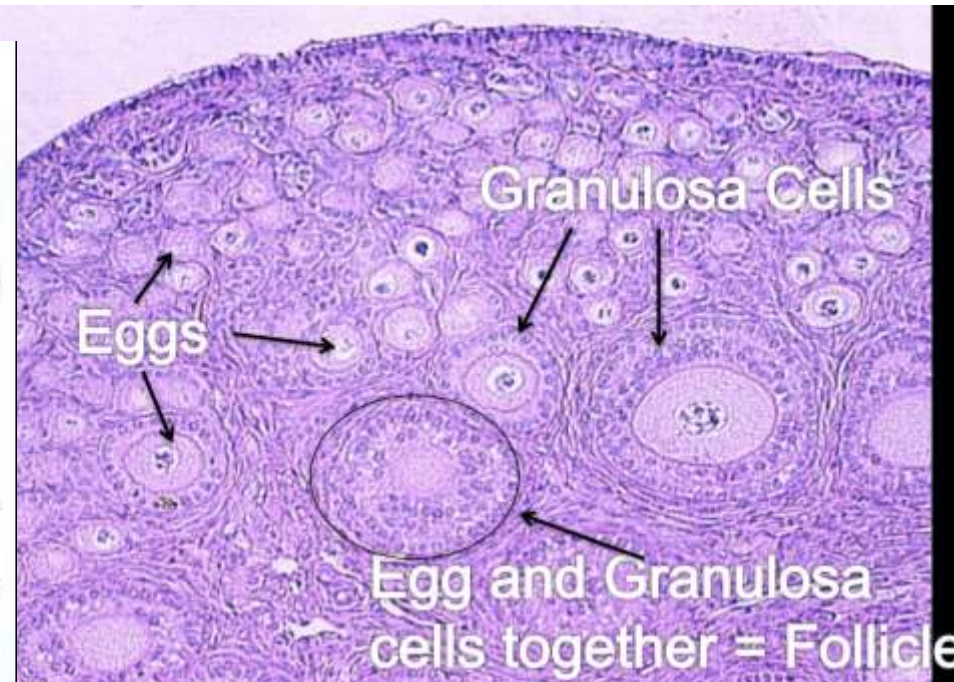
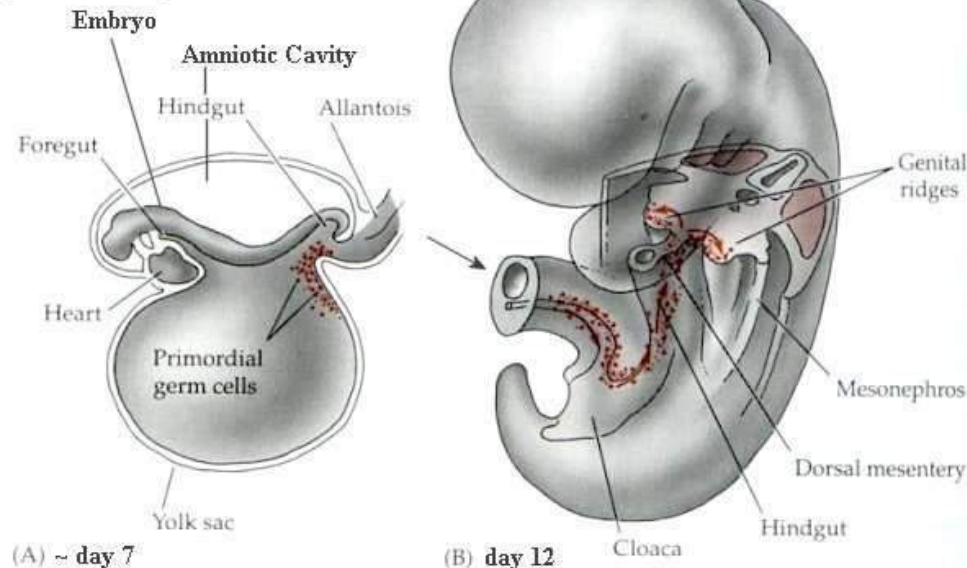
Oogenesis

- 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.

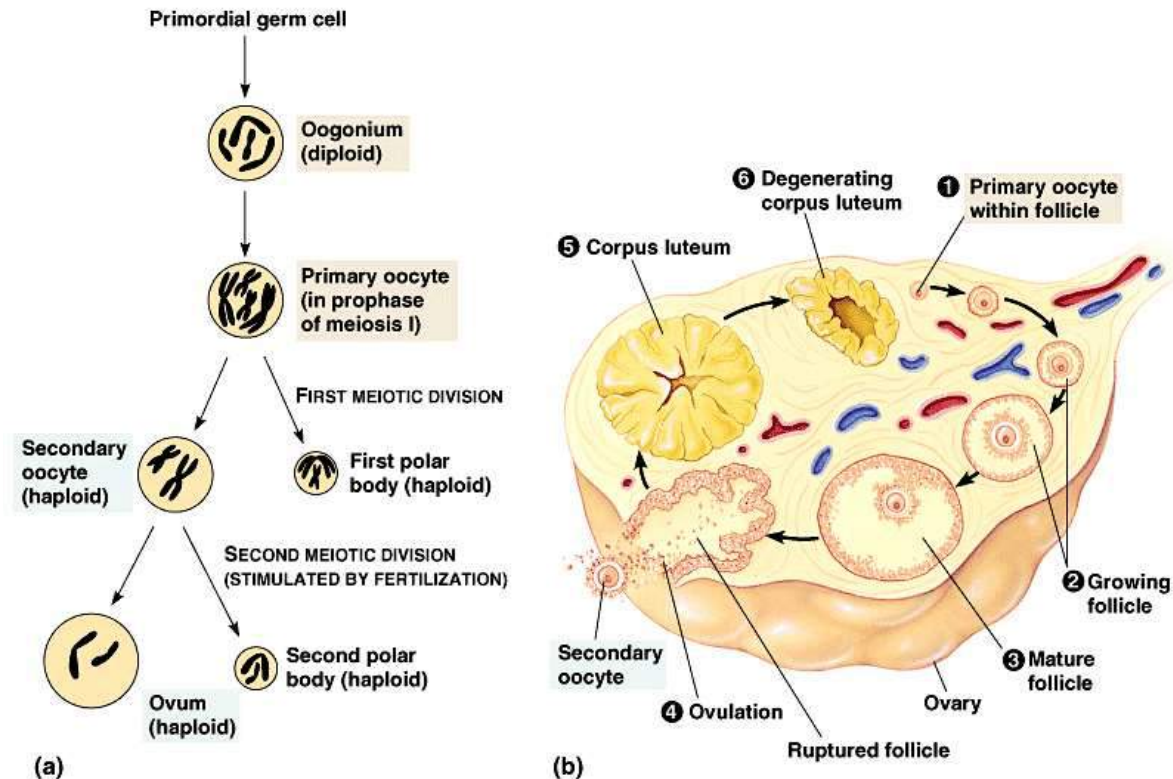


- Once the **PGCs** have arrived in the gonad place of the female embryo, they differentiate into **oogonia (46, 2n)** through a number of mitotic divisions, this occurs during the embryonic life or larval life only.
- Then the epithelium of the ovary around the oogonia will differentiate to **monolayer epithelial tissue** called **granulosa cells** surrounds the oogonia.

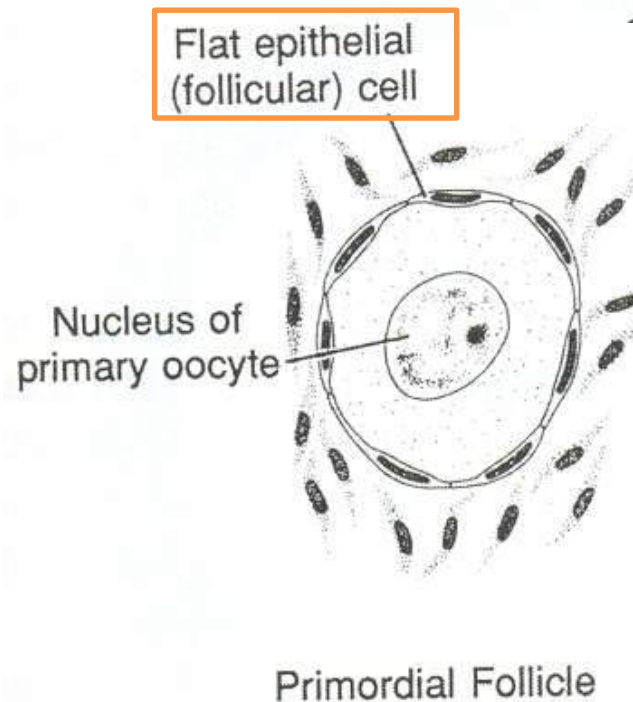
Migration of mammalian primordial germ cells



- The oogonia undergo-DNA replication, and enter the **meiosis I (prophase 1)** as in the mitosis, the amount of the DNA doubles from the diploid **2n to 4n** or **tetraploid**,
- In contrast to the mitosis, prophase is prolonged for months and even years, thus called the **arrested_prophase**, which is the marked feature of oocyte meiosis to form **primary oocytes** this occur at the **third month of gestation** within the embryo ovaries,

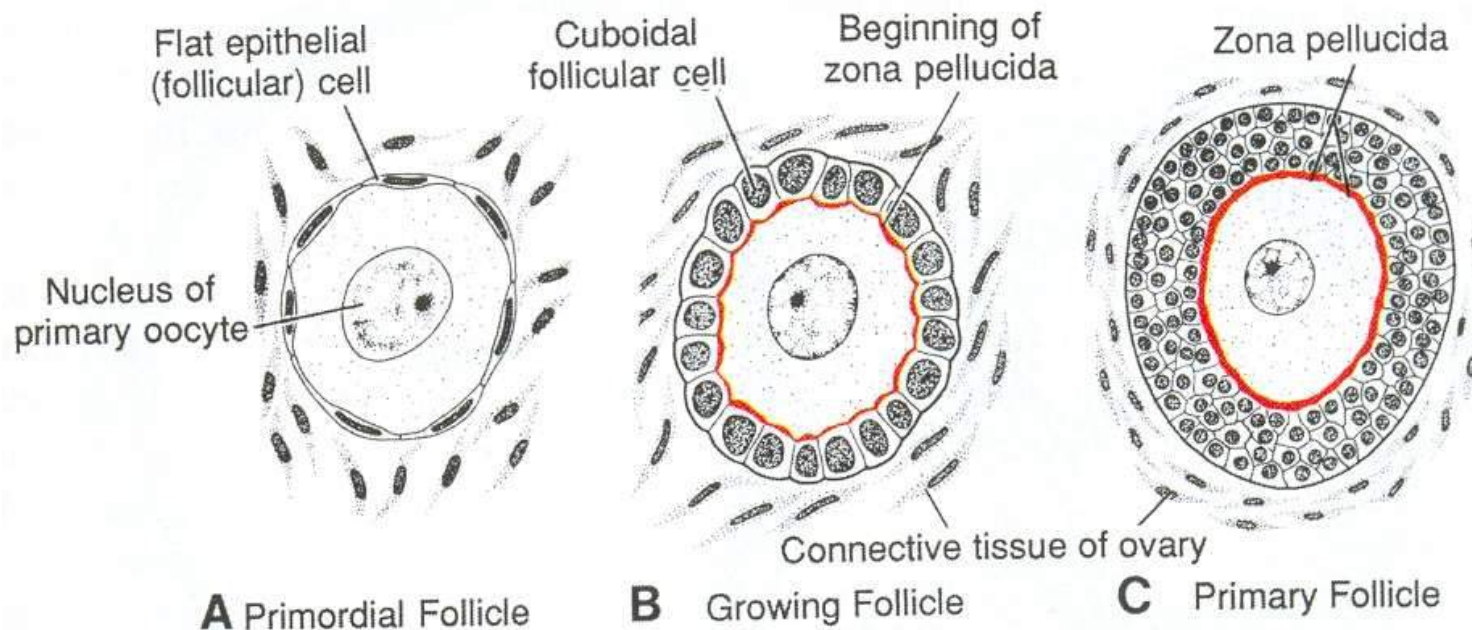


- The primary oocytes which are surrounded by a single-layer of **squamous epithelial cells** derived from the somatic support cells in the ovary that enclosed the oogonia tightly, The primary oocytes with this capsule of epithelial cells, called **primordial follicle**.
- Once primary oocyte stop dividing the cells enter a prolonged **(resting phase)**. Stay in the ovary during prophase I **(diploten)** for long year until reach the puberty. Then each one of primary oocyte will complete the **meiosis I**.

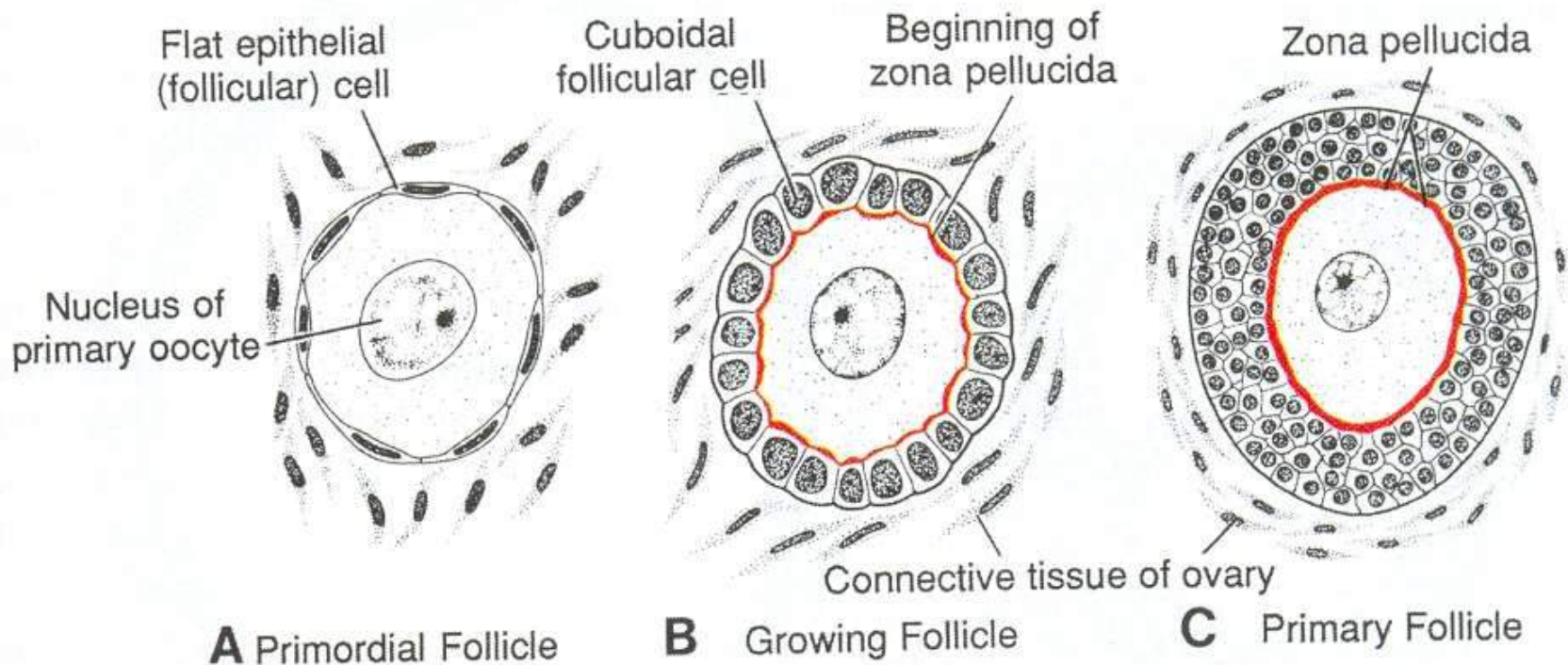


Development of the ovarian follicles

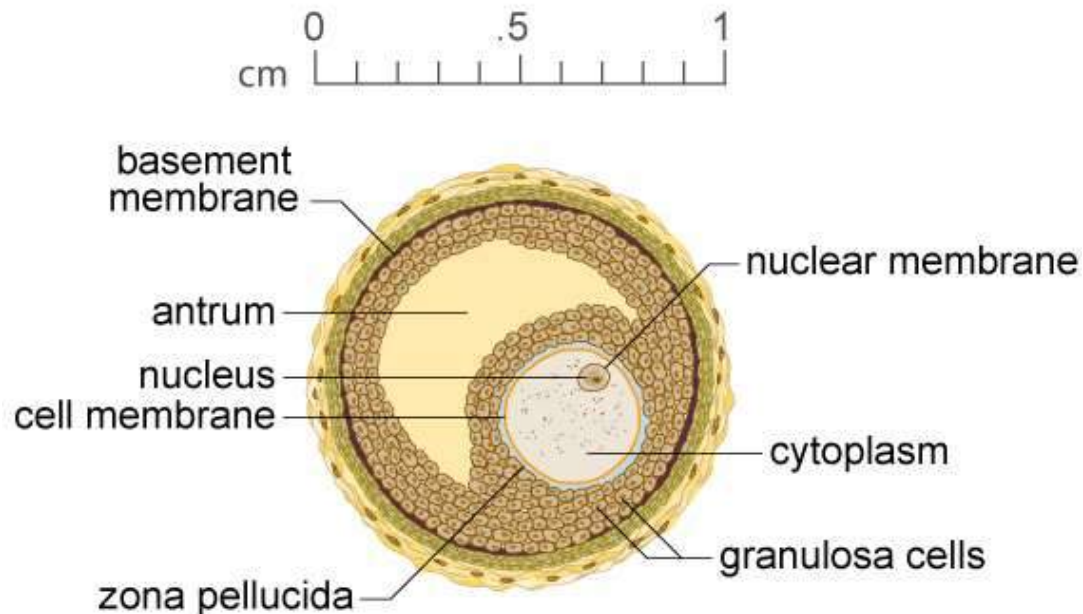
- Before puberty and without hormonal control of the pituitary gland, the follicular epithelium of a small group of primordial follicles thickens, converting the single-layered follicular epithelium from a layer of squamous cells to cuboidal cells, these follicles is now called **primary follicles**



- The oocytes with the follicle cells secrete a thin layer of cellular material composed of only a few types of glycoproteins, into surface of the oocyte that are deposited as an outer layer this layer will name (**Zona pellucida**), the zona pellucida appears to form a complete physical barrier between the follicle cells and the oocyte, this layer is penetrated by projections from the follicle cells to contact with the oocyte membrane to exchange the metabolites and mechanical support

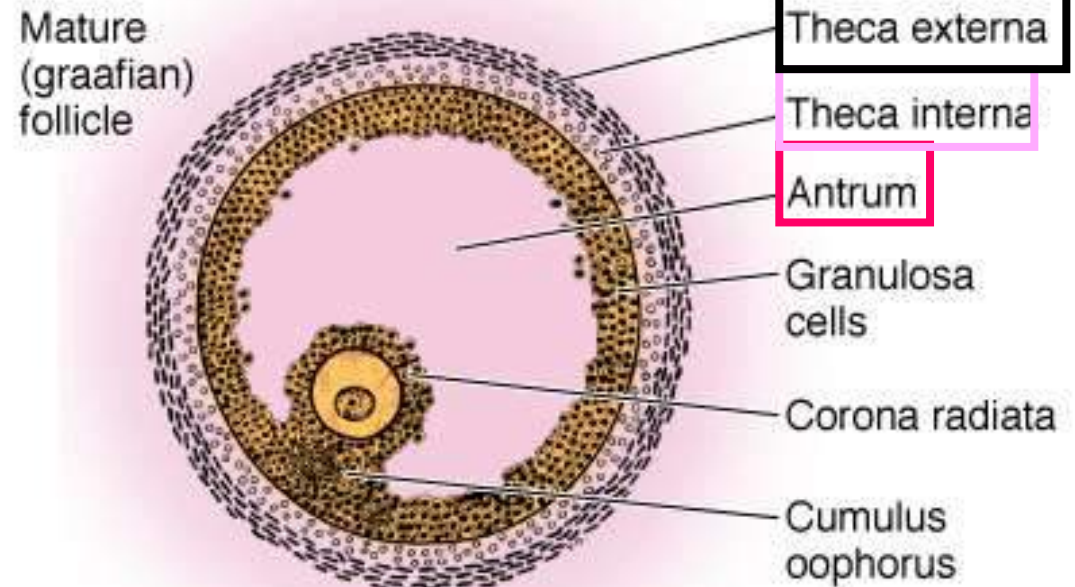
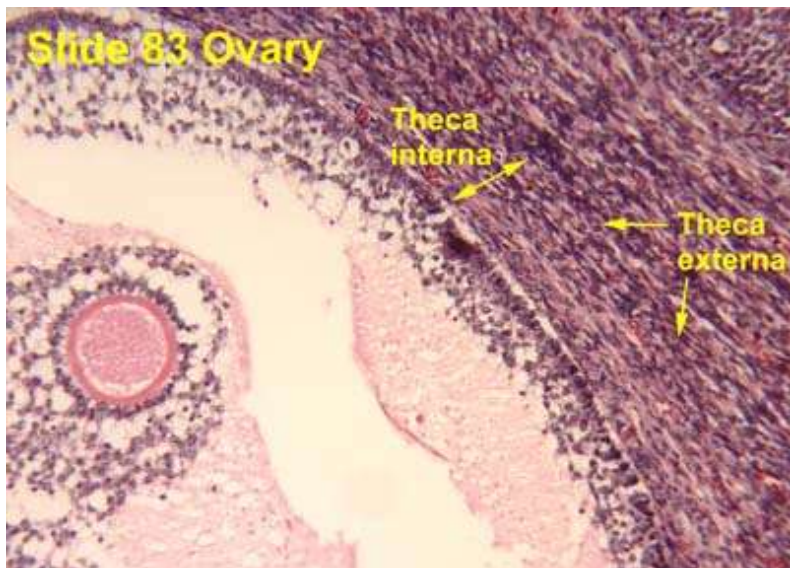


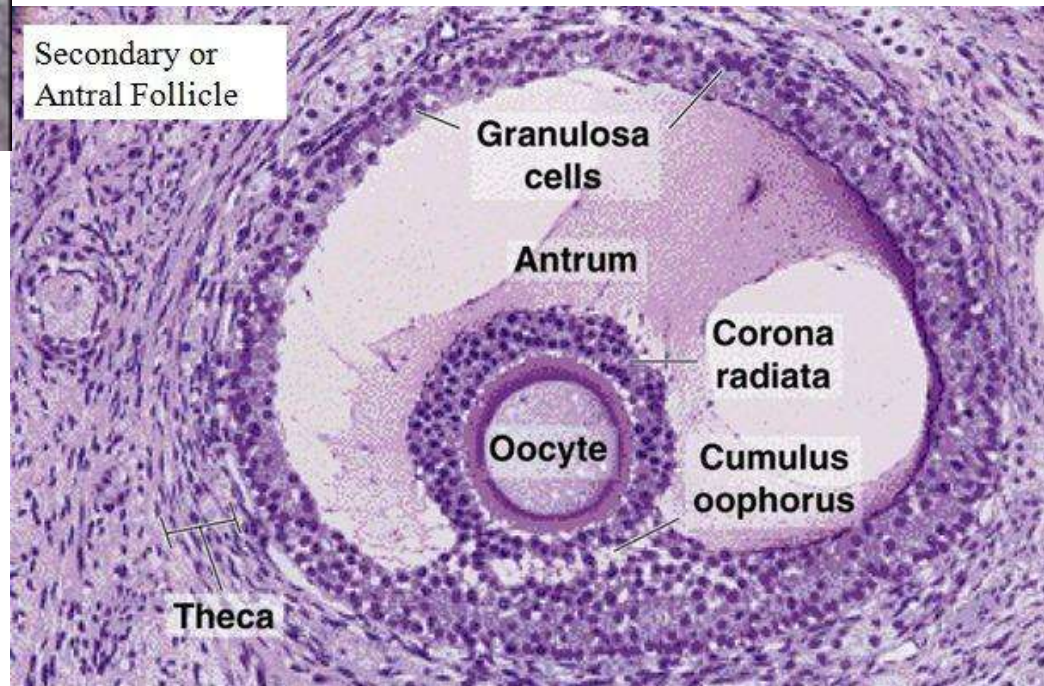
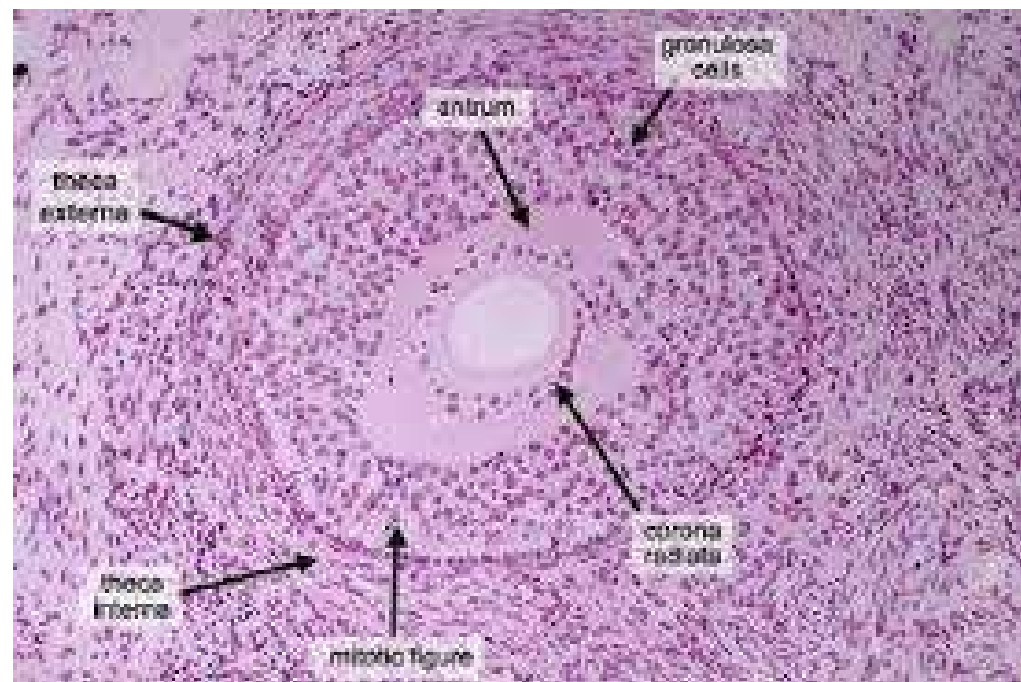
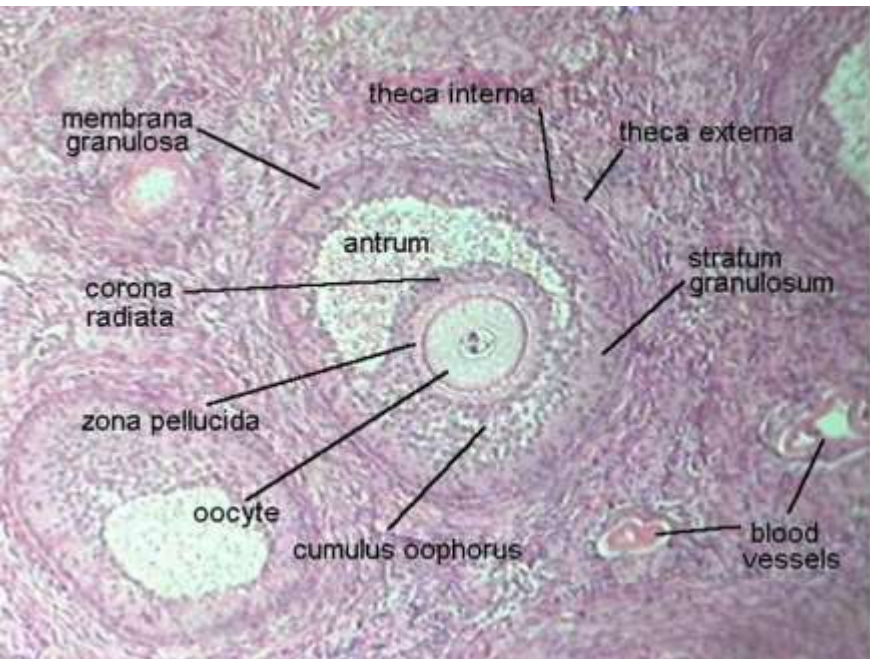
- Just before puberty, some of the growing follicles stop to develop and degenerate, whereas a few continue to enlarge in response to rising levels **Follicular Stimulating Hormone (FSH)**.
- **This hormone stimulates the follicle cell to:**
 - ❖ Resume the growth and complete the **meiosis I**
 - ❖ Form two daughter cells non equal in size, a **secondary follicle (23,2n)** and **first polar body** , which degenerate later,



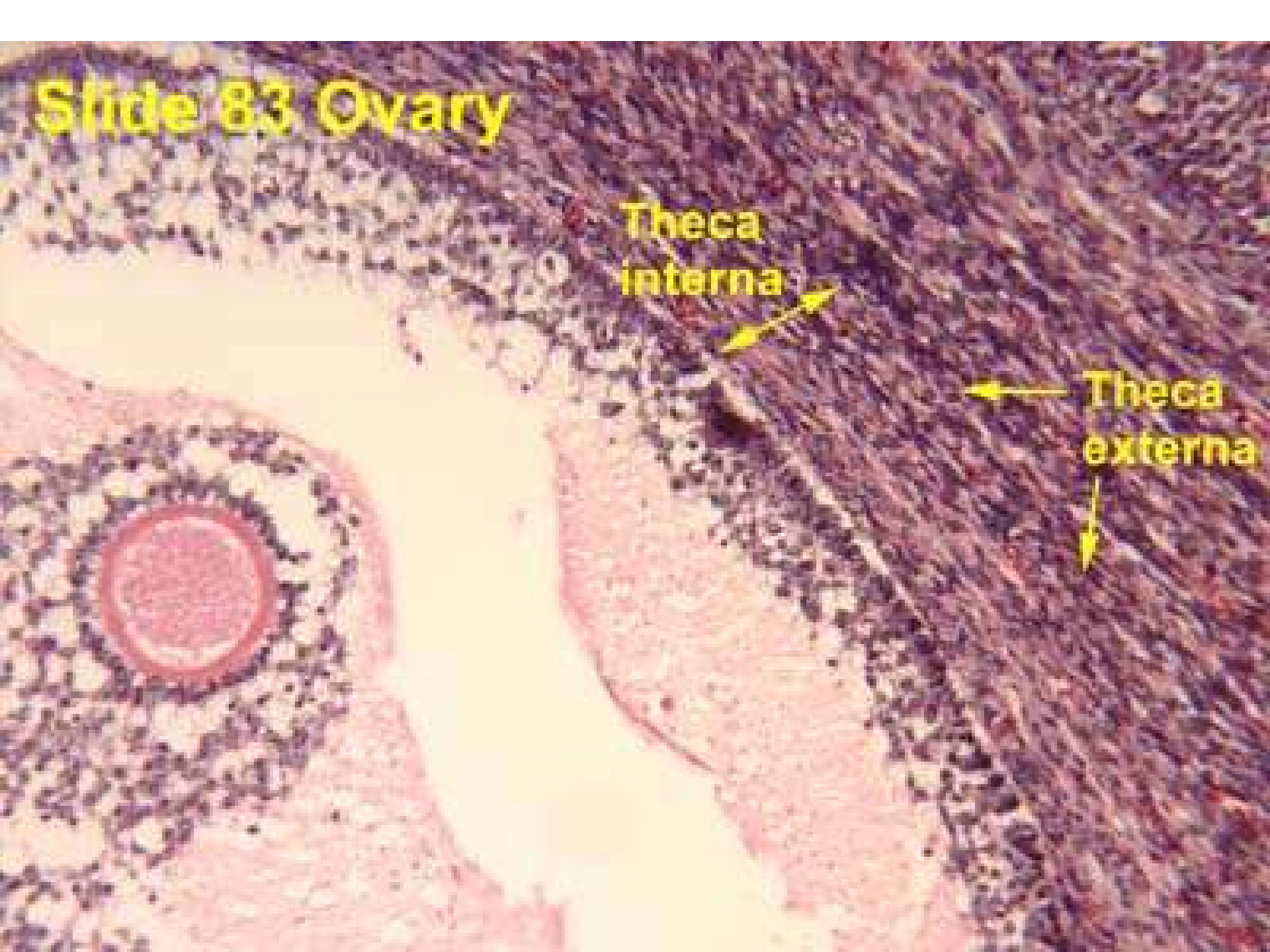
Secondary or Antral Follicle

- Follicle cells then produce a fluid between the cells and form a cavity called the **Antrum**,
- At the same time the connective tissue of the ovary (stroma) around the **secondary follicles** will differentiate to two layers:
 - ❖ The inner, **Theca interna**
 - ❖ The outer, **Theca externa**,
- The **theca interna** is responsible for synthesis and produce the **steroids hormones**.



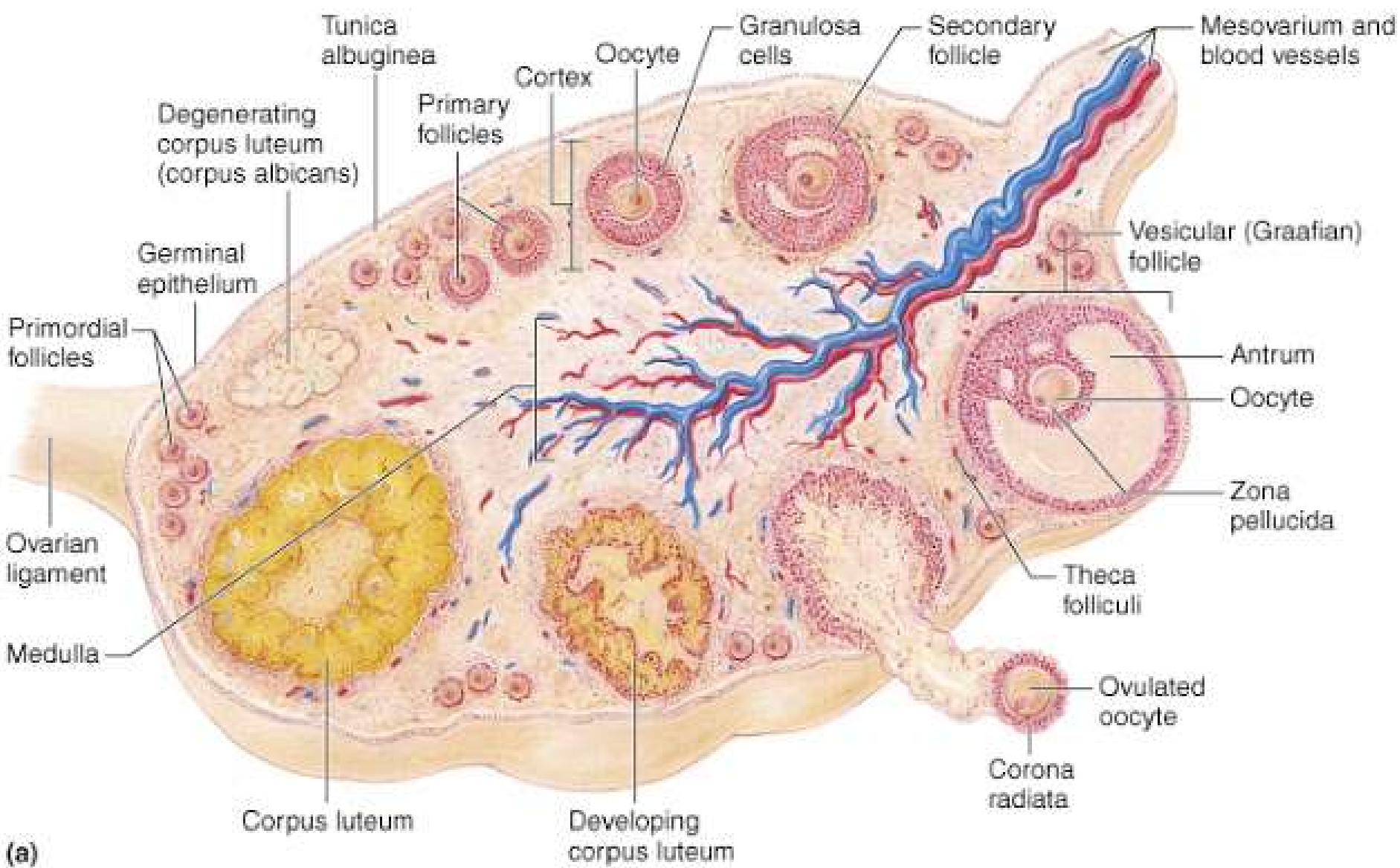


Slide 83 Ovary



Theca
interna

Theca
externa

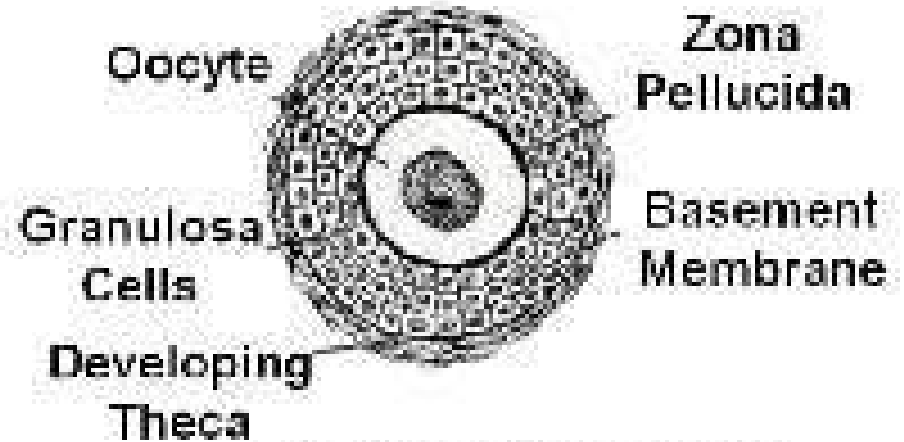


(a)

Primordial Follicle

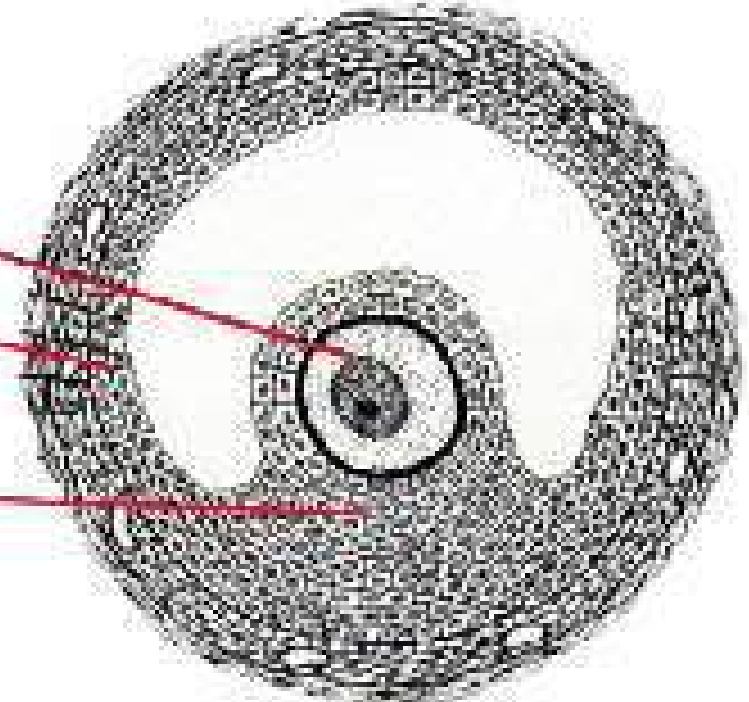
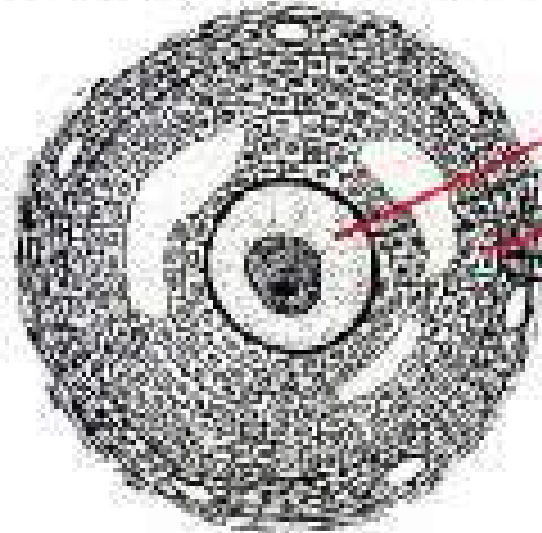


Primary Follicle

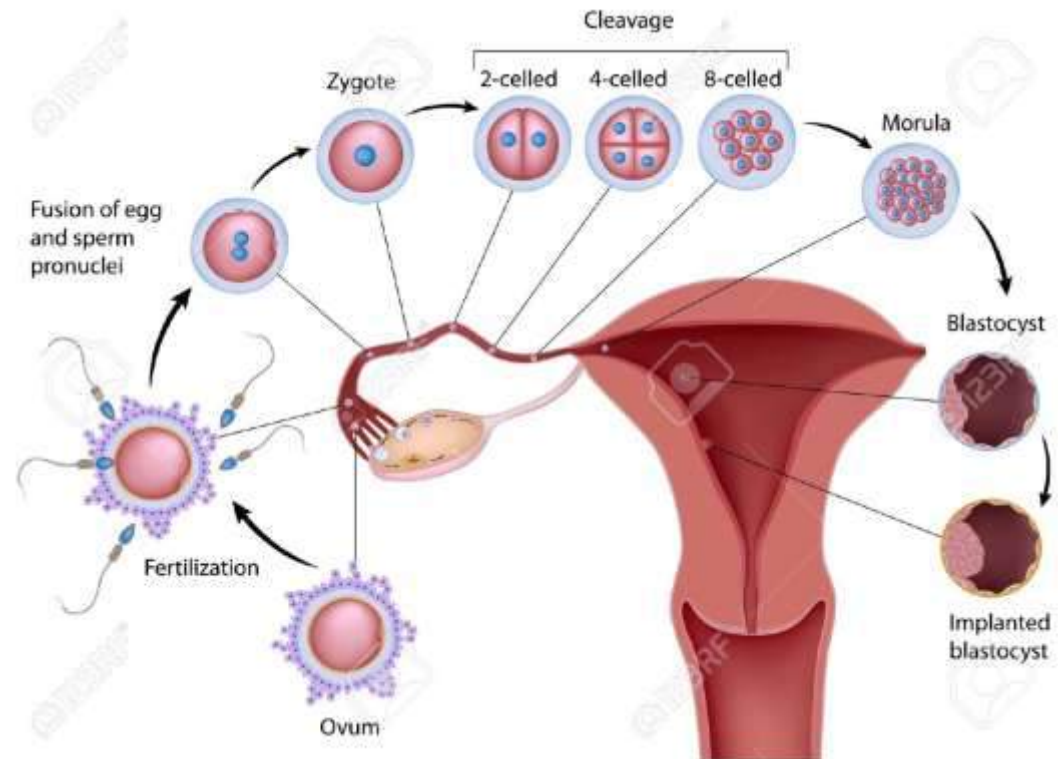
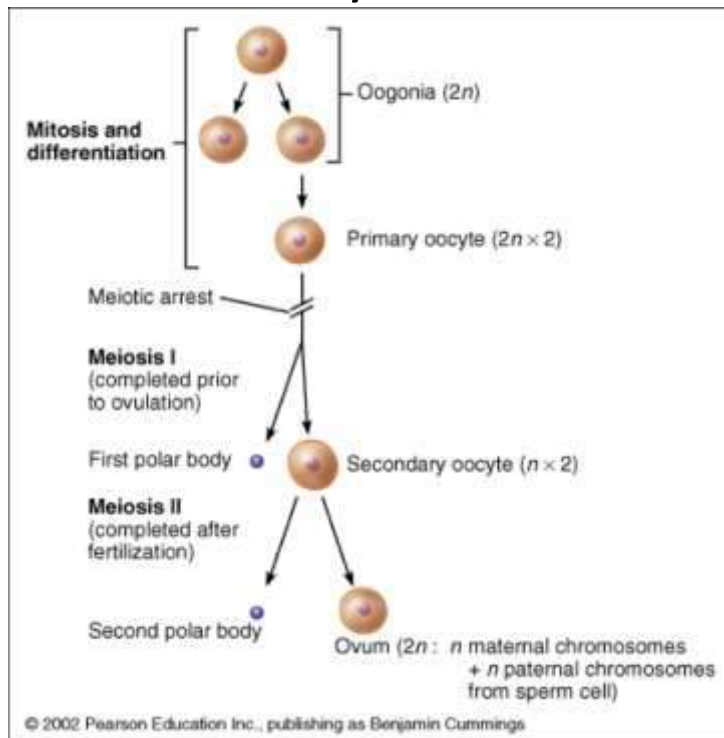


Maturing Follicle

Secondary Follicle

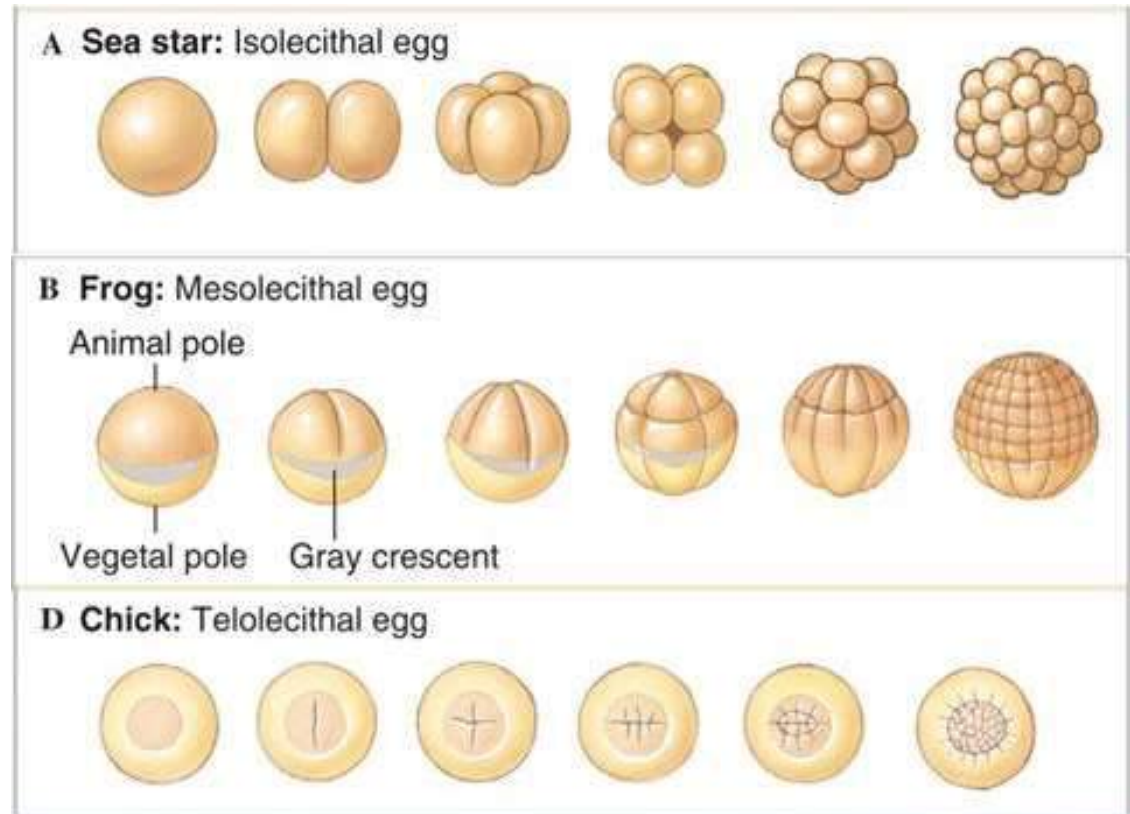


- After the meiosis I was complete, the secondary follicle is ready to enter the meiosis II, and stay in the metaphase II until few time before ovulation,
- **If the fertilization is occur** the secondary follicle complete the following stages of the meiosis II after leaving the ovary and reach the uterus to form a mature oocyte **(23,In)** and the second polar body
- **If fertilization not occur** it will degenerate and out through the menstrual cycle



Amount and distribution of yolk and types of eggs

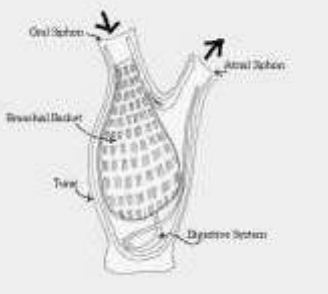
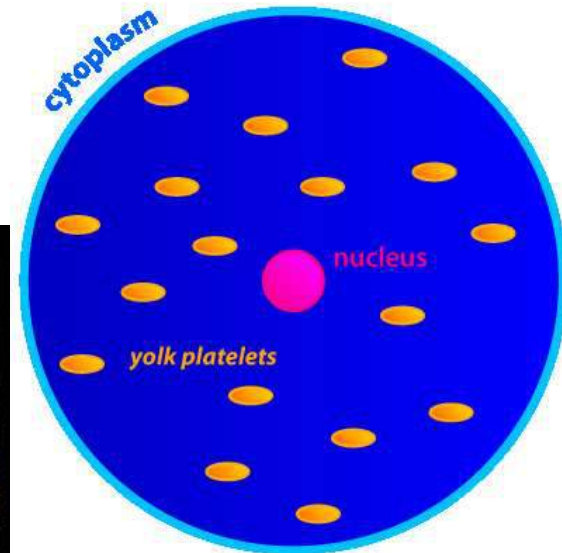
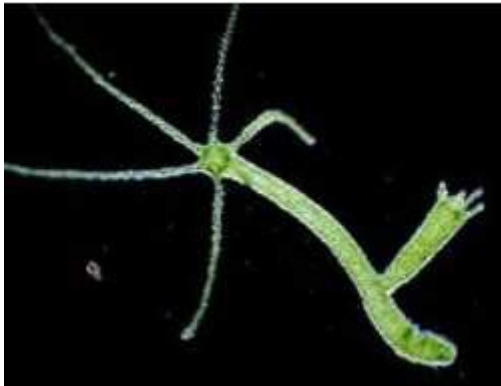
- **Yolk**, the major nutritional reserve of the oocytes during the growth and development and after the fertilization to provide the embryo with nutrition, the yolk varies greatly in **amount and distribution in different animal groups**



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

1. Microlecithal (oligolecithal) eggs

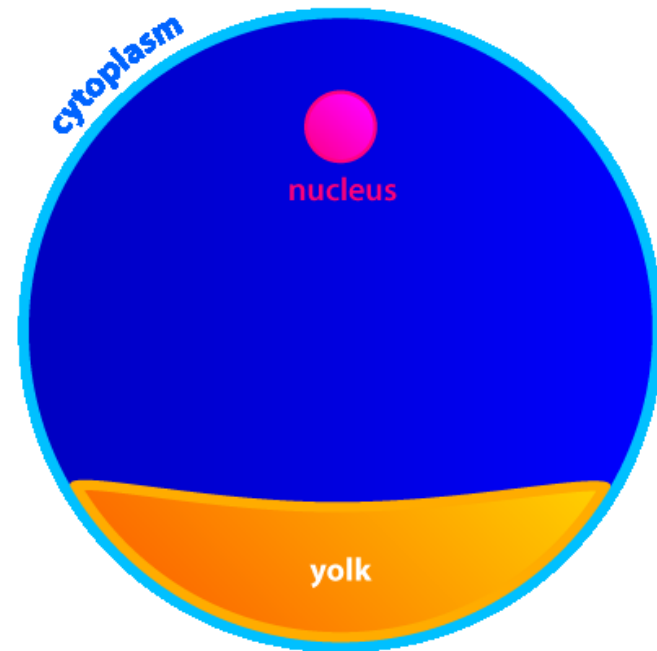
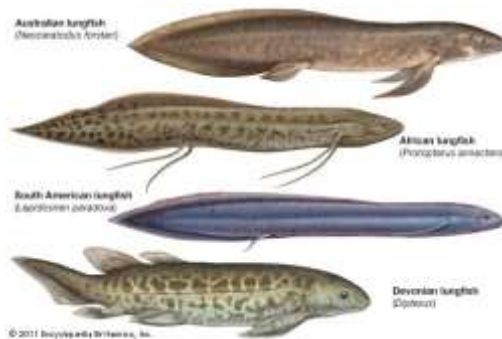
- These are small sized eggs which contain a very small amount of yolk distributed in the cytoplasm (ooplasm), this type found in certain **marine invertebrate**, ex: **Hydra**, and some chordates like **Amphioxus**, **cephalochordates**, **tunicates**, and the **eutherian mammals**, in the **mammals**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

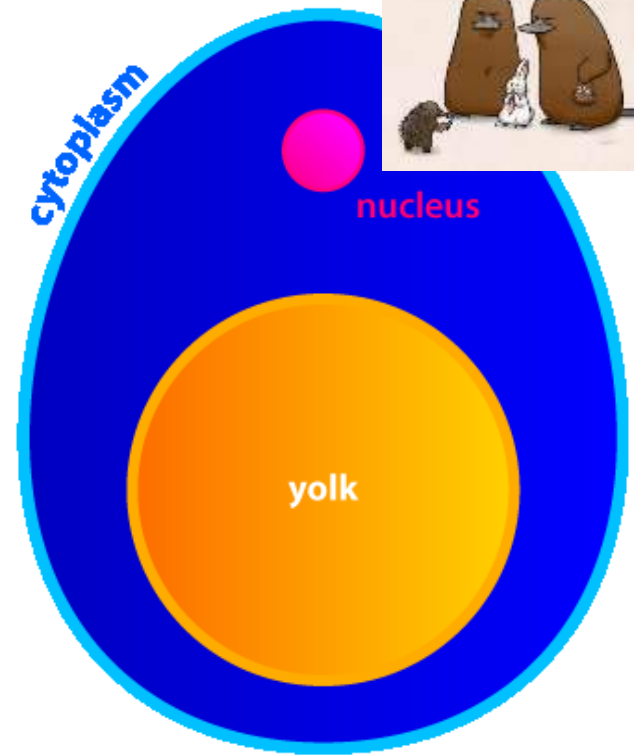


3. Macrolecithal (megalecithal) eggs

- These eggs contain enormous amount of yolk, found in **insects**, **chondrichthyes**, **reptiles**, **birds** and **monotremes**



monotremes

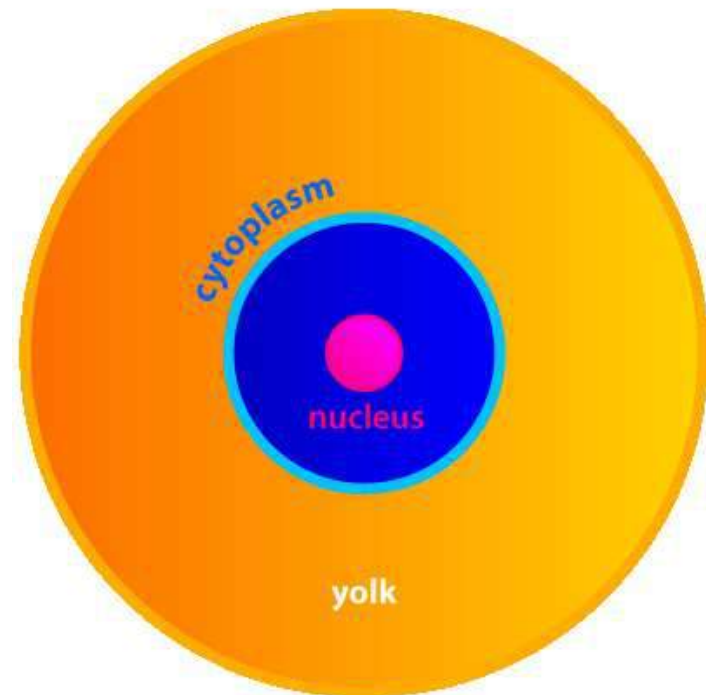


Telolecithal (Megalecithal)
Bird

based on the distribution of the yolk

1. Homolecithal or Isolecithal eggs

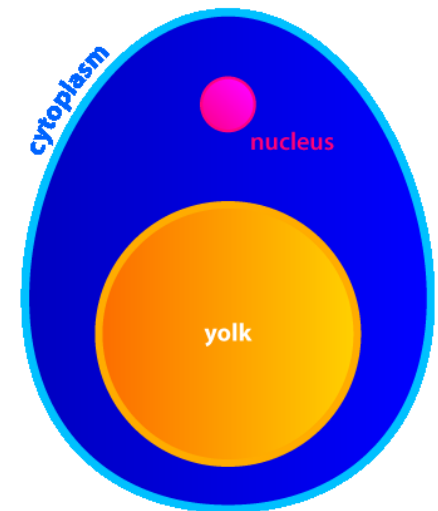
- In **microlecithal eggs**, the amount of yolk is little, therefore it is found almost scattered through all the cytoplasm of the egg.





2. Telolecithal eggs

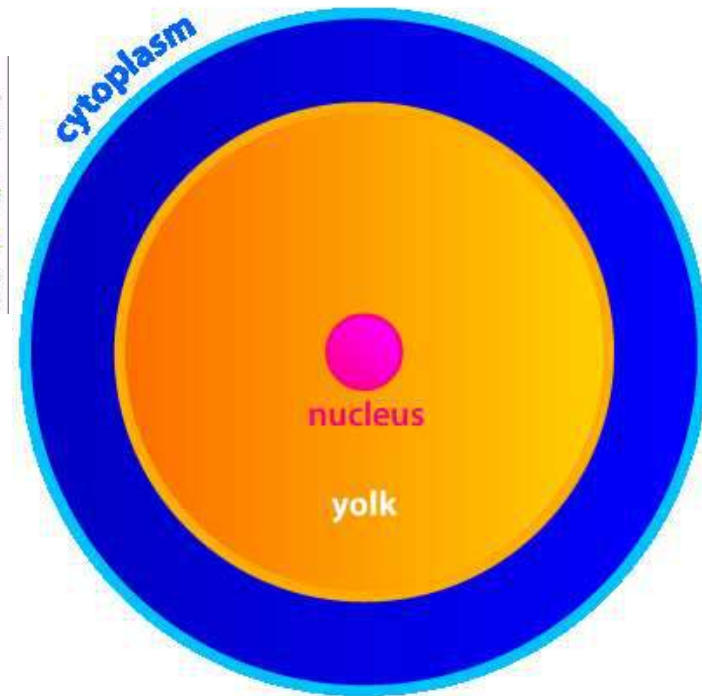
- This type of egg has a **polarized** distribution of yolk in the ooplasm due to the gravity of the yolk, it concentrated more in one side than in the other.
- The side that contain no or very small amounts of yolk is called the **animal pole**,
- The side where the yolk concentrated more called **vegetal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



Telolecithal (Megalecithal)
Bird

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.



Centrolecithal
Insect
studentreader.com

Spermatogenesis	Oogenesis
1. Occur in the testes	1. Occur in ovaries
2- The reserve food material depend on the sertoli cells	2-Yolk is the reserve food
3- The yield of the meiosis is four functional spermatozoan equal in size	3- The yield of the meiosis is four cells Not equal in size, one big active oocytes and three small inert polar bodies
4- After complete the meiosis the spermatozoon need to differentiation to be functional	4-After complete the meiosis the oocytes ready to start development without differentiation
5- The meiosis 1 begin after reach the puberty	5- The meiosis 1 begin during the embryological development.
6-The meiosis continue to the last stages during puberty	6-The meiosis stop in the prophase I, and resume after puberty
7-The spermatogenesis continue until death	7-Oogenesis stop after many years
8-The meiosis II complete inside the testes after puberty	8-The meiosis II begin at puberty reach the metaphase II and stop again, resume its action after fertilization.

THANK
YOU!





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Lec. Dr. Ruwaidah F. Khaleel

Formation of egg membrane

- In most animals, except the **sponges** and **coelenterates**, oocyte maturation is not completed until additional structures, called **egg membranes**,
- Egg membranes are produced outside the plasma membranes of egg and vary in different animal groups and sometime reflect the adaptations by the animals.



Sponges

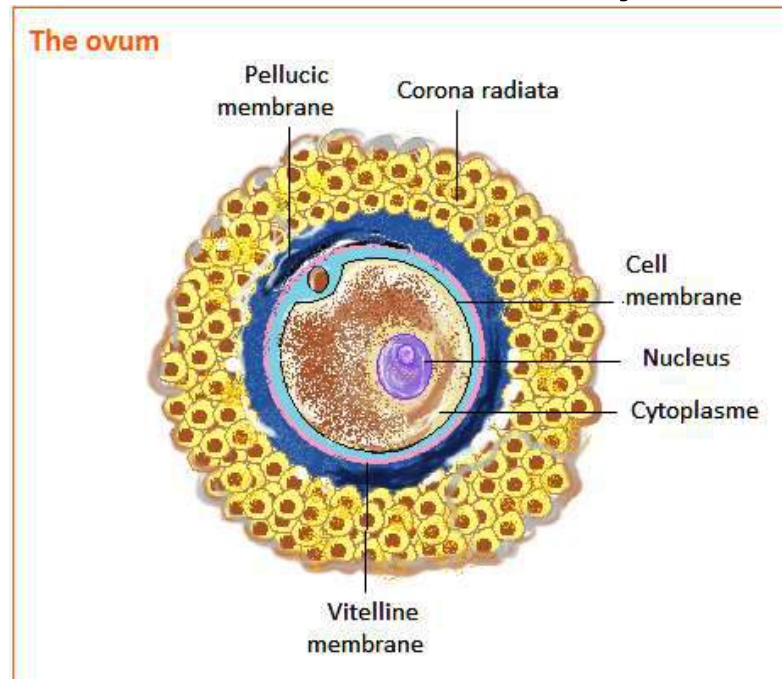


Coelenterates

There are several ways of classifying the egg membranes, but the simplest way is according to their origin as follow:-

1. Primary egg membranes

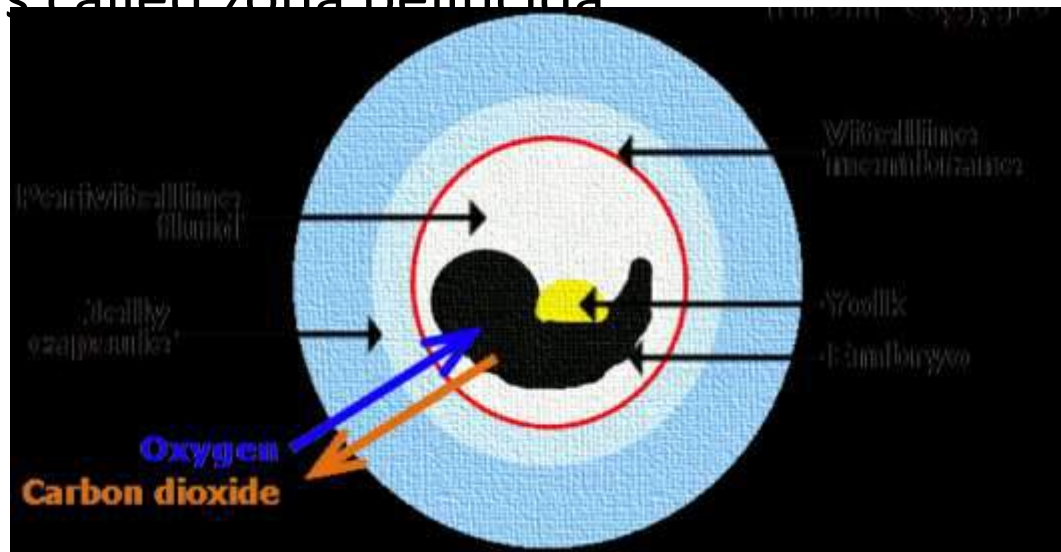
- These membrane are formed in the ovary between the egg plasma membrane and follicle cells they are formed either by **ovum of follicle cells,**



The type of egg membranes includes:-

a- Vitelline membrane

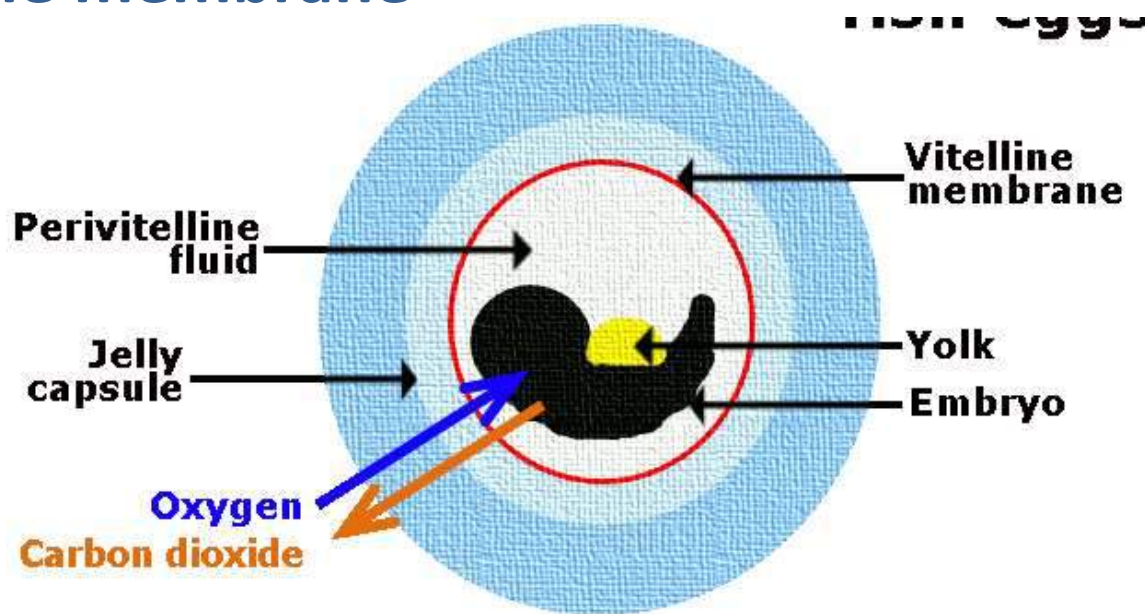
- In fact it is not a membrane, but a non-cellular transparent layer of mucoprotein out of egg give the physical support and elasticity.
- The vitelline membrane is a structure directly adjacent to the outer surface of the plasma membrane of an ovum
- Vitelline membrane has different names for example, in amphibian and birds is contact to the ooplasm until the fertilization then will separate therefore it's called the **fertilized membrane**, in fish called chorion, and in the reptiles and mammals called zona pellucida



1) Primary egg membranes

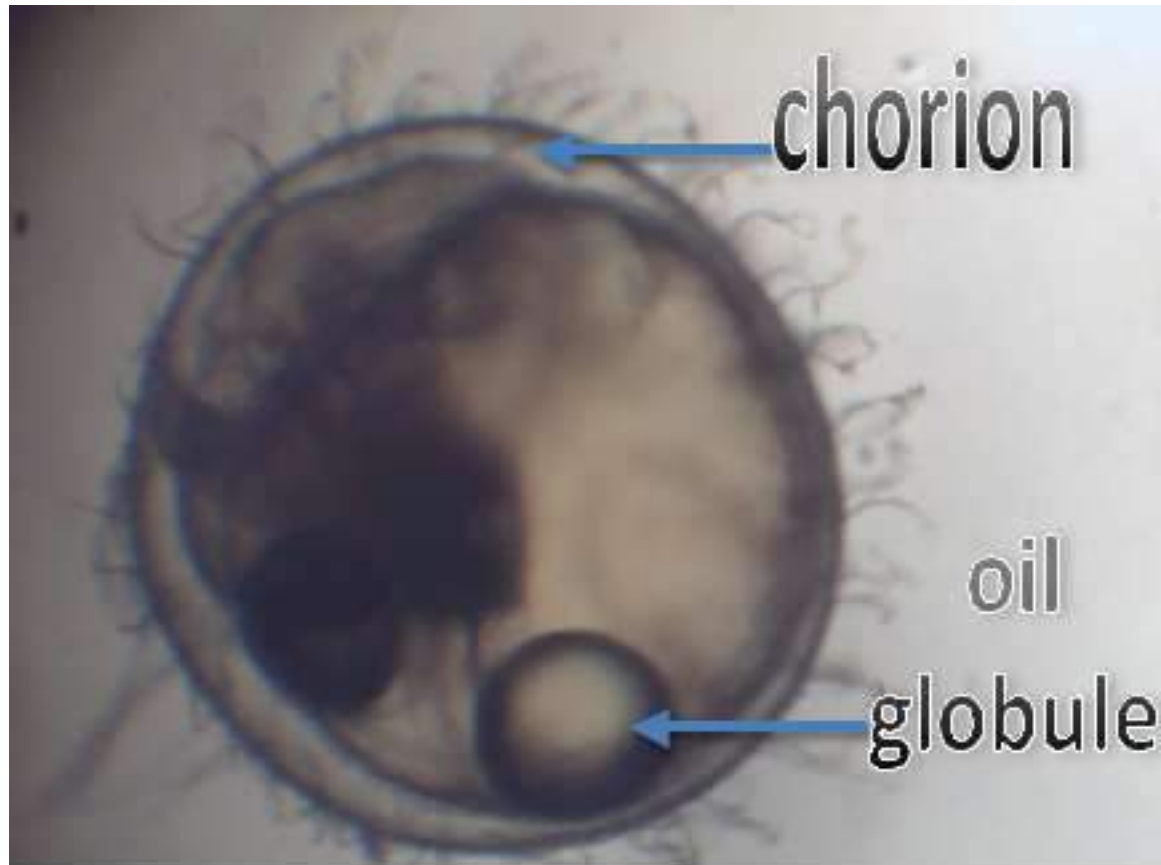
these membrane are formed in the ovary

a) Vitelline membrane

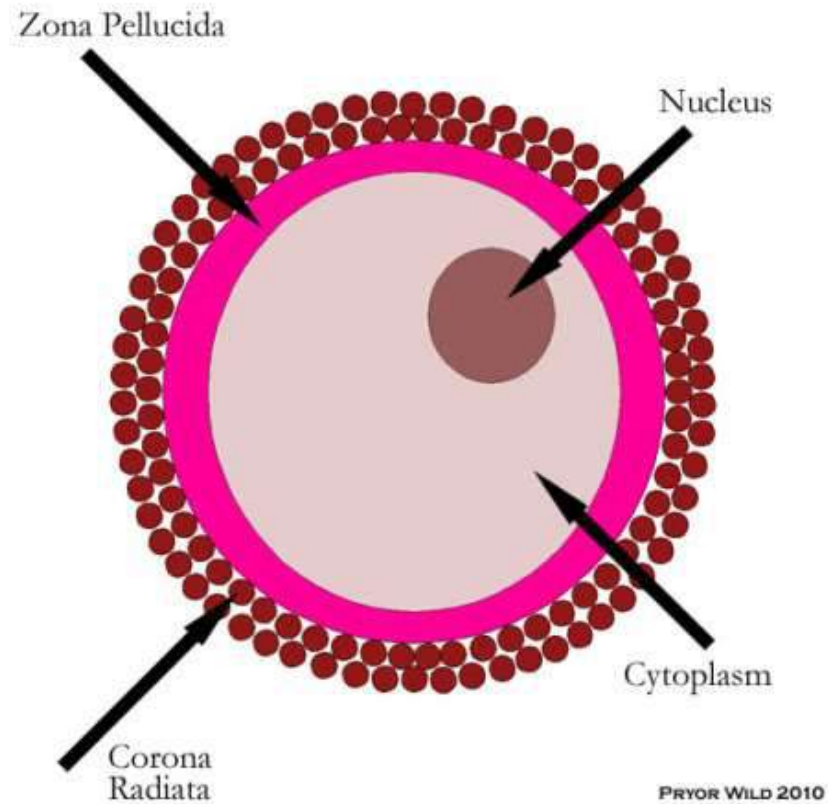


Amphibian and bird >>> contact to ooplasm until the fertilization then will separate there for is called the **fertilized membrane**

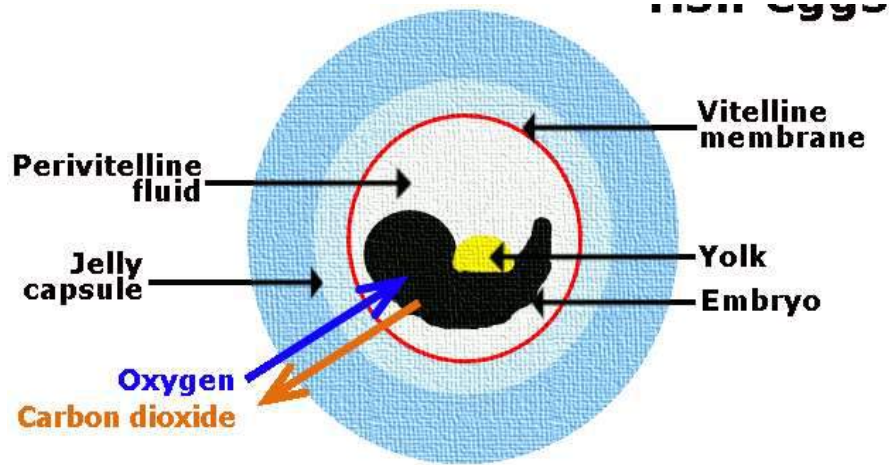
Fish >>> chorion



Reptile and mammals >>> zona pellucida



b) Jelly envelope



In echinoderms and many egg of marine invertebrates, the primary egg envelopes is much thicker structure like **jelly coat**



2) Secondary egg membrane

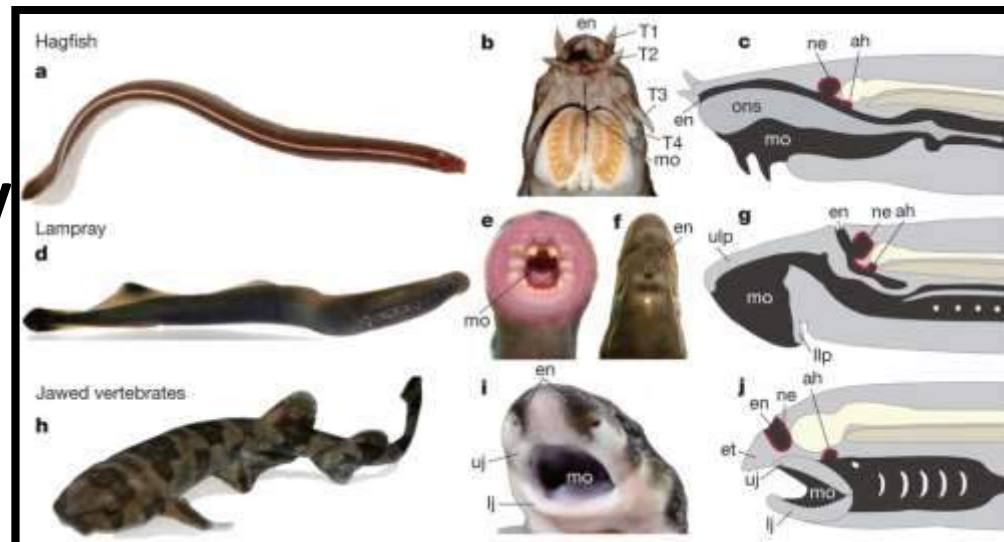
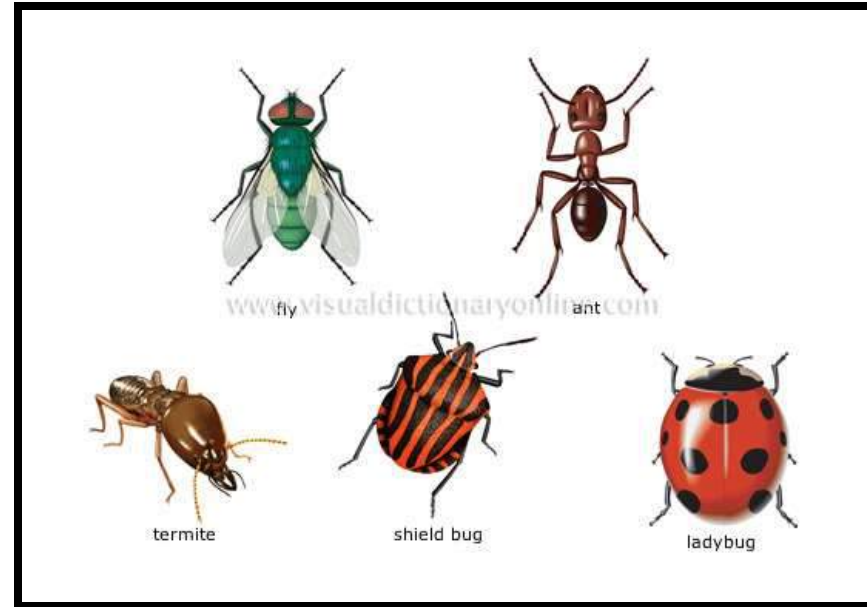
Secreted outside the primary egg membrane by follicle cells.

It occurs in the form of **chitinous shell** around egg in **insects and cyclostomes**

and called chorion

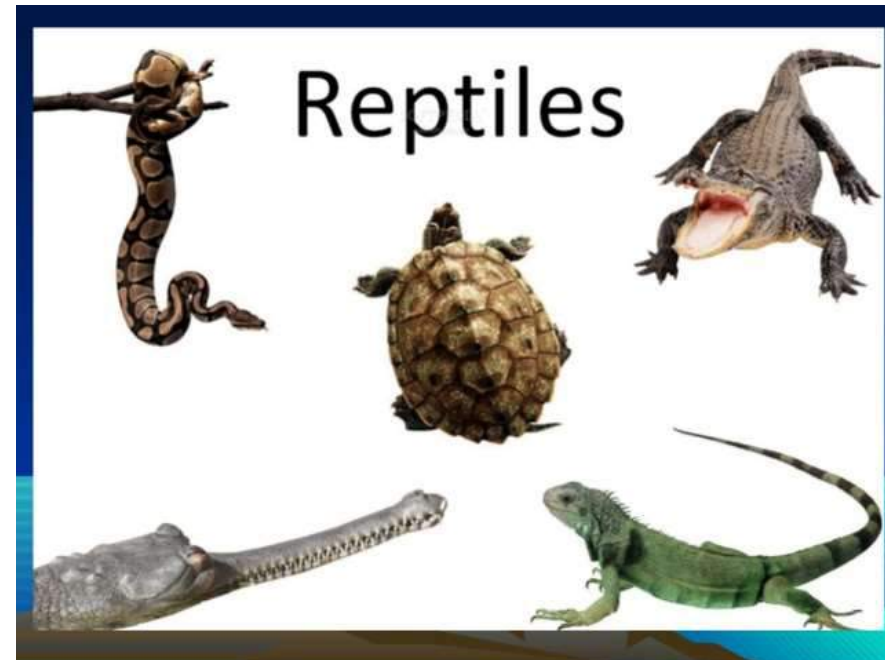
This chorion **different** from chorion fish that formed by oocyte and contains

proteins and polysaccharides



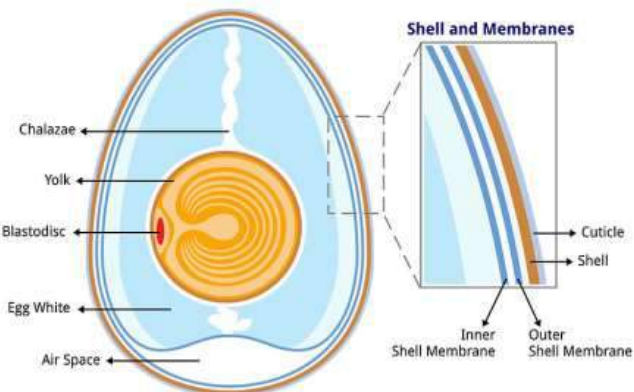


No secondary membranes are found in =
amphibians, **reptiles**,
birds and **even**
mammals eggs



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 egg from infection and predators**
- In **reptiles, bird's** five tertiary membranes make up the envelopes of the egg out of the vitelline membrane.



Reptiles and birds

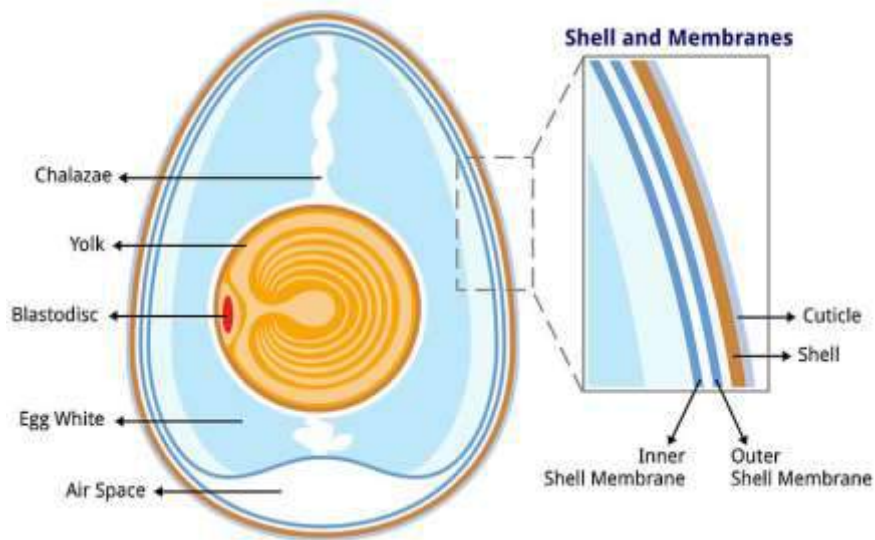


Oviparous sharks



Amphibians

3) Tertiary egg membrane



Reptiles and birds



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Oviparous sharks



Amphibians

Ovulation and transportation of ova

- The ovulation and transportation of the ova are done by ovaries and accessory reproductive organs of the female.
- The female accessory reproductive organs include organs which assist in the transportation of mature eggs from the place of origin to the exterior in the oviparous animals' like **fish, amphibians**, or to female reproductive organ such in uterus as in the **viviparous animals**



Female reproductive organ
viviparus



Oviparus

Time and regulation of ovulation

Environmental control (1)

The time of ovulation is directly related to the breeding cycle of animal, three methods that control the ovulation in the animals

Many factors that effect on the ovulation in animals like

- ❖ Light
- ❖ Temperature
- ❖ Rain fall



most animal time their breeding and ovulation with the good seasons, for example, when rats and mice were kept *in* dark all day they changed the time of ovulation from the midnight to near noon and continuous exposure to light Resulted in inhibition of ovulation,

Sexual photoperiodicity

Is phenomenon in which the light controls the ovulatory or sexual cycle of female

2) Hormonal control

The function of the ovary and ovulation in vertebrates are regulated by, hormones of pituitary gland. In mammals the function of the ovary are under three gonadotropic hormones of pituitary

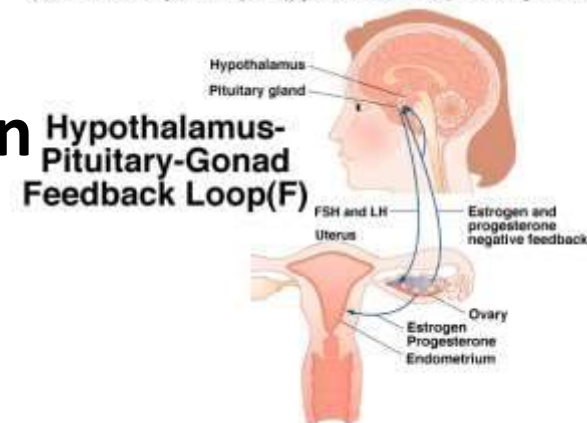
Gonadotropic hormones of pituitary

FSH (Follicle Stimulating Hormone)>> induce growth of the follicles

LH (Luteinizing hormones)>> act with FSH on maturation of the follicles and ovulation and formation of corpus luteum

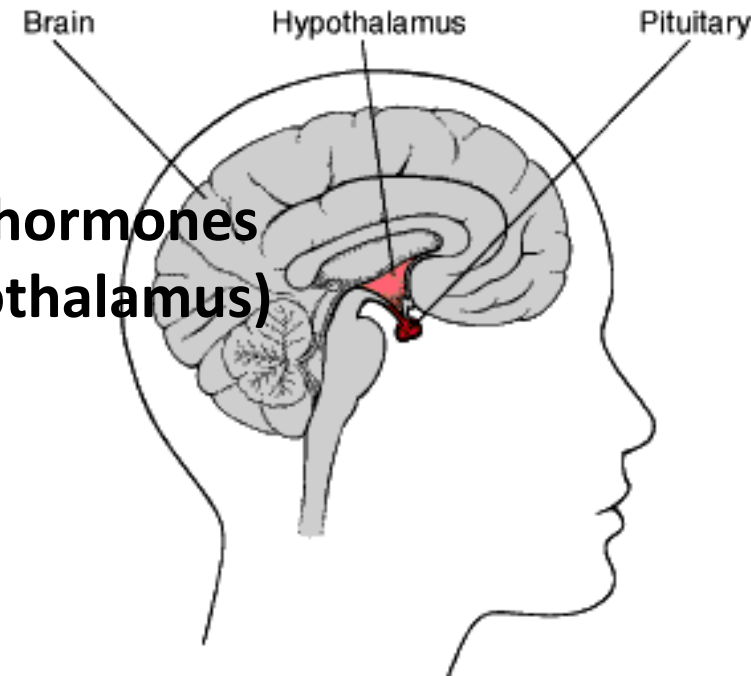
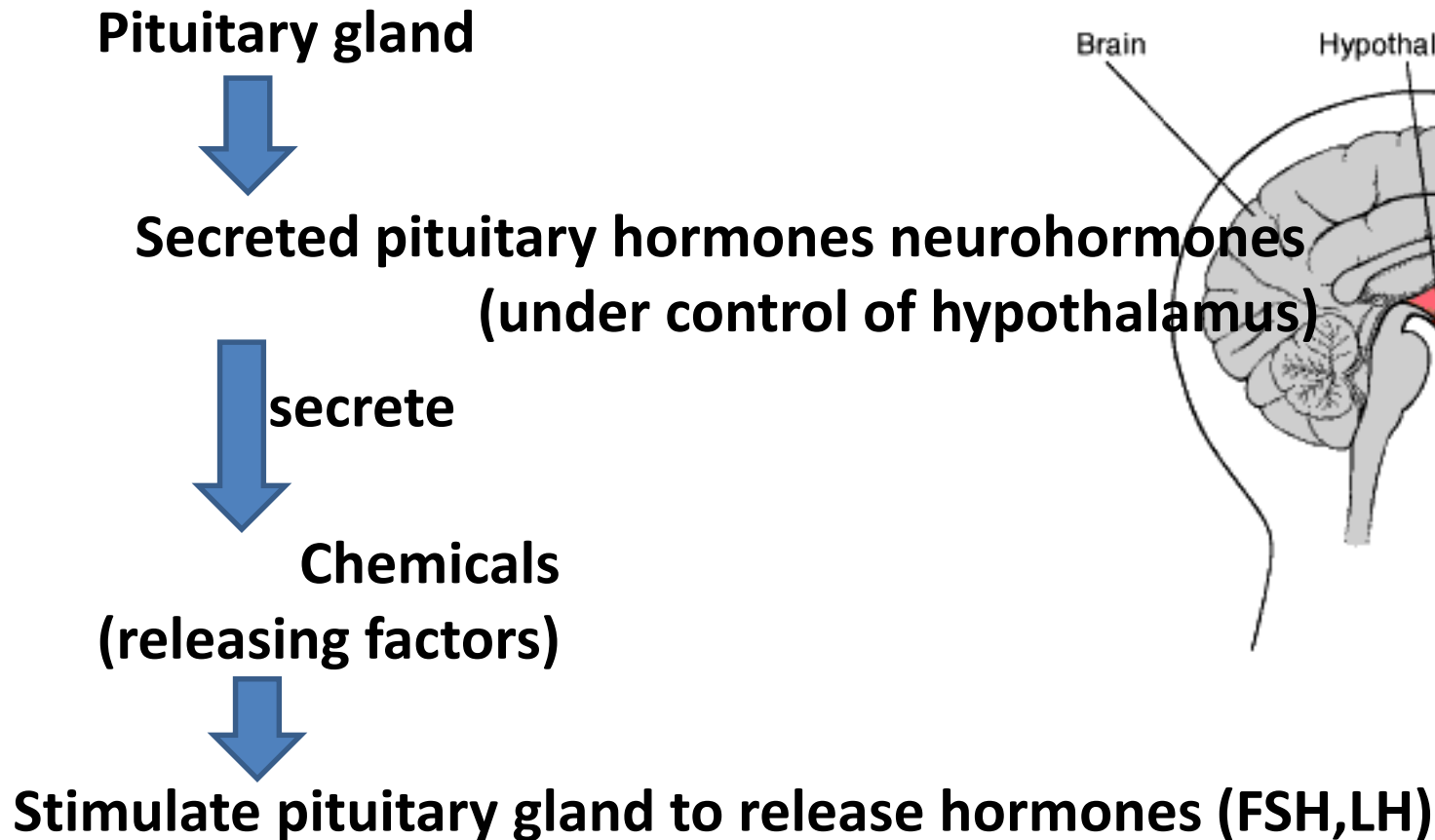
Prolactin>> responsible for milk secretion

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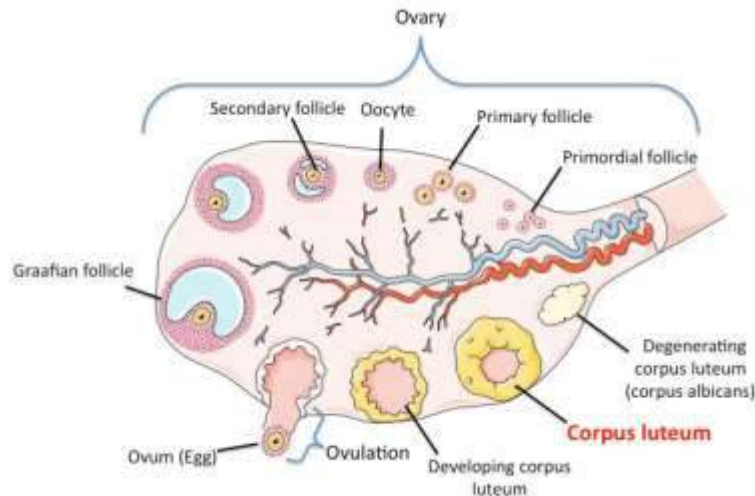
3) Neural control

The nervous system of vertebrates has indirect effect on the ovulation through the pituitary gland



Ovulation

- **Is the process of releasing the ova from the ovaries**
- **The ovulation occurs by different method in different vertebrates.**
- ❖ The female reproductive or breeding activities of almost all animals are cyclic
- ❖ the reproductive cycles are seasonal, in most vertebrates, the reproductive cycles is yearly, like sheep,
- ❖ while in higher primates including the human, which can breed at any time.
- The female mammal that follows an annual reproductive season, passes through several shorter sexual cycles during her breeding season, when, they to more_receptive of the males and when ovulation occur spontaneously these seasonal reproductive cycles called **estrous cycles**



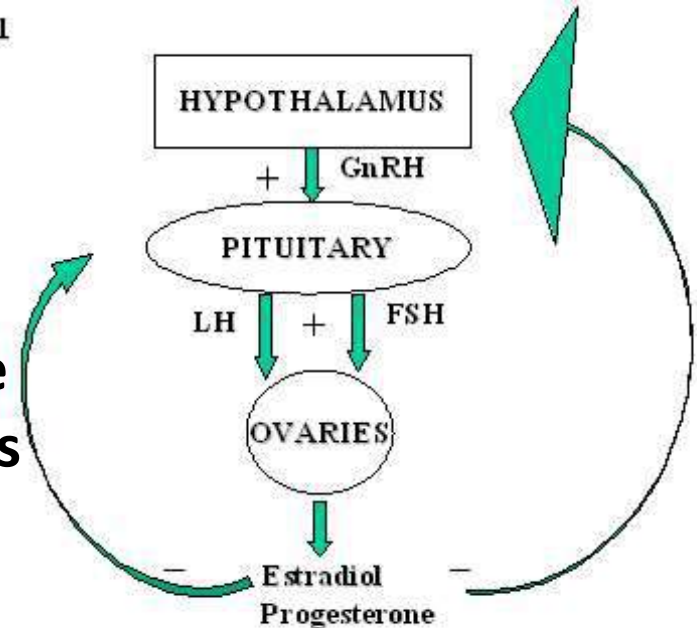
Ovulation

Estrous cycles

Seasonal ovulation changes in females because the physiological and histological events in the female reproductive system in some animals makes the females are more receptive of the males

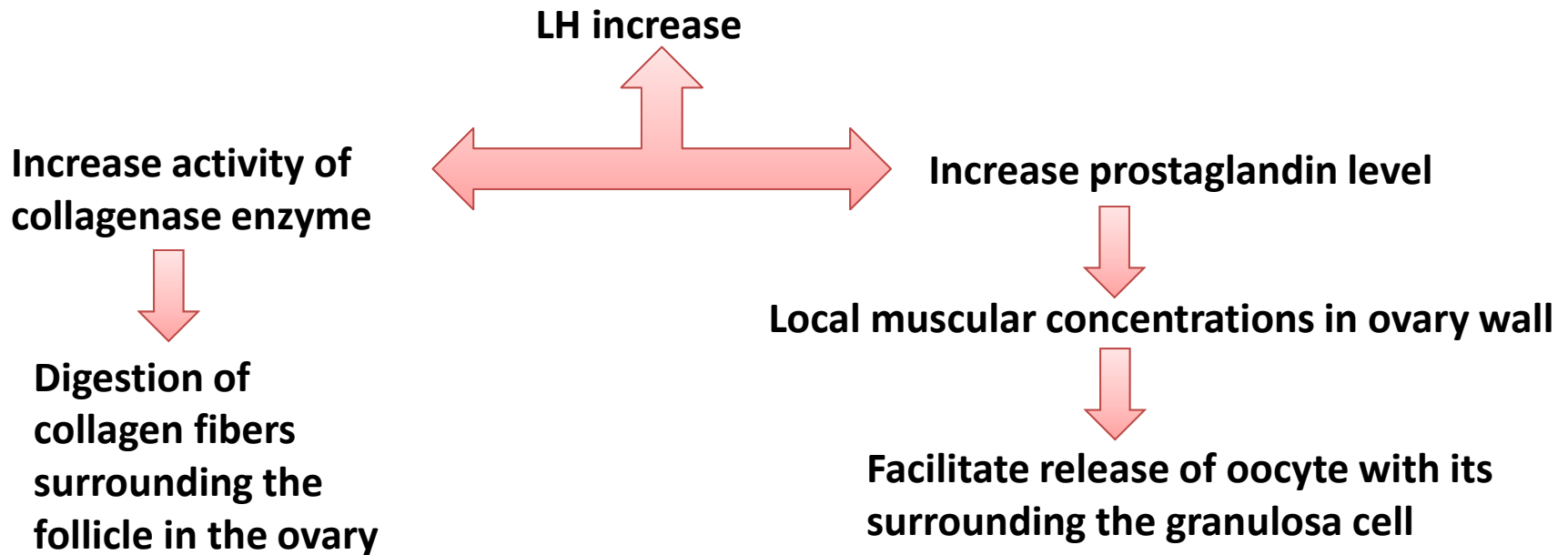
while in the primates including human females the sexual cycle and changes in the endometrium of the uterus, all are hormonally control occur monthly

Figure 1



Mechanism of ovulation

In the days immediately Before ovulation secondary follicle grows Under (FSH,LH)



After ovulation, some of the granulosa cells remain in the ovary with the effect of the LH hormone both the granulosa cells and the theca interna of the ovary develop yellowish pigment mass of cells called corpus luteum, this mass begins secrete the prostaglandin hormone

The oocyte transport out the ovary

- The oocyte with the granulosa cells surround it are carried from the ovary by the movement of the cilia of the-ovarian

tube,



- The oocyte enter the ovarian tube



- The junction between oocyte and the granulosa cells are lost,



- The oocyte move toward the uterus.

(In the human oocyte need 3-4 days to reach the uterus after ovulation)

If fertilization not occurs

- ❖ the corpus luteum reaches its maximum development



- ❖ then shrinks and degenerates after 14 days



- ❖ transform to corpus albicans



- ❖ the oocyte will rupture and degenerate

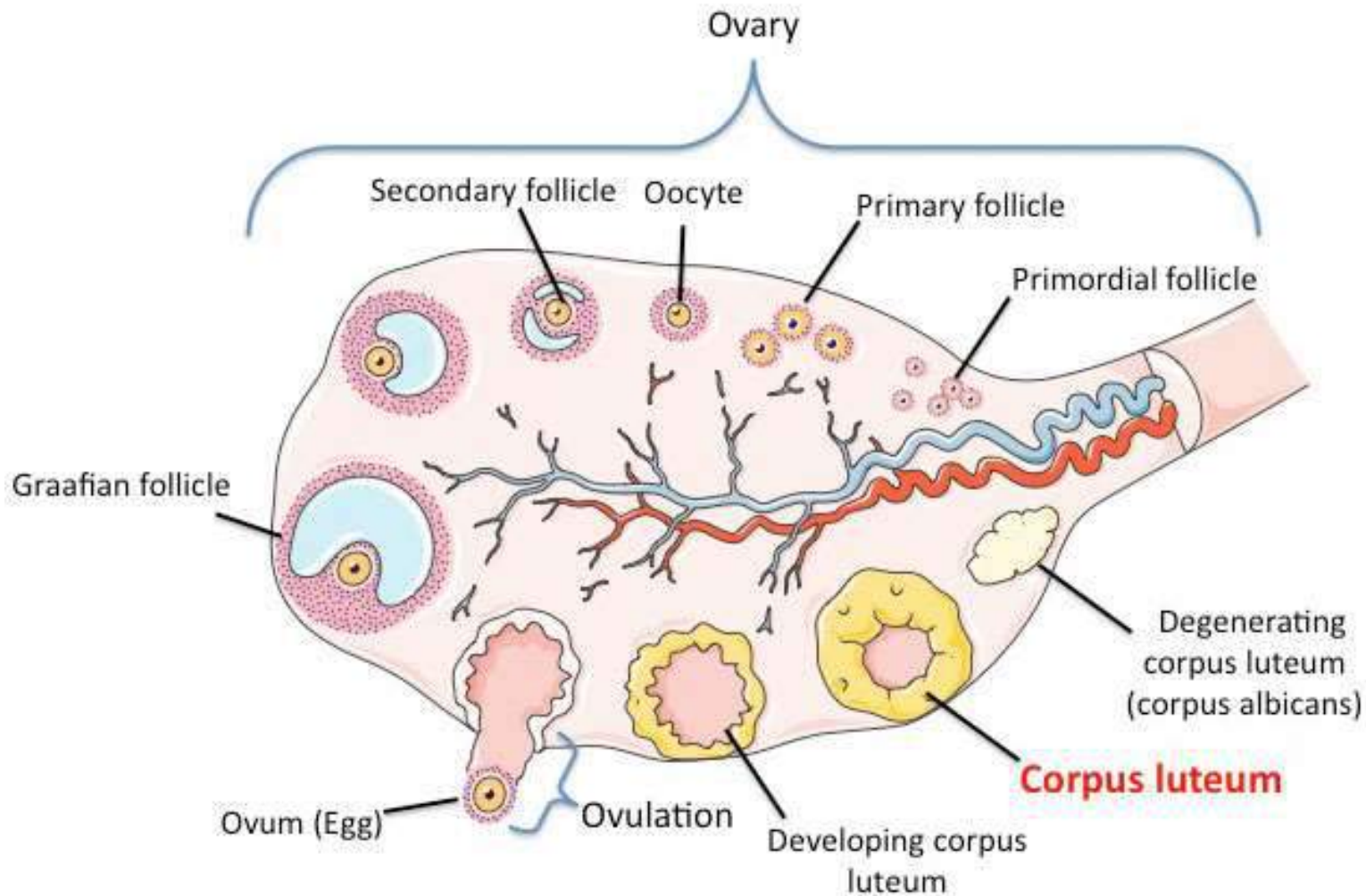
If fertilization is occur

- The corpus-luteum remain active and produces and secrets the prostaglandin for 4 months

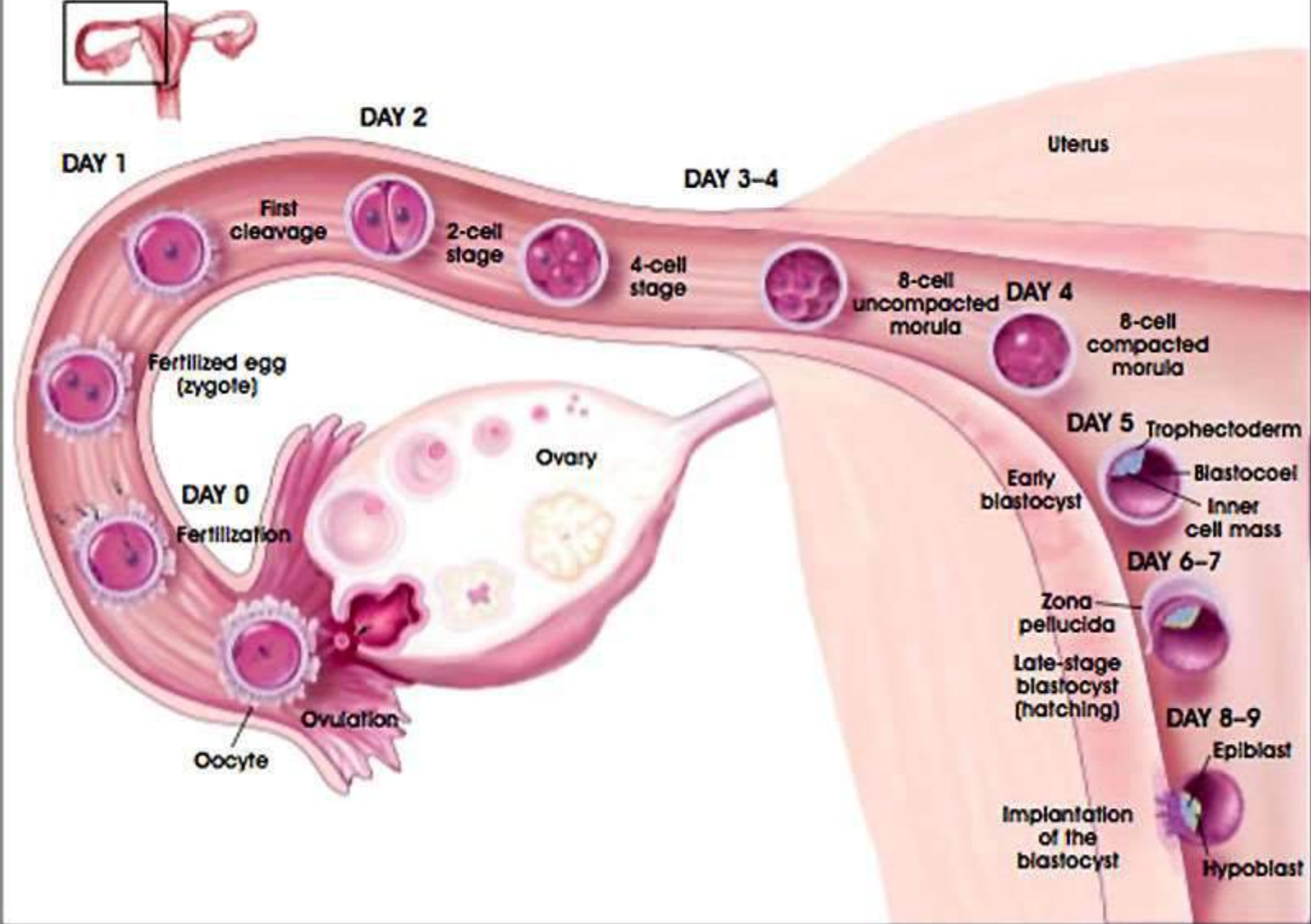


- This due to the human chorionic gonadotropin (hCG) that produced by the embryo cells, this hormone called also the pregnant hormone, keep the corpus leuteum active during this period

The oocyte transport out the ovary



Figures were produced using Servier Medical Art: www.servier.com



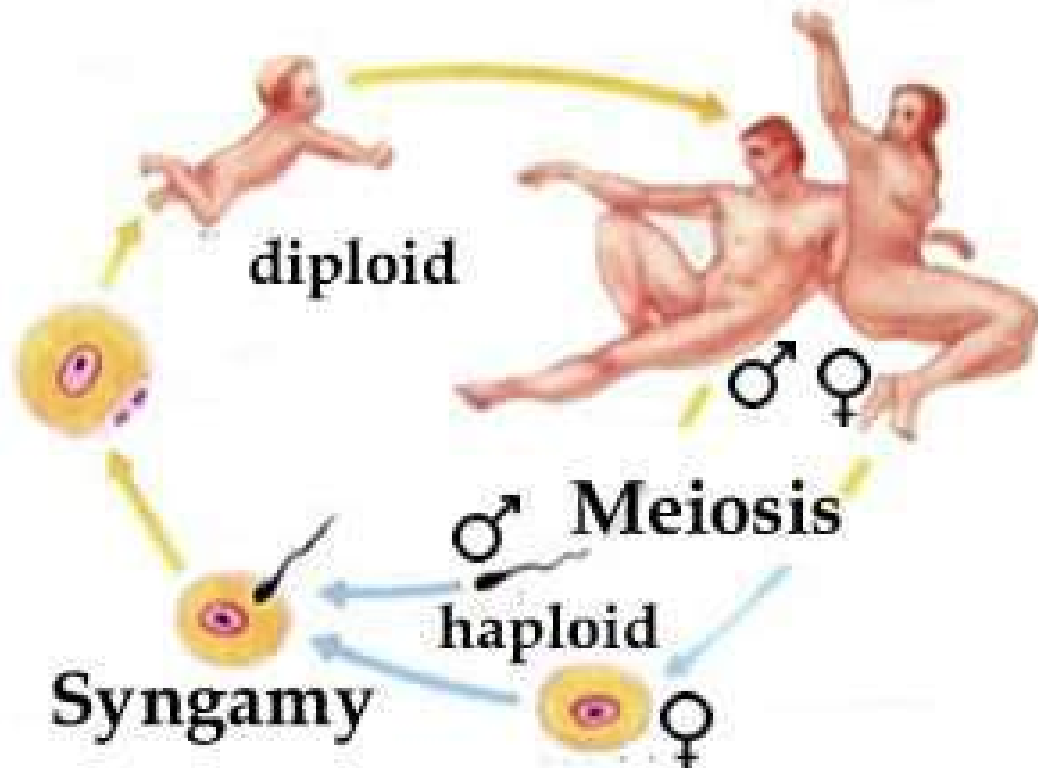
Fertilization

Is process by which male and female gametes is fuse together, to produce the zygote and considered the first step in the embryogenesis

Syngamy

Is process that two haploid nuclei of the male and female gametes are fuse and a diploid nucleus of the zygote which soon starts the first division.

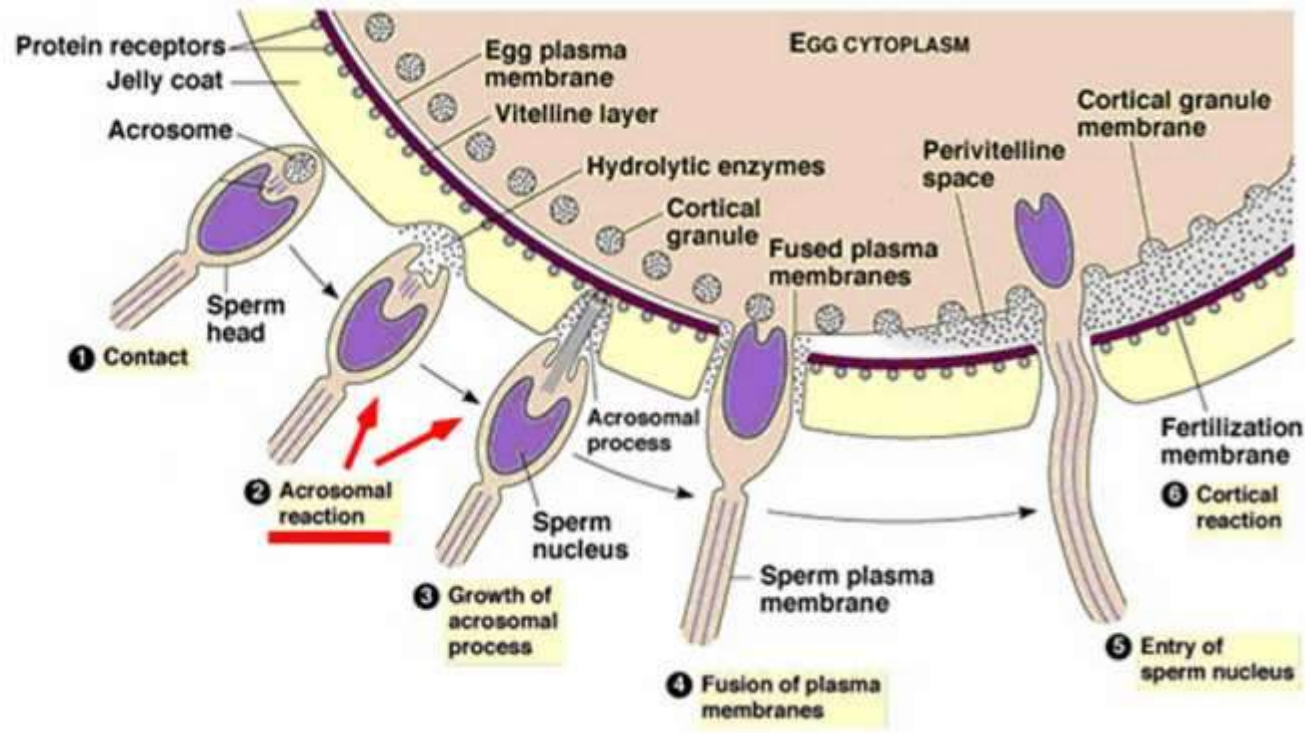
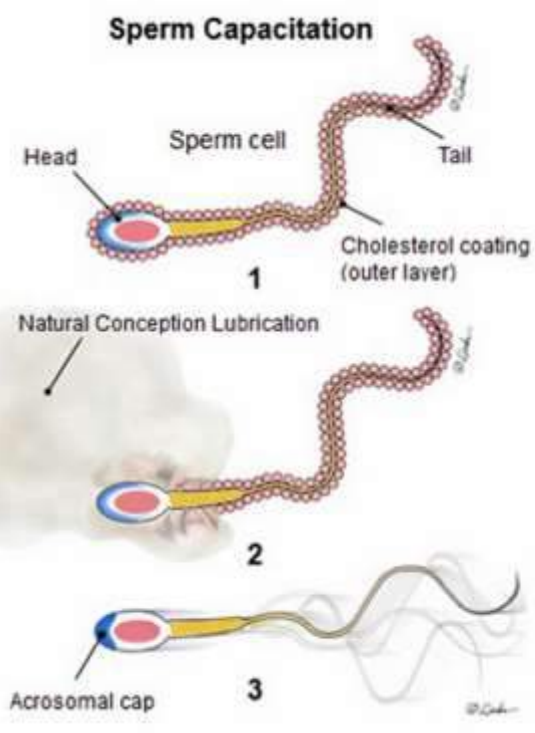
- The important point that noticed in the fertilizations is that the fertilization is **species-specific** that mean the sperm from one species cannot fertilize the egg of another species.
- This is the main reason for the stability of species



Generally in most animals the process of fertilization requires the following factors to occur successfully

1. In most animals the fertilization must occur in a fluid medium. example Sea water in **oviparous animals**, or body-fluid in **viviparous animals**.
2. The life-span of gametes is short, therefore **in the most water invertebrates, fish, and amphibian**, must be fertilized not more few minutes, while eggs within, the body of the female have a life-span longer example. **Human eggs can be fertilized for at least 24h. after ovulation**
- ❖ Also the sperms have the same aspect, for example: **the human sperms can be viable in the female genital tract about 24h**
3. In the normal fertilization, the number of the sperms must be more than the eggs number

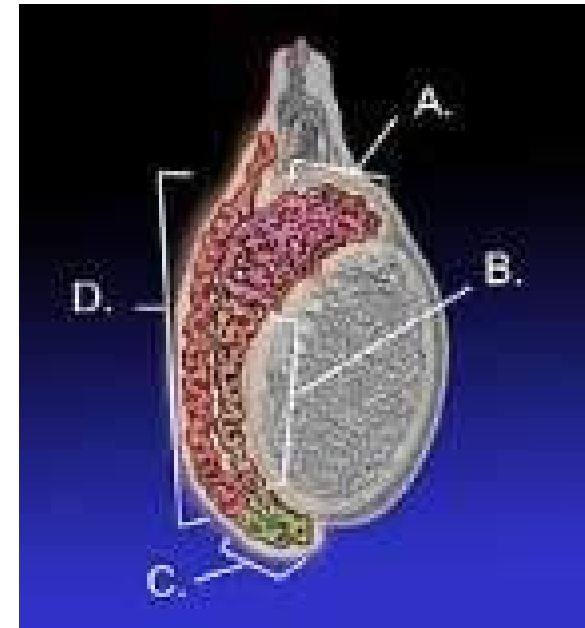
- Before fertilization the spermatozoa are not able to fertilize the oocyte immediately after inter the female genital tract, because, the spermatozoa must undergo physiological and molecular of maturation processes called **the capacitation or acrosomal reaction**.



Capacitation

The final step of sperm maturation includes physiological changes spermatozoa to be capable of fertilizing the ovum

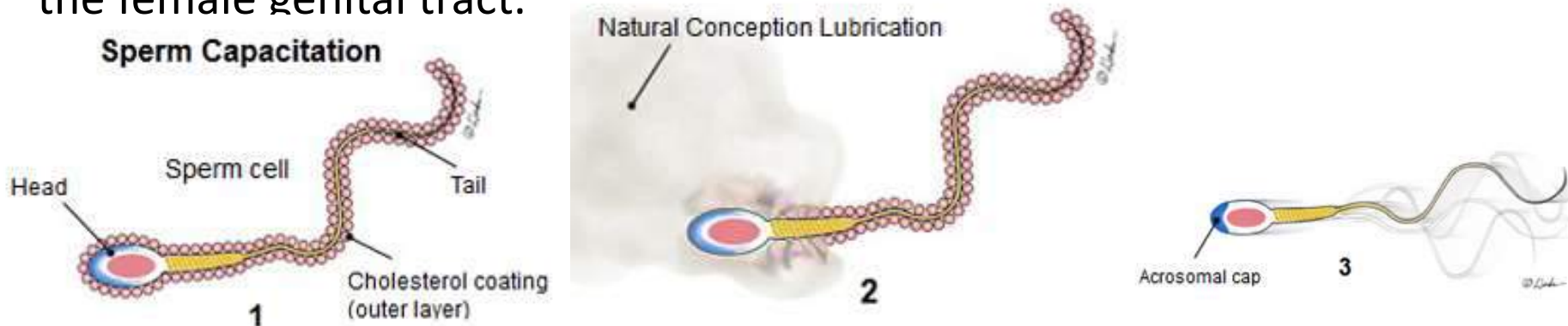
- In most animals spermatozoa produced in the **seminiferous tubules** in non- motile form
- then stored in the lower part of the epididymis to become motile, but are not able of fertilize the ovum directly unless inter the female reproductive tract,
- during the journey of the sperms in the female tract, the sperm interacts with the epithelium of the mucosal surface of the uterine tube and undergo several physiological changes there.



Adult human testicle with epididymis: **A.** Head of epididymis, **B.** Body of epididymis, **C.** Tail of epididymis, and **D.** Vas deferens

Mechanisms of the capacitation

- The acrosome plays an essential role in capacitation,
- The acrosome contain **hydrolytic** and **Proteolytic enzymes** can destroy the male genital tract if all the sperms release these enzymes
- Therefore there are the fluids in the seminiferous tubules and all the male genital tract all contain floating vesicle filled with cholesterol cover the cell membrane of the sperm and prevent the releasing of the **acrosome enzymes** but after the sperm are release from the tract,
- The sperms swim away from the vesicles and lost the cholesterol after few hours and become capacitated and the sperm can penetrate the ovum.
- In the mammals the capacitation doesn't occur unless the sperms inter the female genital tract.



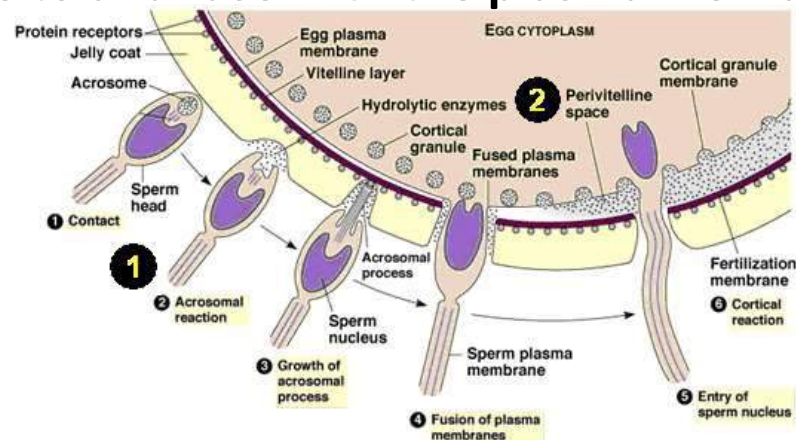
Acrosome reaction and contact of sperm and ovum

Acrosome reaction :The first reaction of the sperm when it comes in contact with the egg surface by the action of the acrosome

- In human females and other mammals, the fertilization occur soon, after the ovum enters the fallopian tube

Before sperm can enter the ovum must

1. Penetrate the multiple layers of granulosa cells out of the ovum
2. The follicular cells bind together by a substance called **hyaluronic acid** so, the acrosome will release **hyaluronidase enzymes** to dissolve the attachment between the granulosa cells over the ovum
3. After attachment occurs between the sperm and zona pellucida the hydrolytic enzymes are released from the acrosome. This primates the spermatozoon to penetrate the zona pellucida matrix
4. This processes is stimulated by zone pellucida enzyme
5. The sperm adhere to and fuse with the plasma membrane of the oocyte

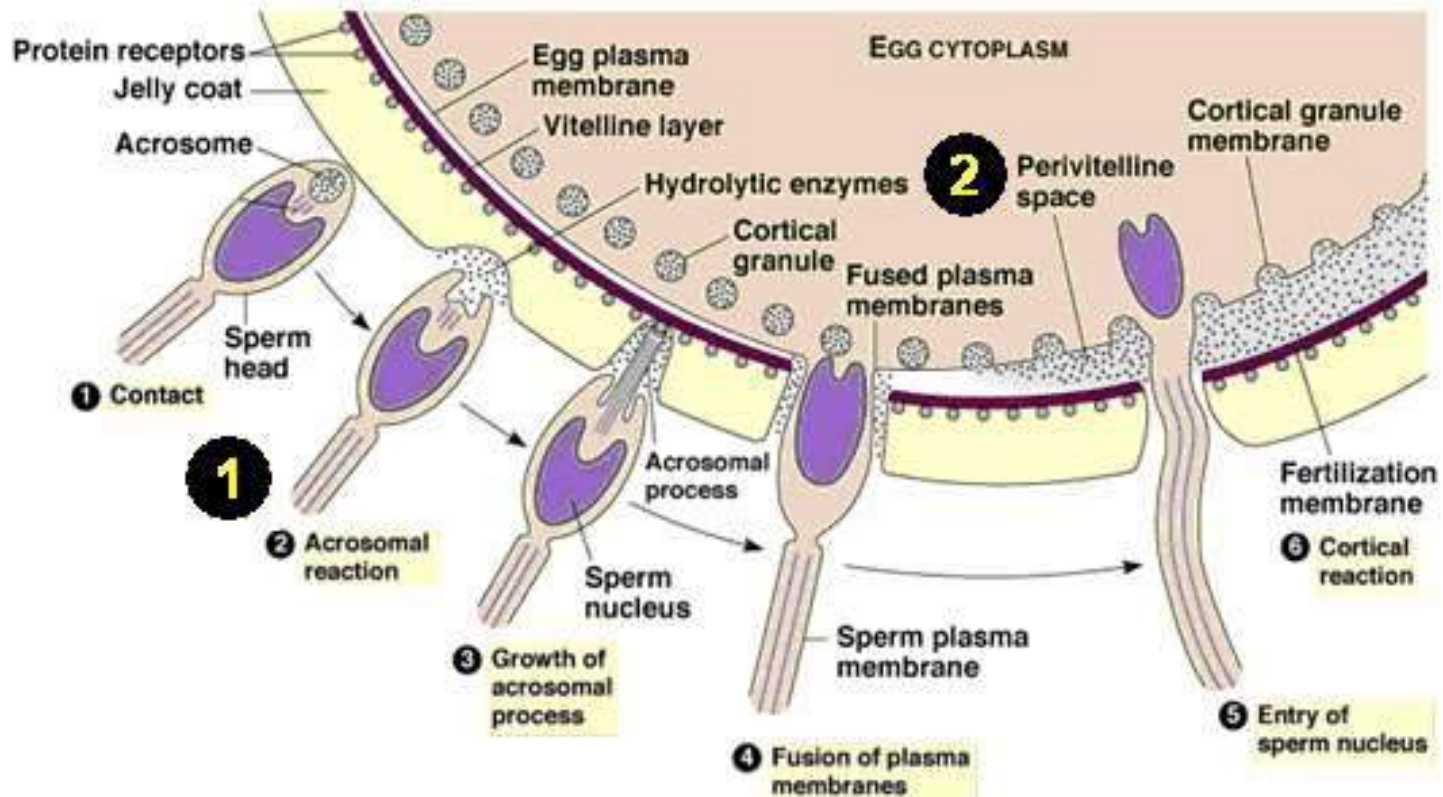


Oocyte activation

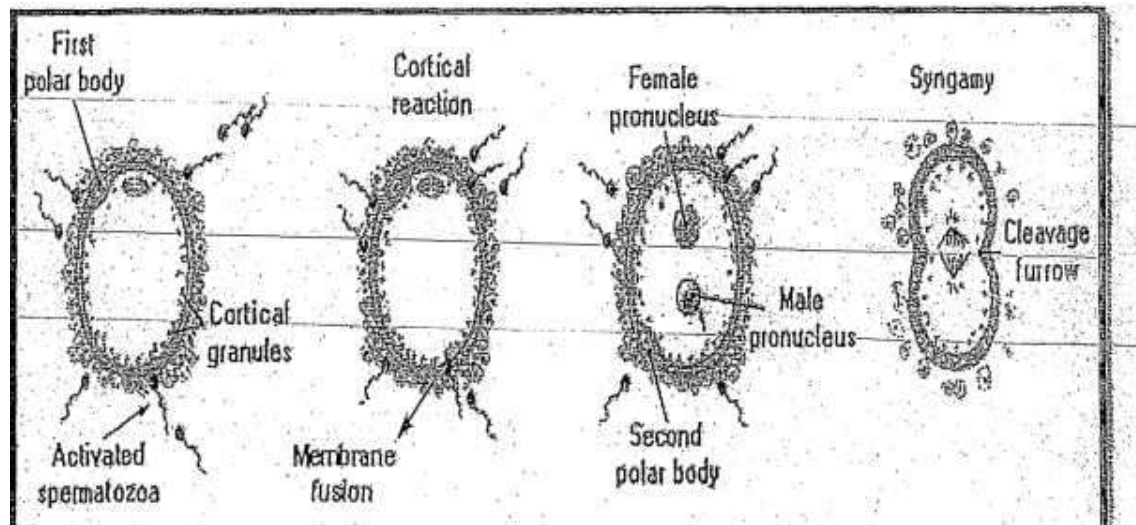
occur after sperm enter the cytoplasm of the oocyte

Changes in ionic permeability of egg plasma membrane after fertilized by a sperm. This activation includes

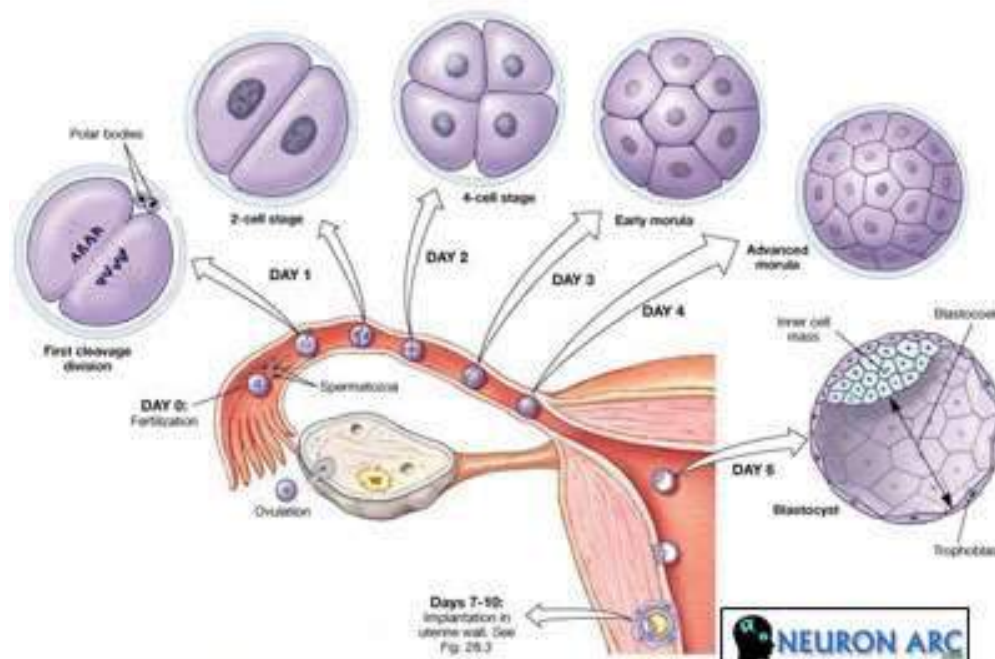
1. Prevent enter another sperm or called block to polyspermy
2. Resumption of meiosis
3. Initiation of embryonic development



- The oocyte after fertilized by a sperm, the plasma membrane is produced granules under the oocyte membrane, between the zona pellucida and the oocyte called **cortical granules**, therefore this process is called **cortical reaction**
- The cortical granules consist of many enzymes like **proteases**, **peroxidases**, in the presence of these granules, the zona pellucida and the oocyte plasma membrane change chemically and the zona pellucida becomes Impermeable by additional sperms.
- After infusion of the sperm membrane with the oocyte membrane the oocyte resume meiosis and complete the **meiosis II**, in this stage the oocyte called **definitive oocyte**
- The nuclear membrane of both sperm and oocyte quickly disappear and fuse their genome together and form the zygote (**46,2n**), by a process is called the **syngamy**.



Cleavage

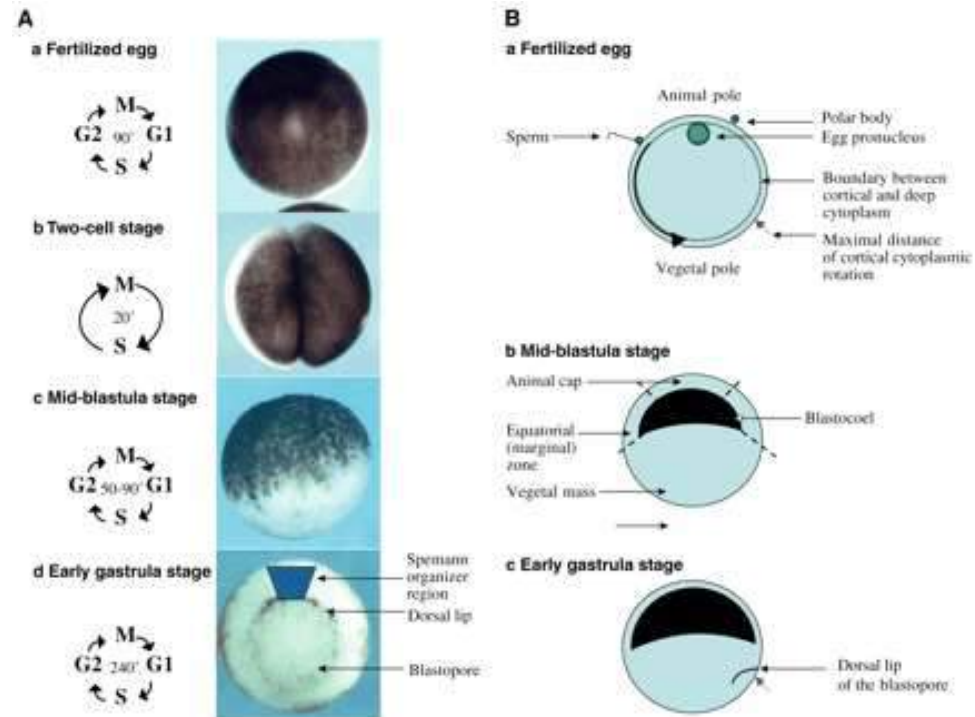


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Cleavage

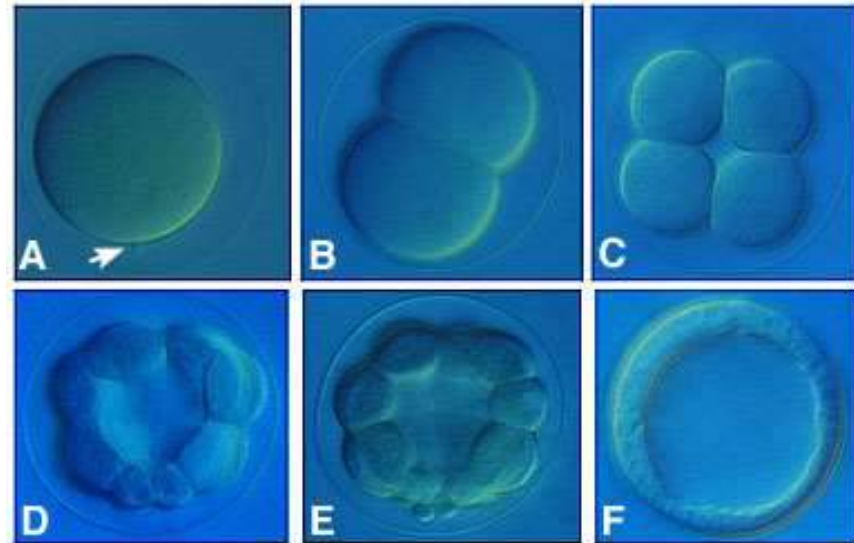
The activated egg is passed through a phase of repeated mitotic cell division to produce an increasing number of cells and build the body of the animal

Cleavage: the splitting or division of activated egg by a series of mitotic cell division into a number of cells which become the building units of future organism

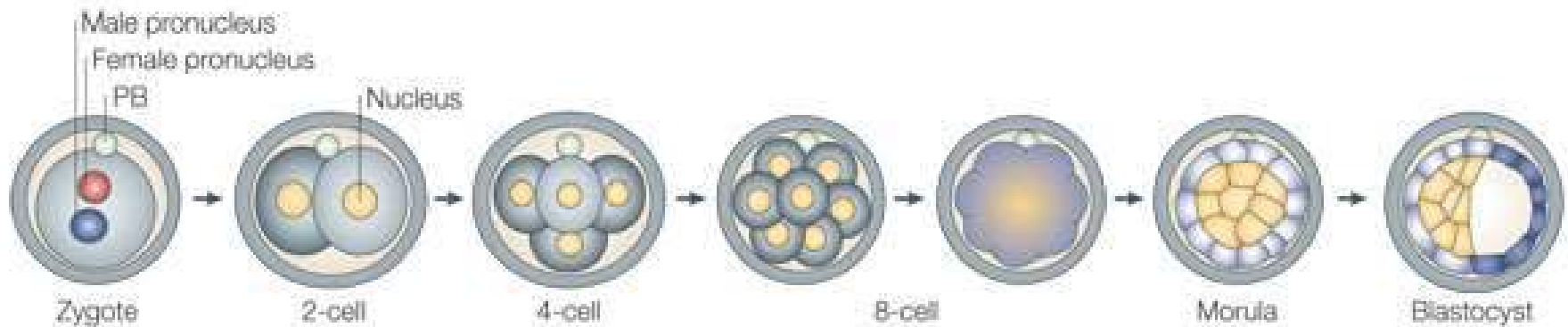


Cleavage is characterized by

1. All divisions of cleavage are mitotic
2. The cleavage occur with out a period of growth, and there is no increase in cell mass between each division, this unlike the cell divisions that take place during cell proliferation and growth of tissue.
3. The interphase remains very short in mitosis of cleavage
4. During cleavage, the blastomeres don't move so that the general shape of the embryo does not change **except** for the formation of cavity **called** the **blastocoel**.



5. The produced cells from the cleavage called the **blastomeres** (blastos>>germ, meros>>parts)
6. The cleavage converts the egg into a compact mass of blastomers called **morula** which transforms into **blastula**, having one-layered thick blastoderm around a central cavity, **blastocoel**
7. The beginning of gastrulation is regarded as the end of cleavage



The amount and distribution of yolk in the oocyte effect on the cleavage

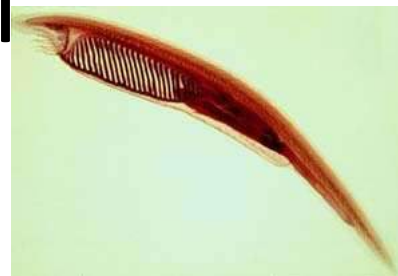
- Cleavage can be classified into the following types:

A. Holoblastic (complete) cleavage

The cleavage divides the egg completely, but two ways:

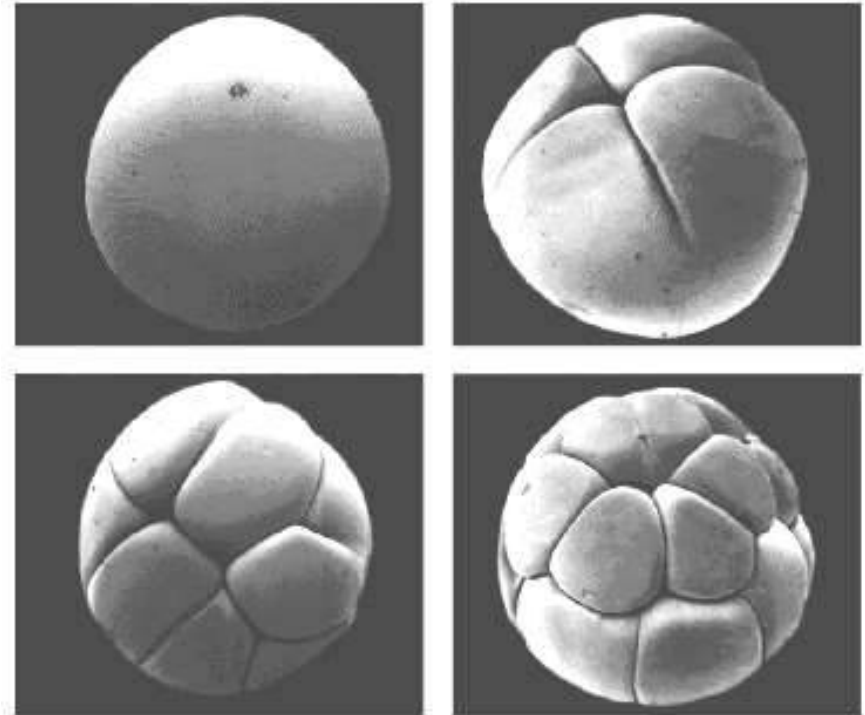
1. Equal holoblastic cleavage

When holoblastic cleavage occur in **microcithal eggs**, it produces blastomeres of equal size, this found in: **amphioxus, and mammal**



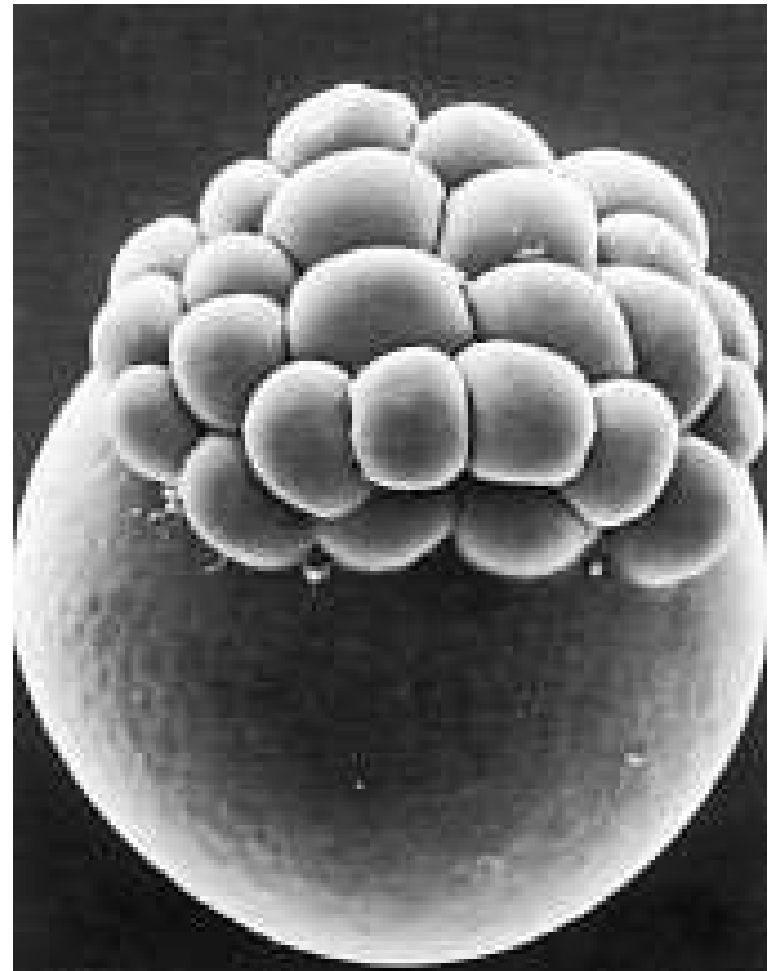
2. Unequal holoblastic cleavage

In **mesolecithal**, the holoblastic cleavage produces unequal size blastomers, which include many small-size blastomers called **micromers**, and few large-size blastomers called **macromers**, this type of holoblastic cleavage found in the **lower fish and amphibians**

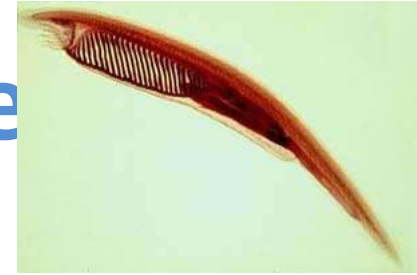


B. Meroblastic (partial-incomplete) cleavage

This cleavage found in the **macrolecithal eggs**, divide the zygote to incomplete cleavage. In such cleavage, the division results to small amount of the active cytoplasm of **animal pole** or periphery of egg and most of the yolk portion of the **vegetal pole** or the central area of the egg remains undivided **e.x chick eggs**



Planes of the cleavage

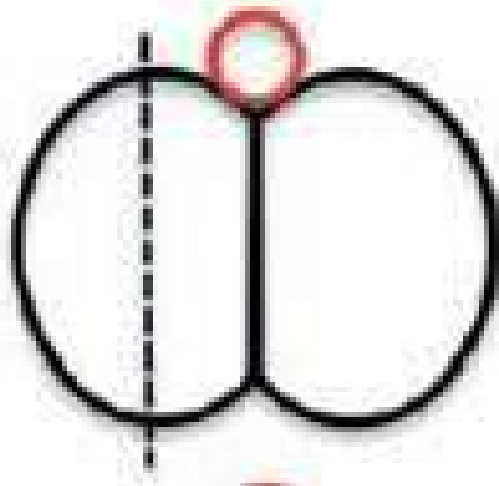


1. Meridional:

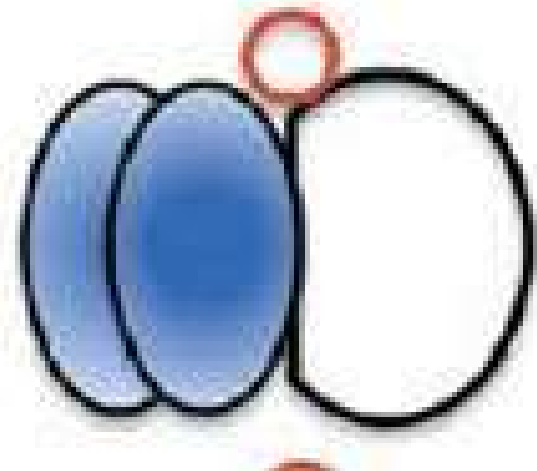
Cleavage furrow passes through the center of animal-vegetal axis bisecting the egg into **two equal parts**, eg. The cleavage in Amphioxus and frog and first cleavage in chick.



A

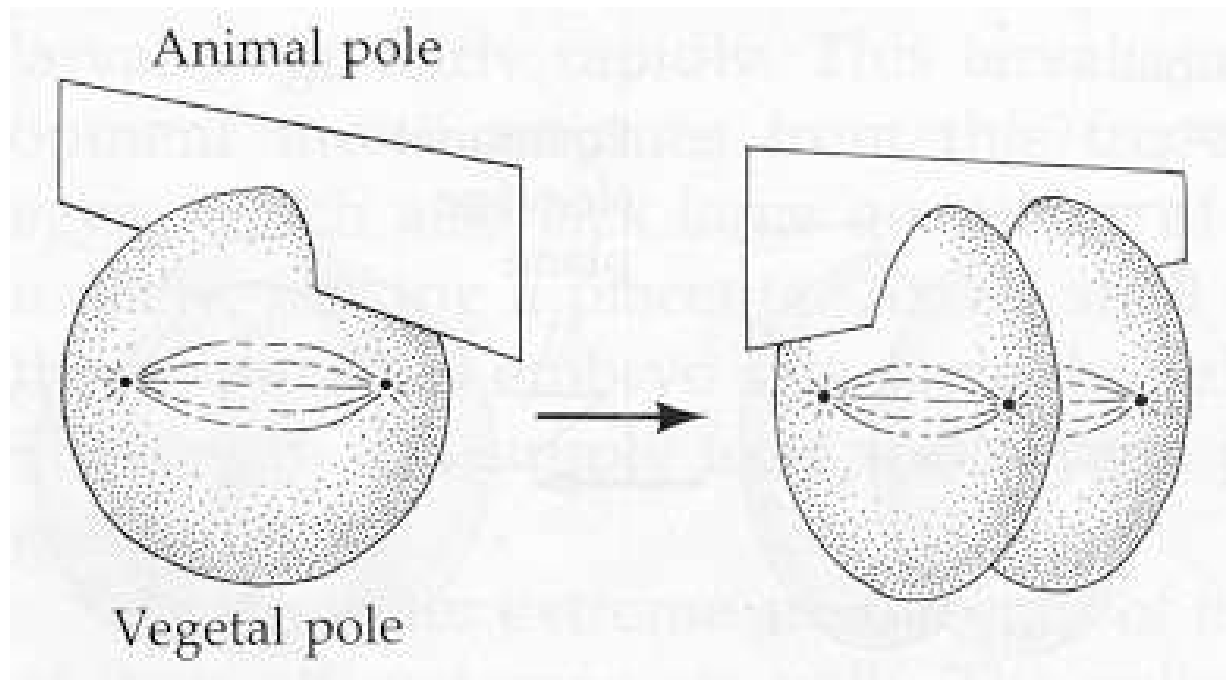


Meridional
Cleavage



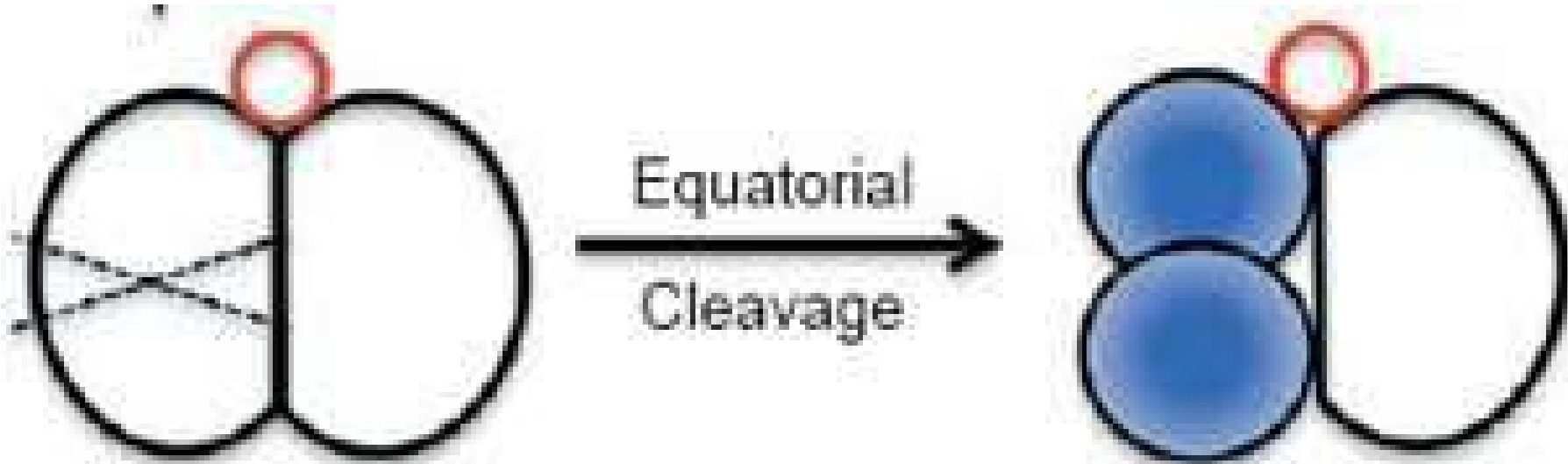
2.Vertical

The cleavage furrows may lie on either side of the meridional plane. The furrows pass from animal to vegetal pole. The cleaved cells may be **unequal in size**. eg, chick



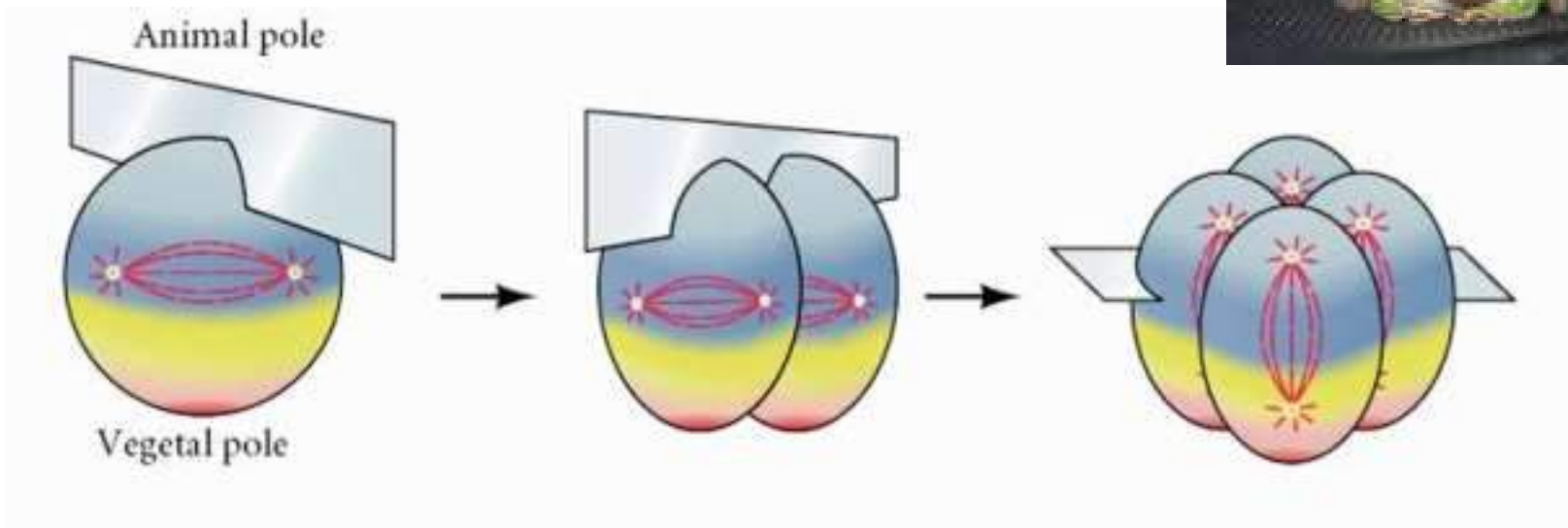
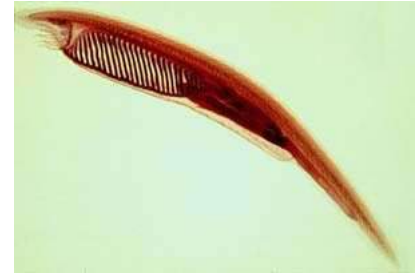
3. Equatorial cleavage

This cleavage plane bisects the egg at right angles to the main axis. It lies on the equatorial plane, it divides the egg into two halves



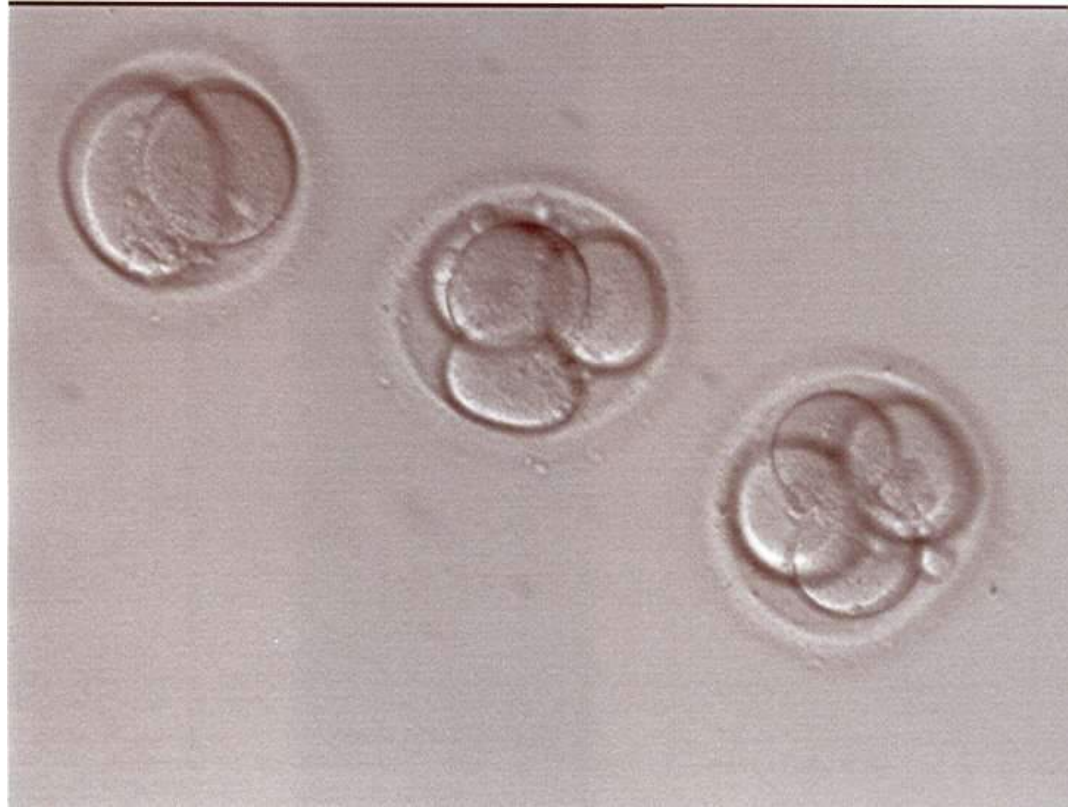
4. Latitudinal (transverse) cleavage

This type is similar to the equatorial plane, but it courses through the cytoplasm on either side of the equatorial plane, parallel to the equatorial plane, it is also called **transverse or horizontal plane**, eg. Third cleavage in the **Amphioxus and frog**



Products of the cleavage

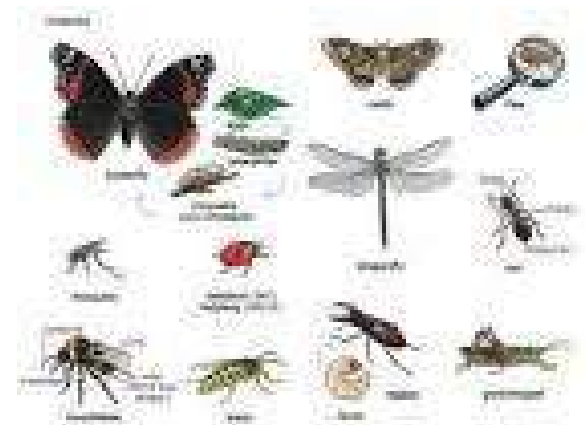
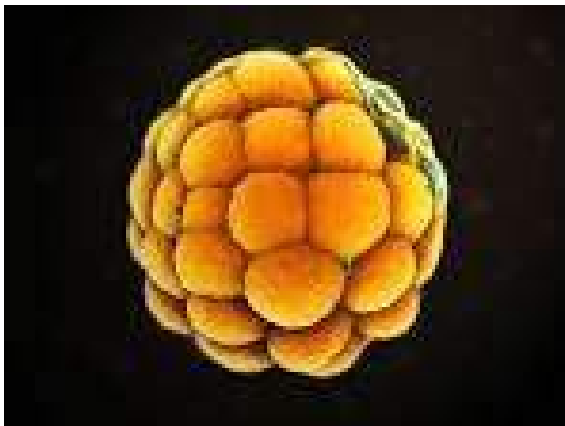
The cleavage is a fractionating process, which splits the (one-cell) zygote into smaller cells, called the **blastomeres**. After each cleavage. The blastomeres increases in a doubling sequence **2,4,8,16,32...etc.**



Morula

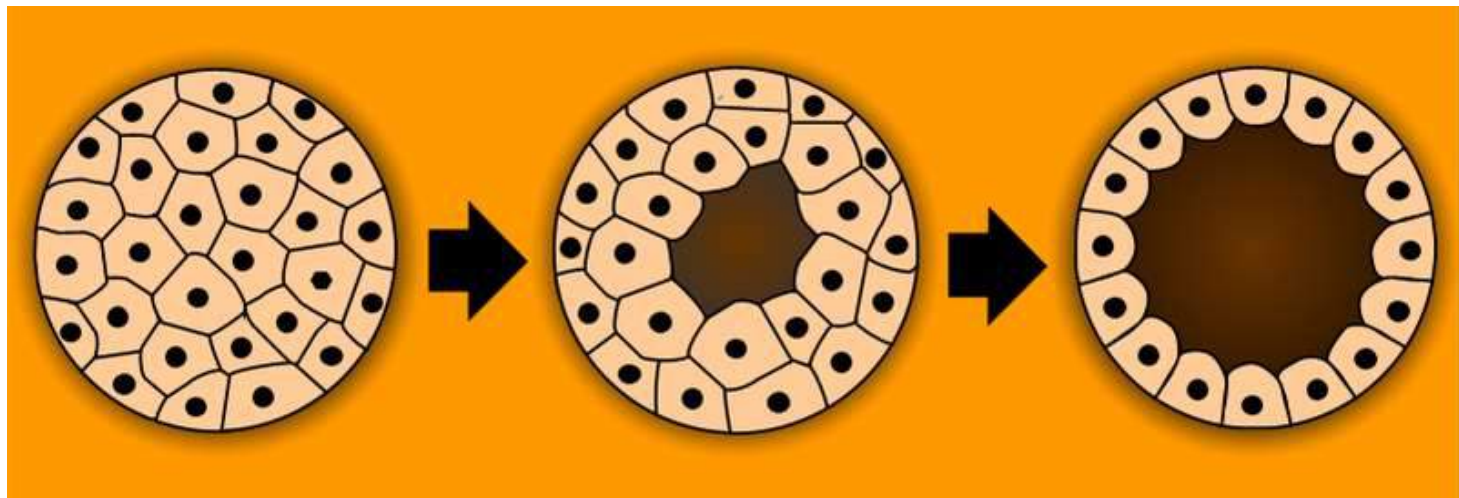
During early cleavage stages, the blastomeres tend to cluster a tightly spherical shape as solid ball of cells about 32 cells this called **morula** (mulberry) and the process is called **morulation**.

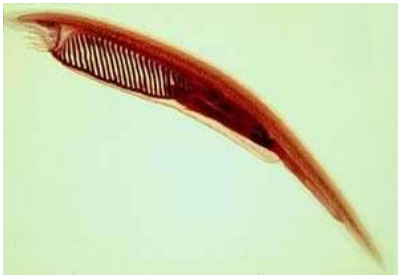
No morula is found in the centrolecithal eggs like insects, while the morula in the telolecithal and isolecithal found real morula



Blastula

After formation of morula, the fluid begins to penetrate through the zona pellucida into the intracellular spaces, and the blastomers undergo rearrangement themselves into a true epithelium in a single cell thick, this epithelium called **blastoderm** gradually the intracellular spaces become a single cavity, called **blastocoel**, in this stage the embryo called **blastocyte**



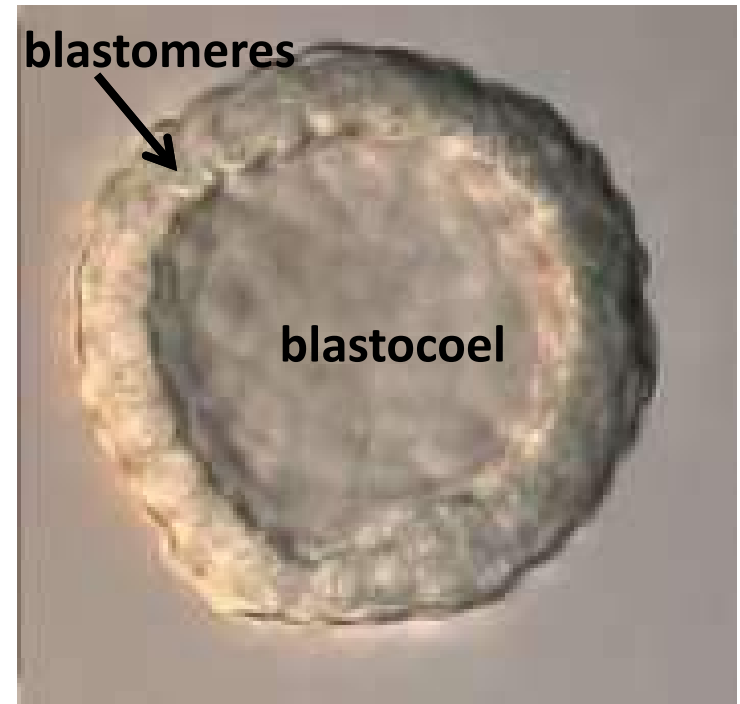


Type of blastula



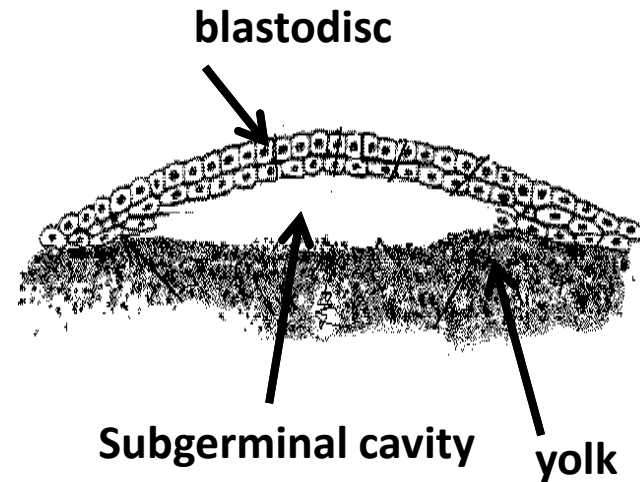
1. Coeloblastula

Found in lower invertebrates like, **echinoderms** and **Amphioxus**, it is in the form of central cavity called the blastocoel filled with fluid and around it a single layer of cells called the blastomere



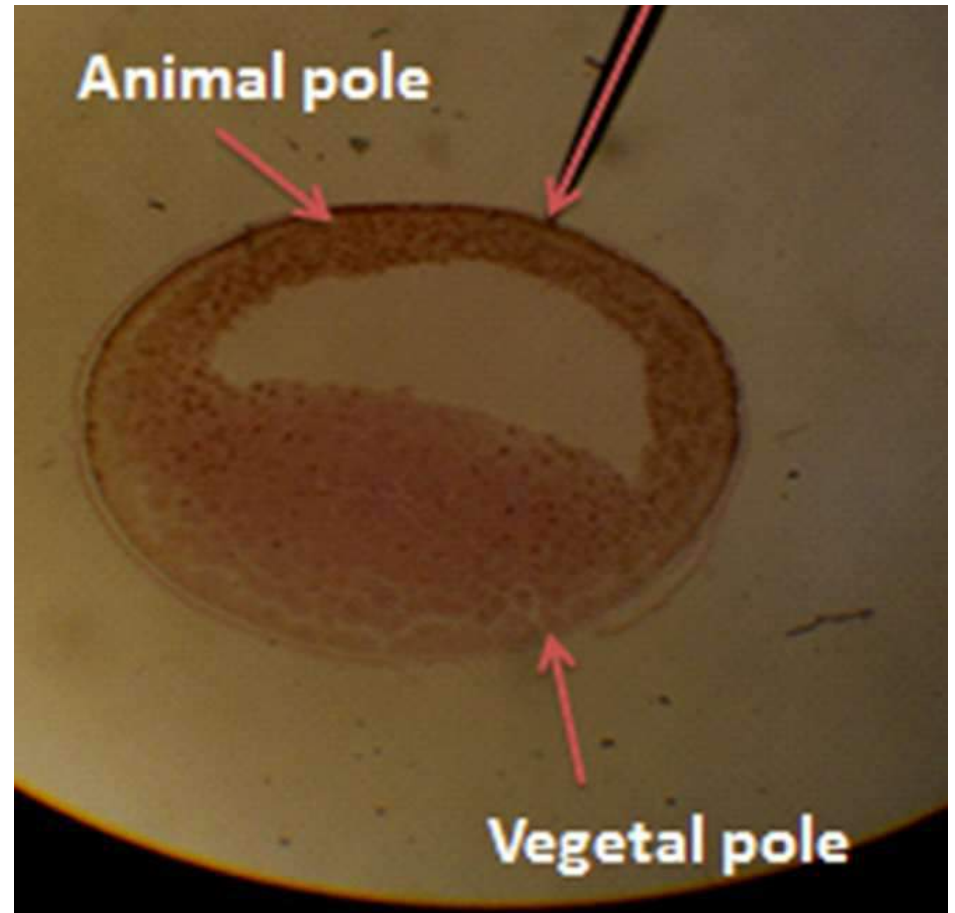
2. Discoblastula

Found in vertebrate like **reptiles, birds and fish** which have large amounts of yolk, therefore the blastula appeared at the animal pole as a small multilayered flat disc separated from the yolk by a narrow space called **the subgerminal cavity**



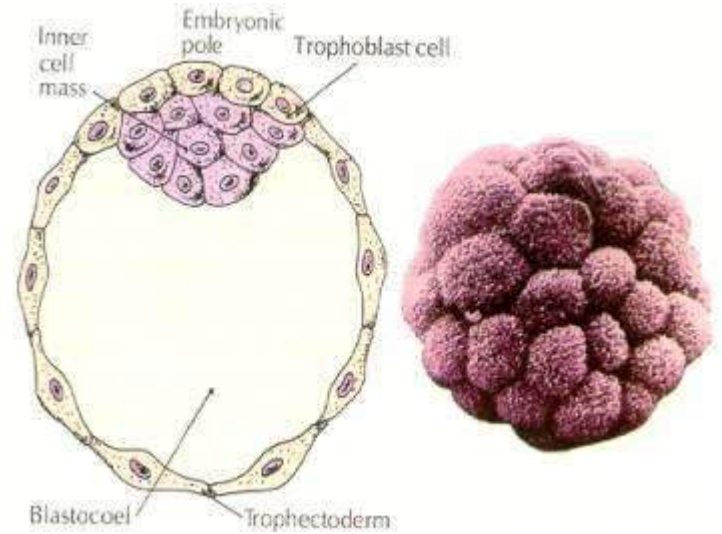
3. Amphiblastula

Found in **amphibians**, blastula contains two types of cells micromeres and macromeres arranged into more than one layer of cells

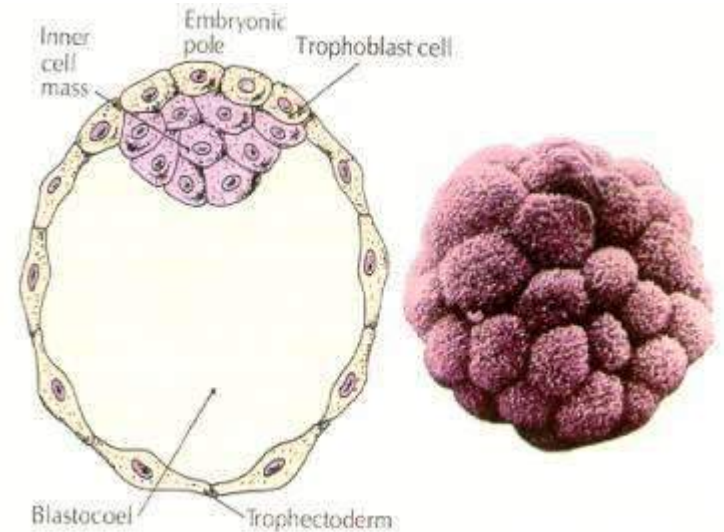


4. Blastocyst

- Such blastula found in mammals.
- The cleavage is regular and small cavity appears inside the dividing cells, the cavity called blastocoel and later become larger,
- the fluid in this cavity push some cells towards a pole of the blastocyte, these cells called the **embryoblast** or **innercell mass**, give rise to the all embryo organs therefore called **embryoblast**,



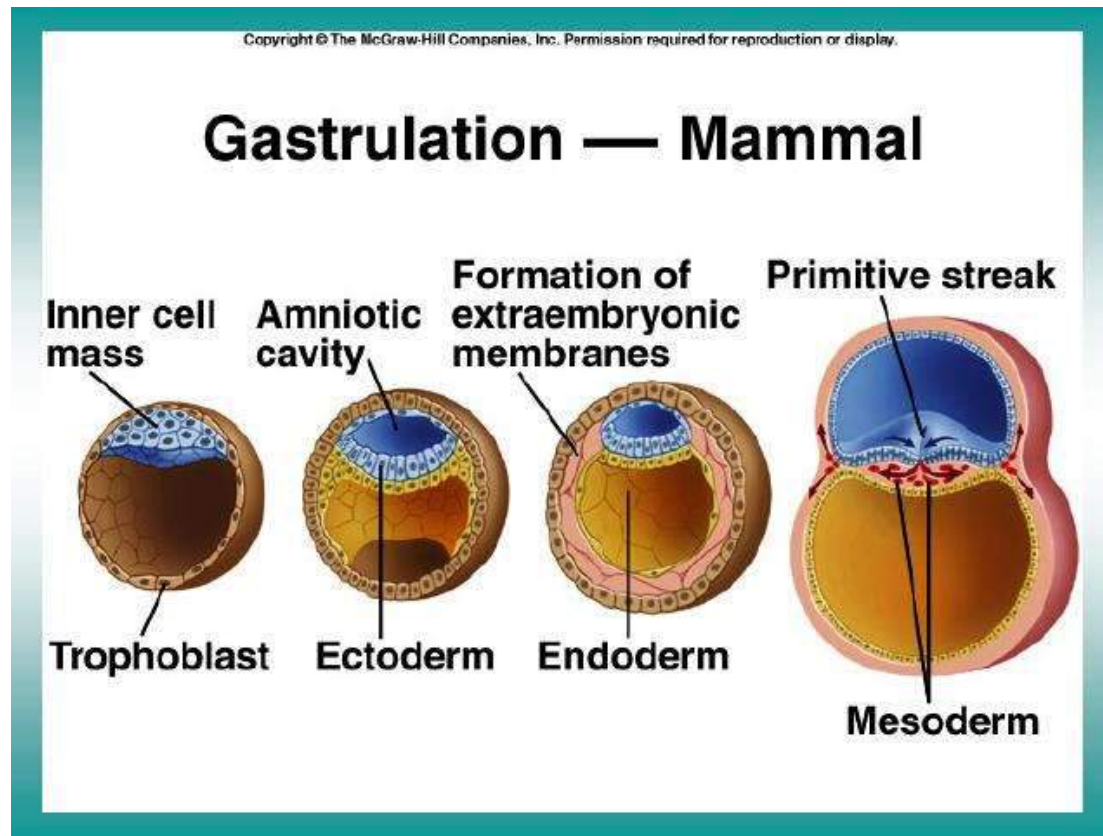
- While the cells that surround the outer of the blastocyte called **outer cell mass** or **trophoblast** give rise the epithelial layer of the blastocyte, considered the primary origin of the placenta, which attaches the fertilized ovum to the uterine wall and supplies nutrition to the embryo
- In the later stage the embryo will implant to the uterine wall by the trophoblast



A vibrant, well-maintained garden scene. A light-colored gravel path winds through the center, flanked by meticulously landscaped flower beds. The beds are filled with a variety of colorful flowers, including yellow, pink, purple, and red blooms. Several tall, slender cypress trees stand prominently, adding verticality to the landscape. In the background, a large, leafy tree and a dense wall of greenery create a sense of enclosure and depth. The overall atmosphere is peaceful and beautiful.

Thank you

Gastrulation



Lec.Dr. Ruwaidah F. Khaleel

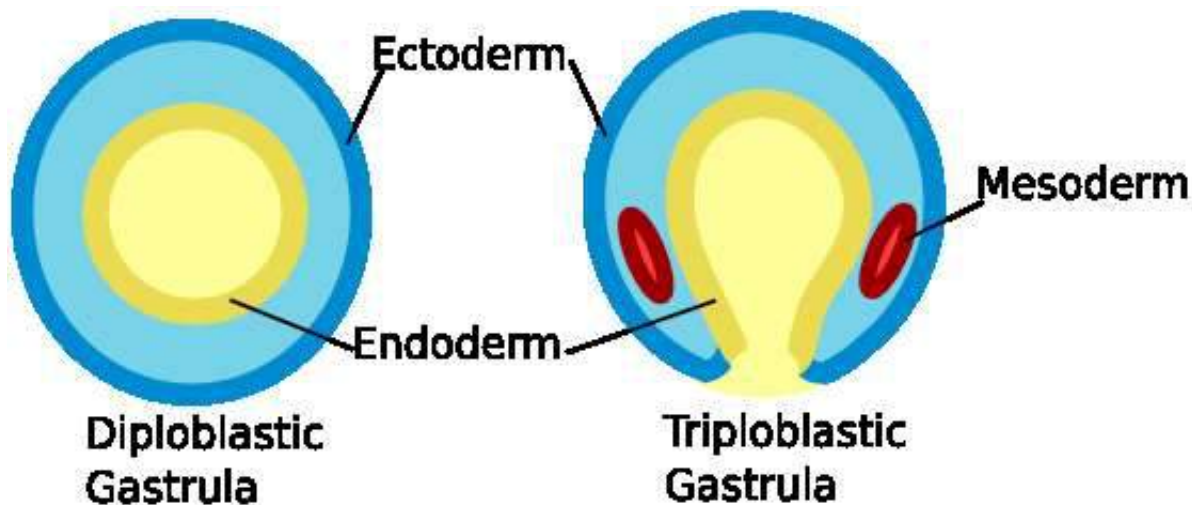
Gastrulation

- Is the dynamic process that deals with the re-organization or rearrangements of the cells of the embryo **which convert from one-layered stage as in all vertebrates.**



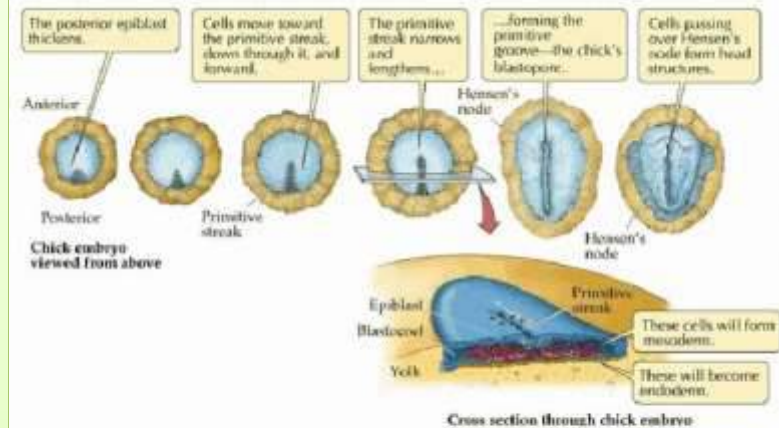
The single layer of epithelium in the blastula is known as **blastoderm**, while in the gastrula it is different:

- ❖ If the gastrula was 2 layered, the outer layer is called **ectoderm**, and the inner layered is called **endoderm**, therefore this gastrula called **diploblastic gastrula**, like in the [Hydra](#)
- ❖ If the gastrula was three layered, the outer layer is called **ectoderm**, the middle layered is called **mesoderm**, and the inner layered called **endoderm**, therefore this gastrula called **triploblastic gastrula**, like in higher animals



The process of gastrulation involves the following physiological and molecular event

1. Rearrangement of blastomeres by the morphogenetic movements
2. The cellular division or cleavage is inhibited
3. Growth. If found is insignificant
4. The nuclei become more active in controlling the activities of the embryonic cells
5. Synthesis of different kinds of protein molecules

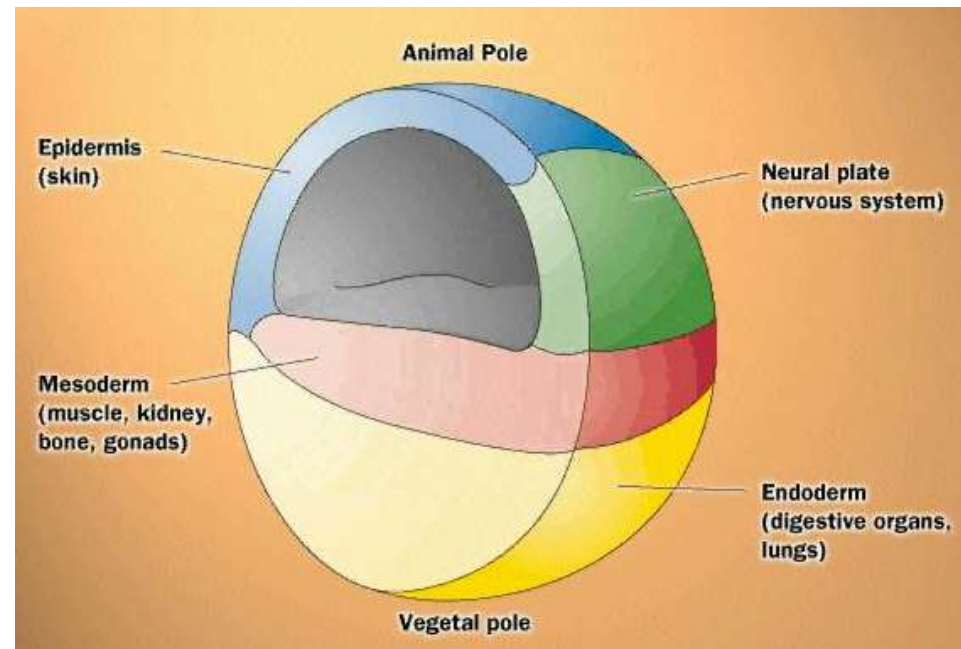


The gastrulation process doesn't occur until cleavage stop. Why?

- In the very beginning of development, during cleavage and early blastula, cells don't be able to move under any condition, therefore the cells at the end of cleavage undergo to differentiation to starting the movement,
- during cleavage and early blastula, cells are dividing so rapidly **therefore the microfilament and microtubule that the major part of the movement are so busy in the cytokinesis and not able to inter in the other activity**, therefore the beginning of gastrular cell locomotion during early development of most of animal groups time happen together with a decline of rapid cell division

Morphogenetic movements

- The movement of blastomeres of embryo (blastula) during gastrulation to reorganization of the cell from one place to another and produce a new structure of the embryo called **gastrula**



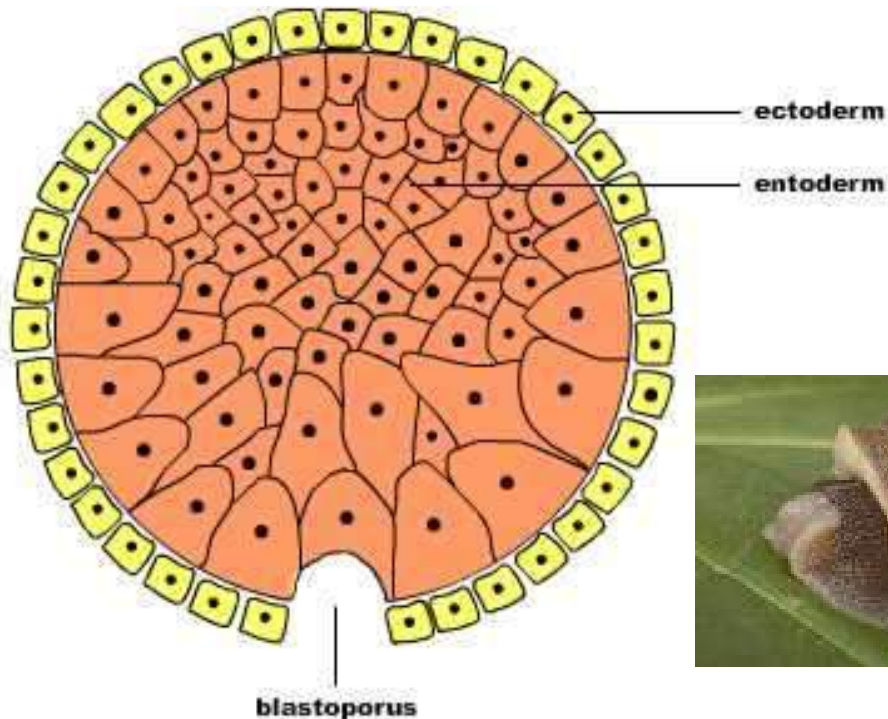
Type of morphogenesis

1. Epiboly

The word epiboly is derived from Greek (extending upon) means spreading of the cell sheet

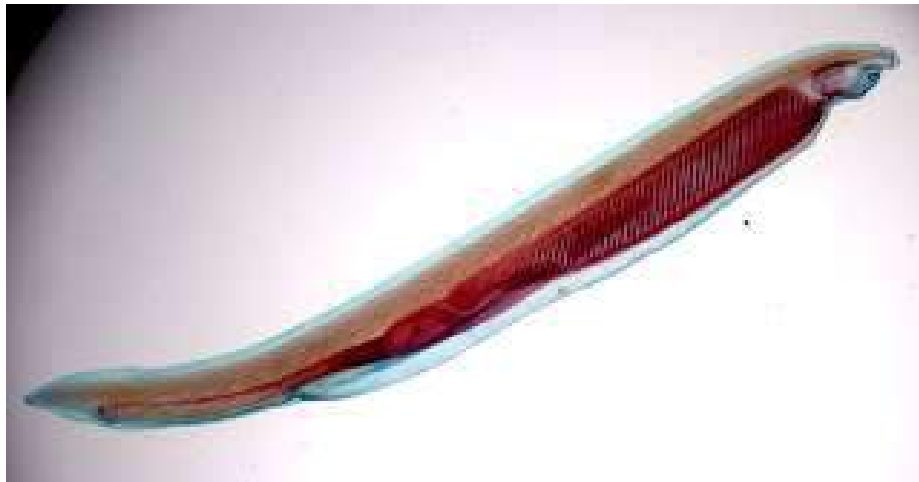
It represented the natural tendency of epithelial sheet (ectoderm) to expand into free areas, outside to envelope and surround inner layers, **ex. Mollusca, and fish**

Epibolie



2. Emboly

This is opposite to epiboly, in embryo the sheets of the cells fold or invaginate, thus the sheet migrate **inside** or **under** another layer, this type of movements occur in the mesoderm and endoderm. This type occur in **Amphioxus**

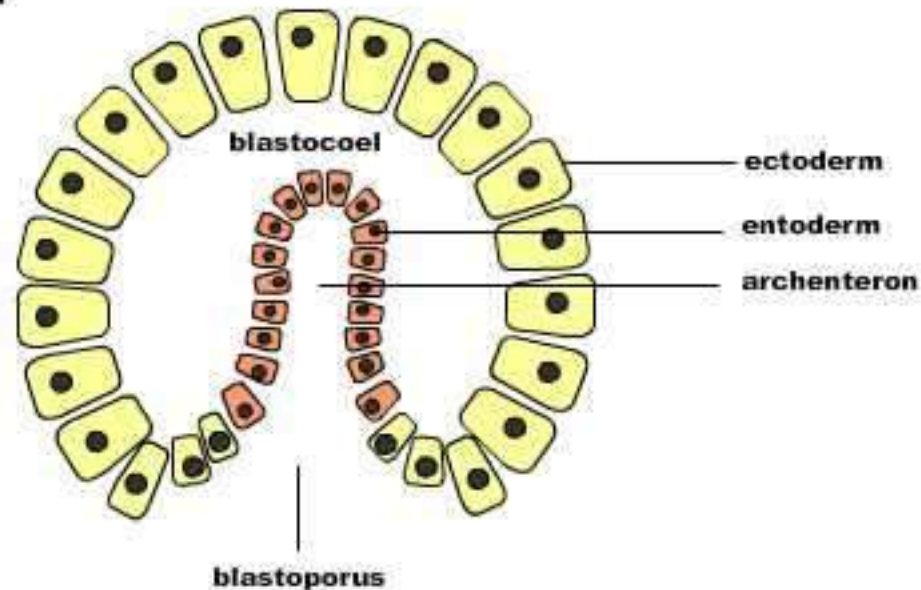


The embolic movement include

a. Invagination

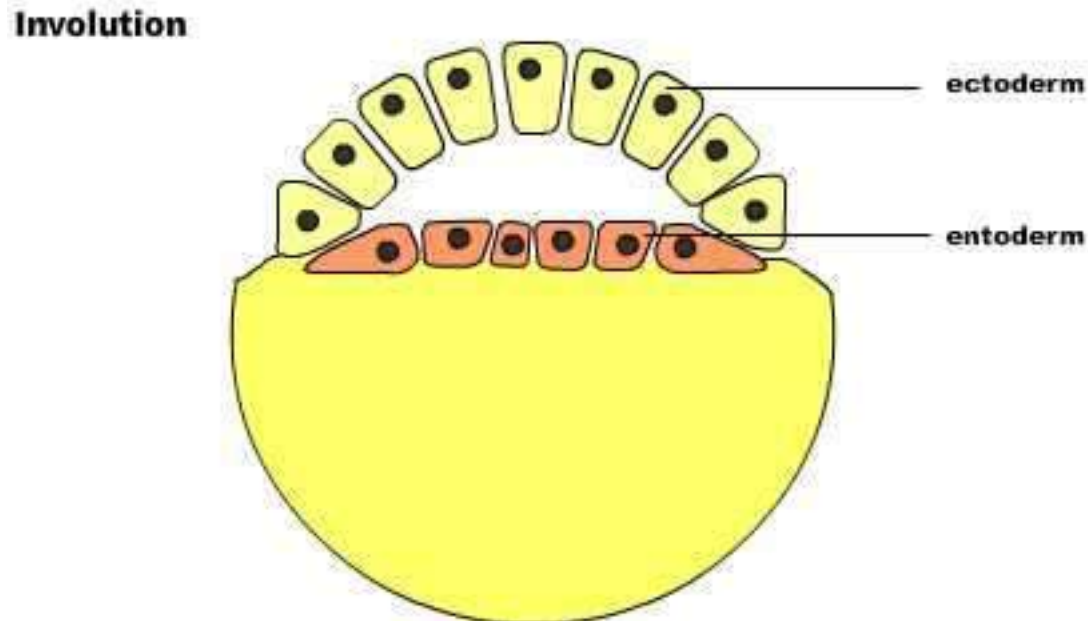
It's a movement of layer of cell inside at a specific point. **Ex.** Invaginate the cell of vegetal pole in Amphioxus embryo into the blastocoel toward the animal pole.

Invagination



b. Involution

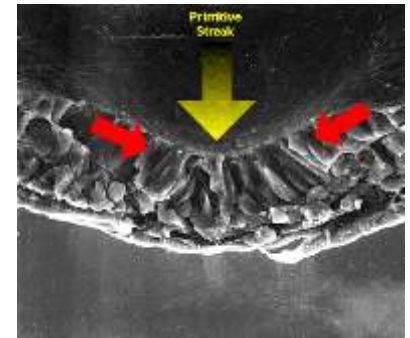
It's a turning of an expanding layer at a specific point, The surface layer of the cells rolls inside itself and continue to expand along the inner surface. ex,. A lip of blastopore during the gastrulation of the **amphibian** the vegetal pole cells move flow over the lip and move inside



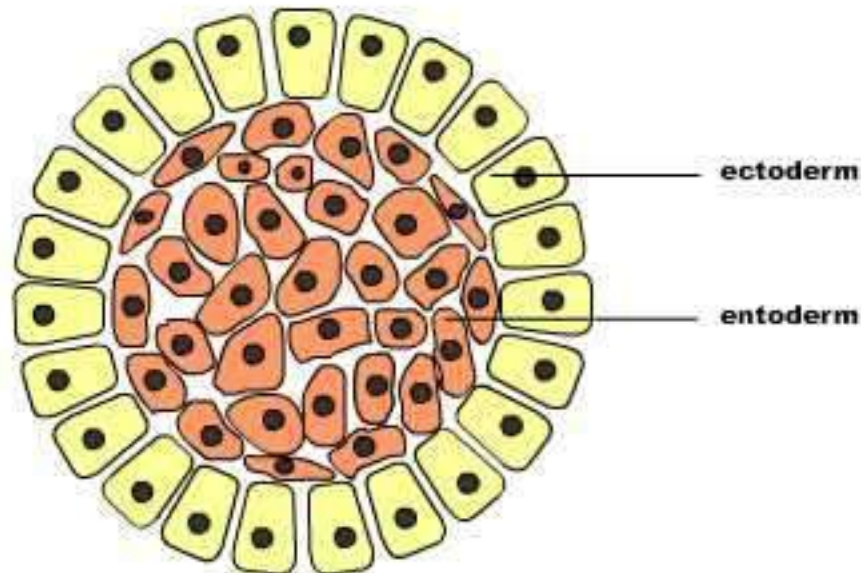
c. Ingression (polyinvagination)

- Small group of cell separate from the epithelial layer into an area.

Like the primary epithelial layer which migrate into the blastocoel cavity as new layer ex. **Primitive streak** in amniotes animals (**reptiles, avian and mammals**)



Ingression



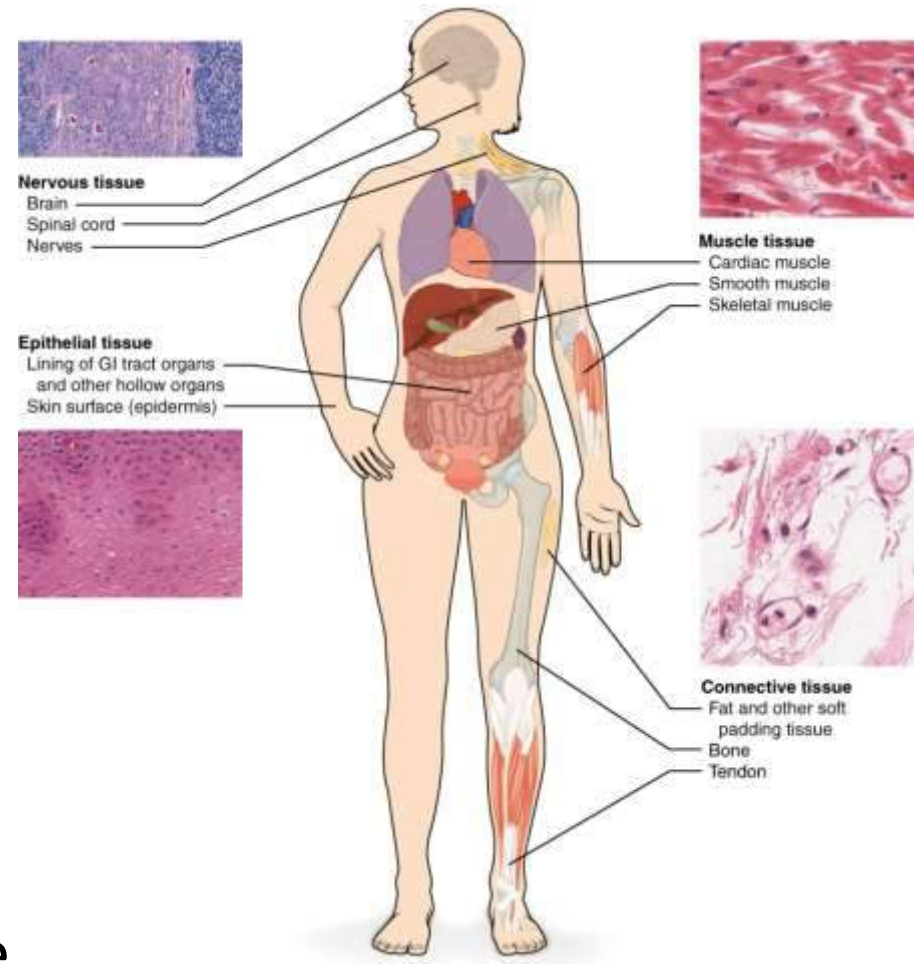
Histogenesis and organogenesis

- After gastrulation the embryo enters the next phase of development called the **organogenesis** during physiological and histogenesis processes
- **Histogenesis**: is the process by which the undifferentiated or pre-functional cells of the germ layers differentiate into specialized functional cells to form the body of the organism, and it's the first step in organogenesis



- Each tissue consist of group of similar cell that carry out similar functions united by intracellular substances, the cells of the tissues are **specialized cells**, but **epithelial and connective tissue are considered less specialized than nervous and muscle tissue**

- The formation of an intracellular substance usually secreted by the cell and often referred to as the **matrix** separates the cell from each other and give the shape to the body, **the intracellular substance of bone and cartilage are examples of this type of tissue.**



Generally all the type of cells is derived from one of the following germinal layer

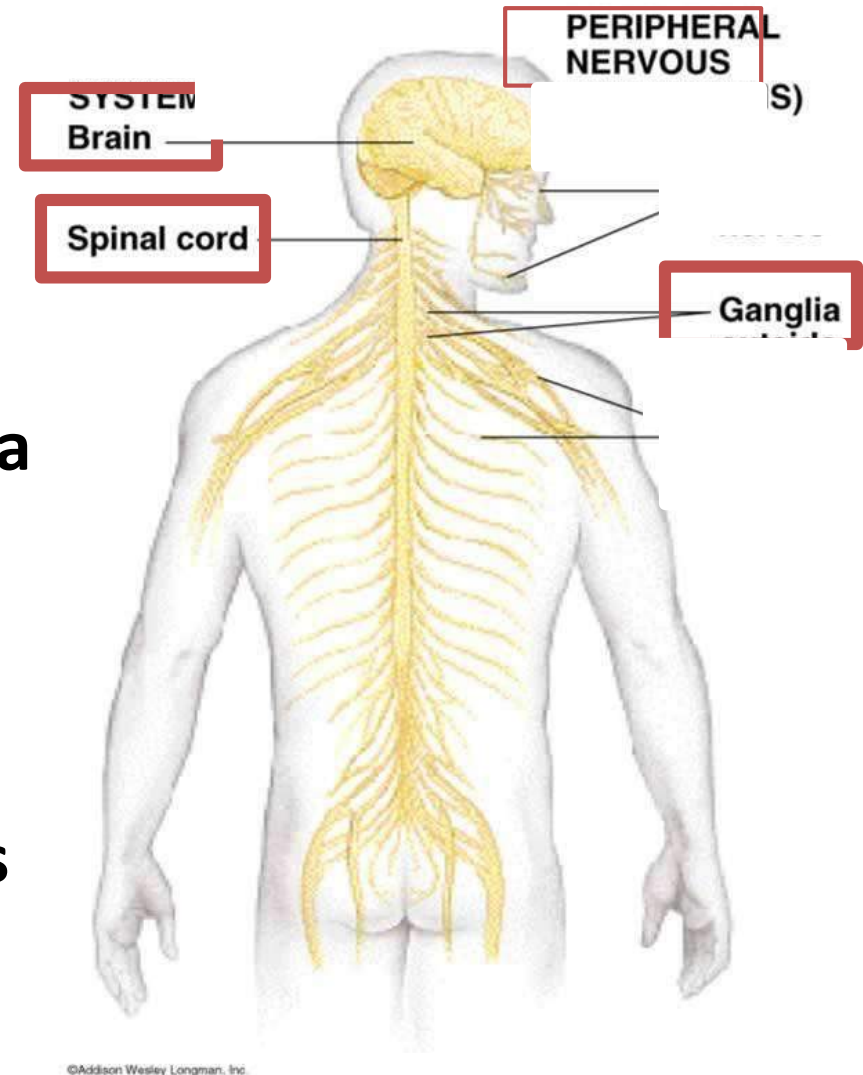
1. Ectoderm

a. Epidermal ectoderm

This type is give rise the epidermis of skin, skin derivatives (**hair, feather, nails, scale, claws, sebaceous, sweat gland, and mammary gland**) also give raise **the epithelium of the oral cavity, nasal cavity, salivary glands and anal canal, external ear of mammal, anterior pituitary gland (adenohypophysis)**

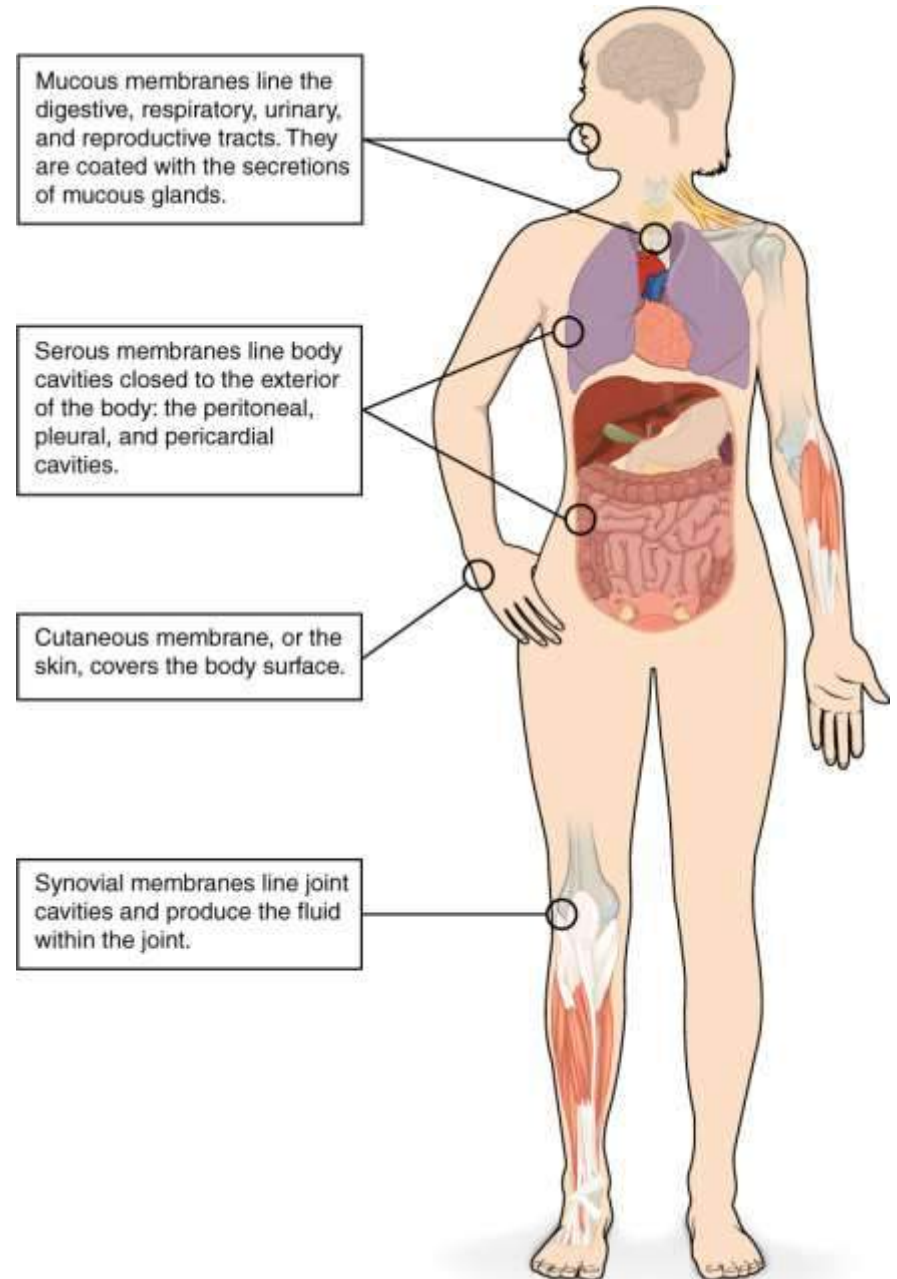
b. Neural ectoderm (neural tube)

- ❖ Brain
- ❖ Spinal cord
- ❖ Peripheral nerves
- ❖ Ganglia
- ❖ Roots and cones of the retina of eye
- ❖ Optic nerve
- ❖ Receptors of skin
- ❖ Auditory and taste receptors
- ❖ Posterior pituitary (neurohypophysis)



2. Endoderm

- Epithelium of the **digestive tract and its derivatives (liver, pancreases, gall bladder)**
- Epithelial lining of the respiratory tract
- Epithelium of the urinary bladder
- Epithelium of the auditory tube
- Primordial germ cells of the some animals, Vagina, urethra and associated glands



3. Mesoderm

a. Notochord

Found in amphioxus while in the other chordates it is replaced by vertebral column (vertebrates)

b. Epimere (dorsal mesoderm)

This type of mesoderm is consist of three parts:

1. **Dermatome:** this give rise dermis of skin
2. **Sclerotome:** this give rise vertebral column
3. **Myotome:** skeletal muscle

c. Mesomere (intermediate mesoderm)

- Excretory glands (kidney)
- Excretory ducts
- Urinary bladder in fish
- Epithelium of gonads (epithelium of the testes and ovaries and genital ducts, and adrenal cortex)

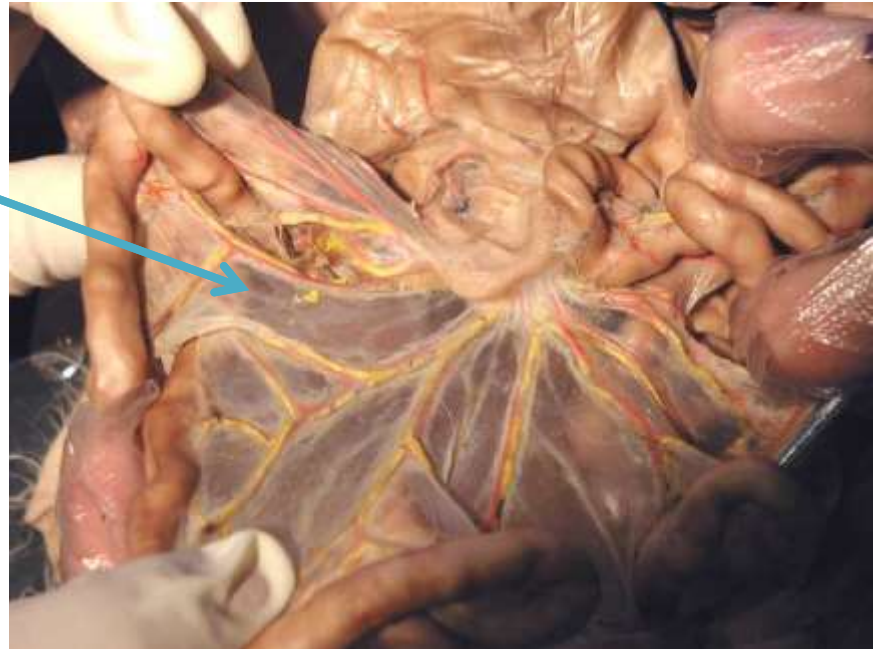
d. Hypomere (lateral mesoderm)

- This type of the mesoderm is consists of three parts
 1. **Somatopleura (somatic mesoderm)**
- **Parietal peritoneum** (lining of the pleura, pericardium and peritoneum)
- Limb muscles (higher animals) and trunk muscle (in chicken)



2. Splanchnopleur (visceral mesoderm)

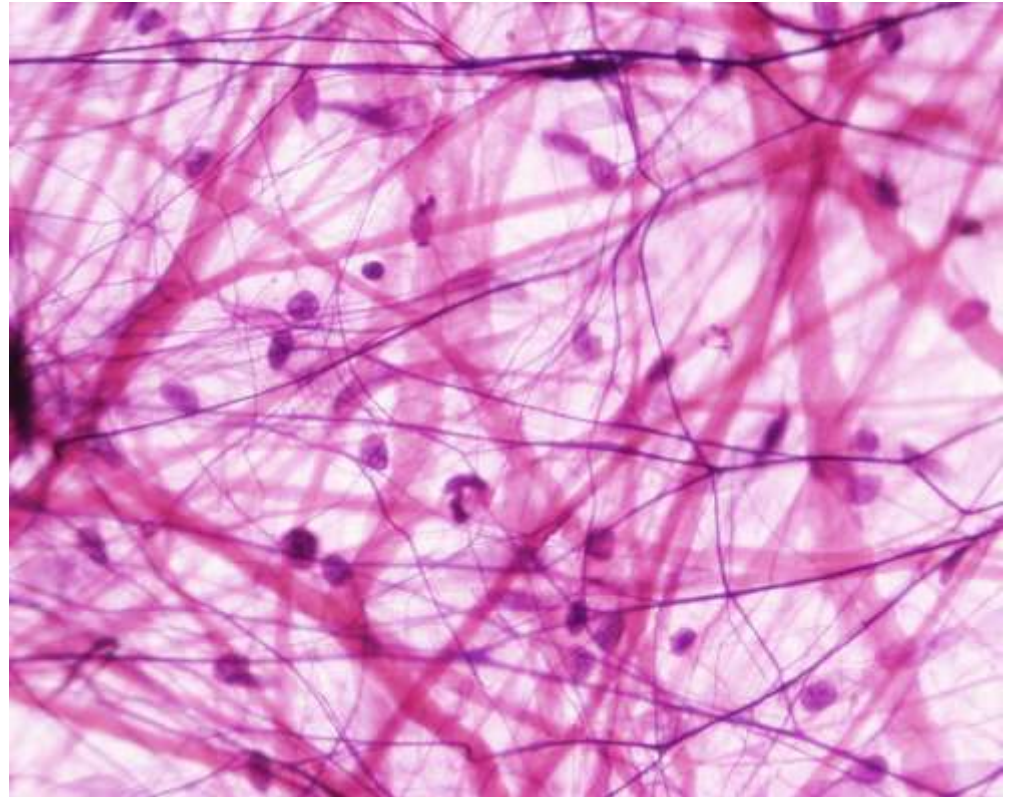
- Visceral peritoneum
- **Mesenteries**
- Heart
- Cardiac muscles
- Bone marrow
- Blood cells
- Blood vessels
- Smooth muscles



3. Coelom mesoderm, give rise the body cavity

Origin of organ systems

- Groups of specialized cells (tissue) combine to form the organs of the animal,
- Certain organs, in turn corporate with other related organs to constitute organ system



the organ systems of adult vertebrate body can be divided according to their general germ layer origin as follow

A. Ectodermal layer

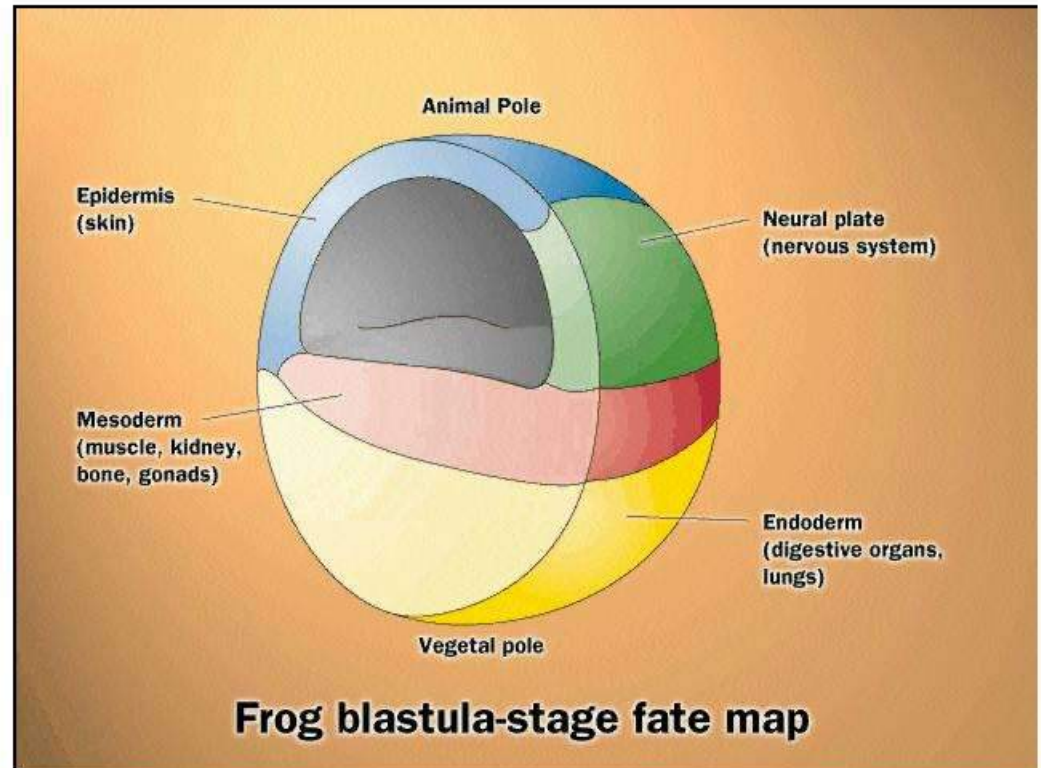
1. Integumentary system
2. Nervous system

B. Endodermal layer

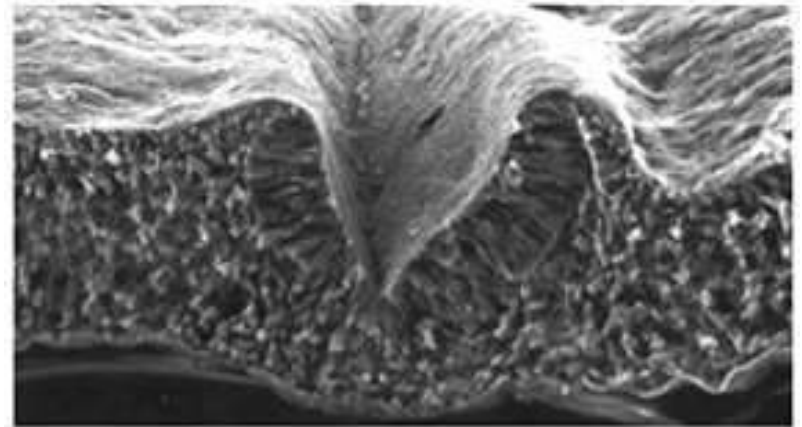
1. Digestive system
2. Respiratory system

C. Mesodermal layer

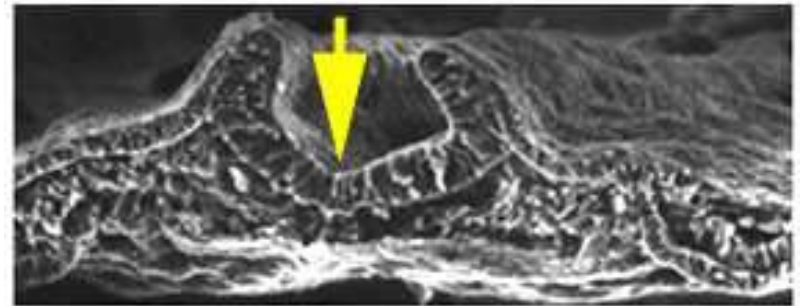
1. Muscular system
2. Skeletal system
3. Circulatory system
4. Excretory system
5. Respiratory system



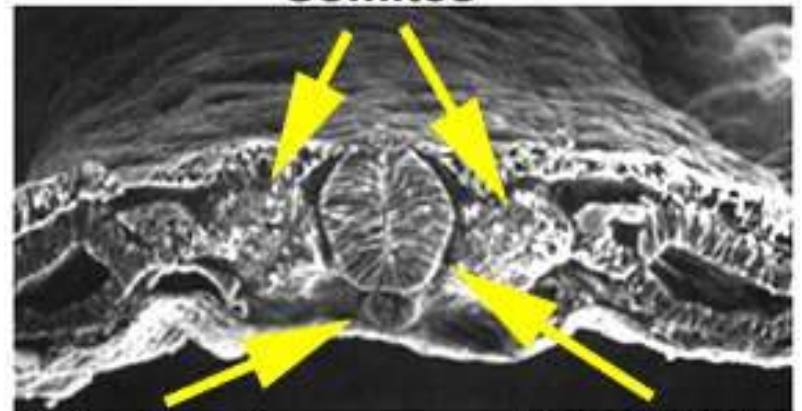
- At the end of gastrulation, epidermal ectoderm covers the embryo, the neural ectoderm will differentiated from the epidermal ectoderm to form the **neural plate**.
- The mesoderm remain closely associated with the **notochord**, forming the so-called **chordamesodermal layer**, the endoderm associated the roof of the gastrocoel to form the embryonic gut extend from the head to tail region



Neural groove



Somites



Notochord

Neural tube



Thank you