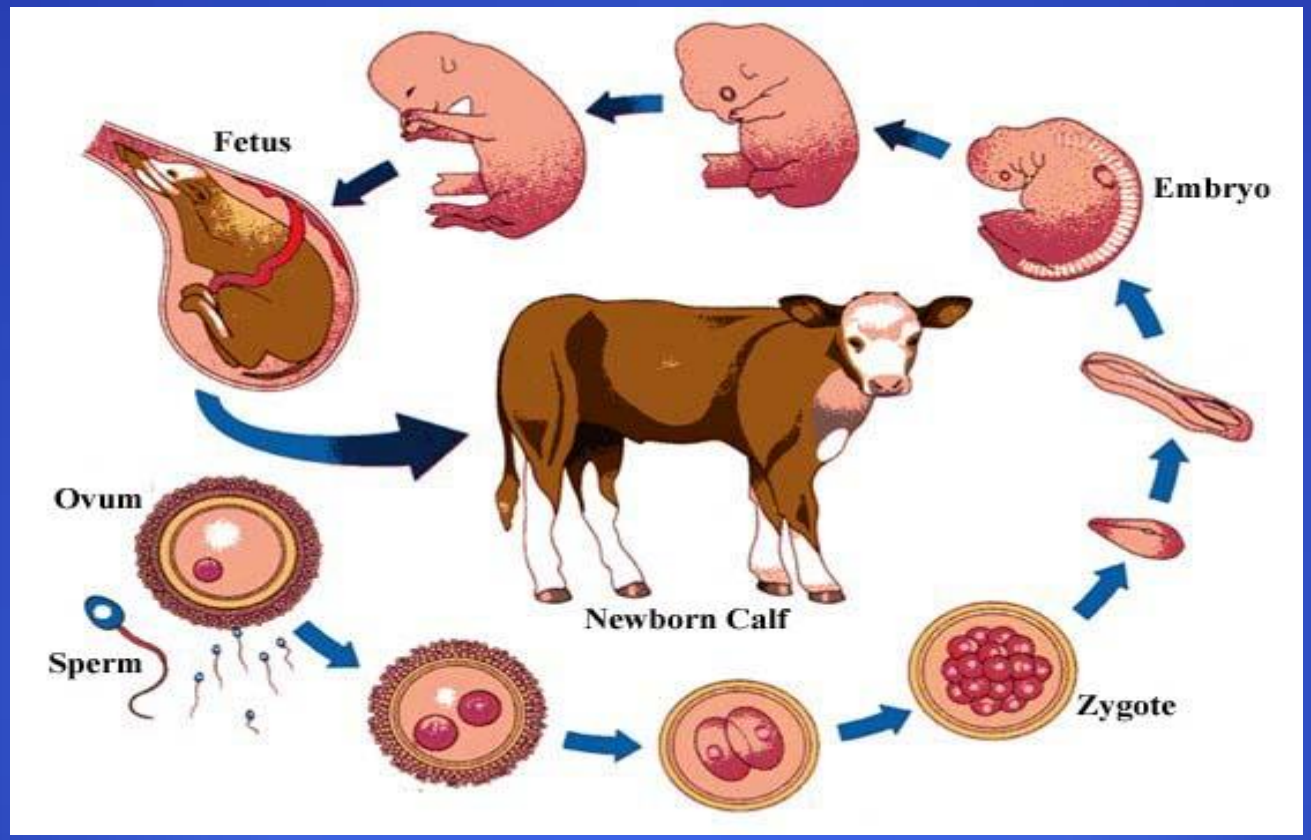
General Embryology

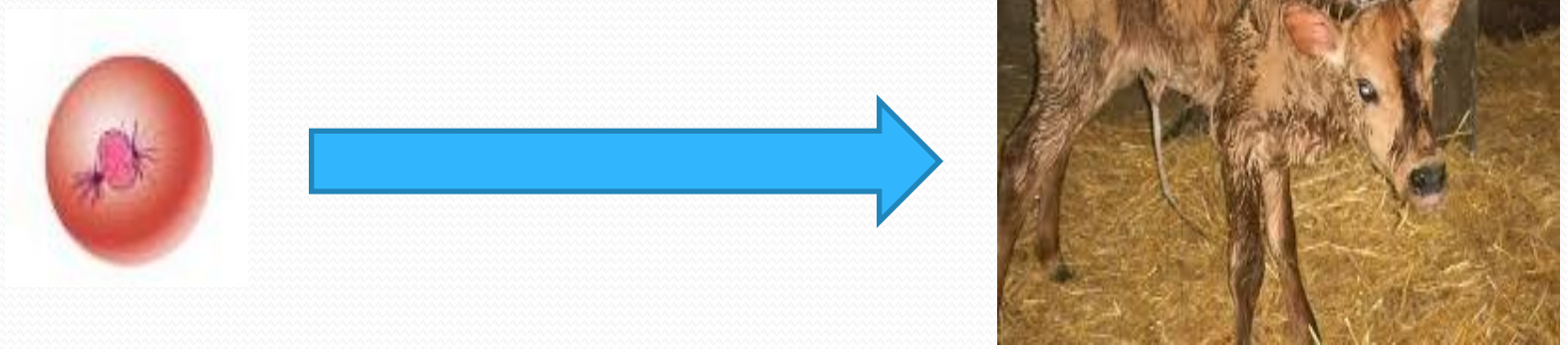
By

Dr. Ahmed AboAhmed



Embryology

Science which deals with the study of the origin and development of the organism from a single cell (fertilized egg or zygote) to a new individual.



Embryology includes:

Embryogenesis

Which studies the early stages of development from gametogenesis to placentation.

Morphogenesis

Which studies the later stages of development in which the different tissues (histogenesis) and organs (organogenesis) will be formed.

- ***Development*** *includes cell division (proliferation), hypertrophy, splitting, migration and cell differentiation or specialization to produce different tissues.*

Ontogenetic Development

- Study of development of organism from fertilized egg into new adult individual.

(Ontogeny = Development)

e.g: chicken development from zygote or fertilized egg

Phylogenetic Development

- Study of evolutionary development التطور التدريجي and history of a species and how it is evolved تطورت and related to others or ancestors.

(Phylogeny = Evolution)

e.g: Ostrich evolution from chicken

Teratology: A division of embryology which deals with abnormal development (birth defects or anomalies)

The development of the organism is divided by the time of birth or hatching into: prenatal and postnatal periods.

1- Prenatal period:

Changes occurring in the embryo from fertilized ovum till the birth *"intrauterine development".*

This period is subdivided into three stages:

A- Germinal stage "zygote": "Fertilized Ovum"

The time until zygote formation.

B- Embryonic stage:

It is the time from fertilization to the earliest (primordial) stages of organ development (about 30 days in dog, cat, sheep, pig; almost 60 days in horse, cattle, human).

C- Fetal period:

the time between the embryonic period and parturition (the end of gestation), during which organs grow and begin to function.

2- Postnatal period:

Changes and development occurring after birth.

Phases or Stages of Prenatal Development include:

1- Gametogenesis: the formation of male and female gametes "spermatogenesis and oogenesis".

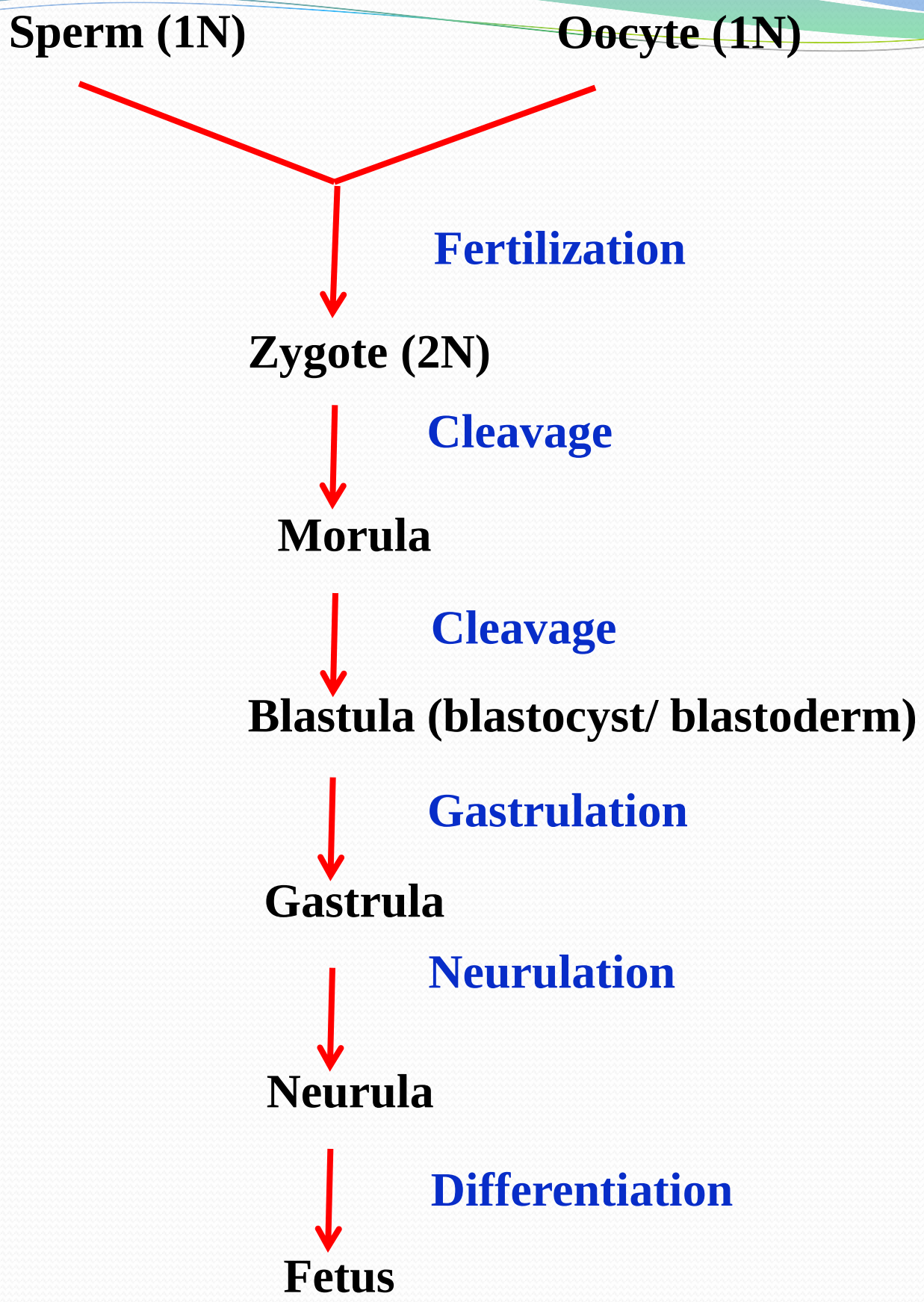
2- Fertilization: union of male and female gametes to form zygote.

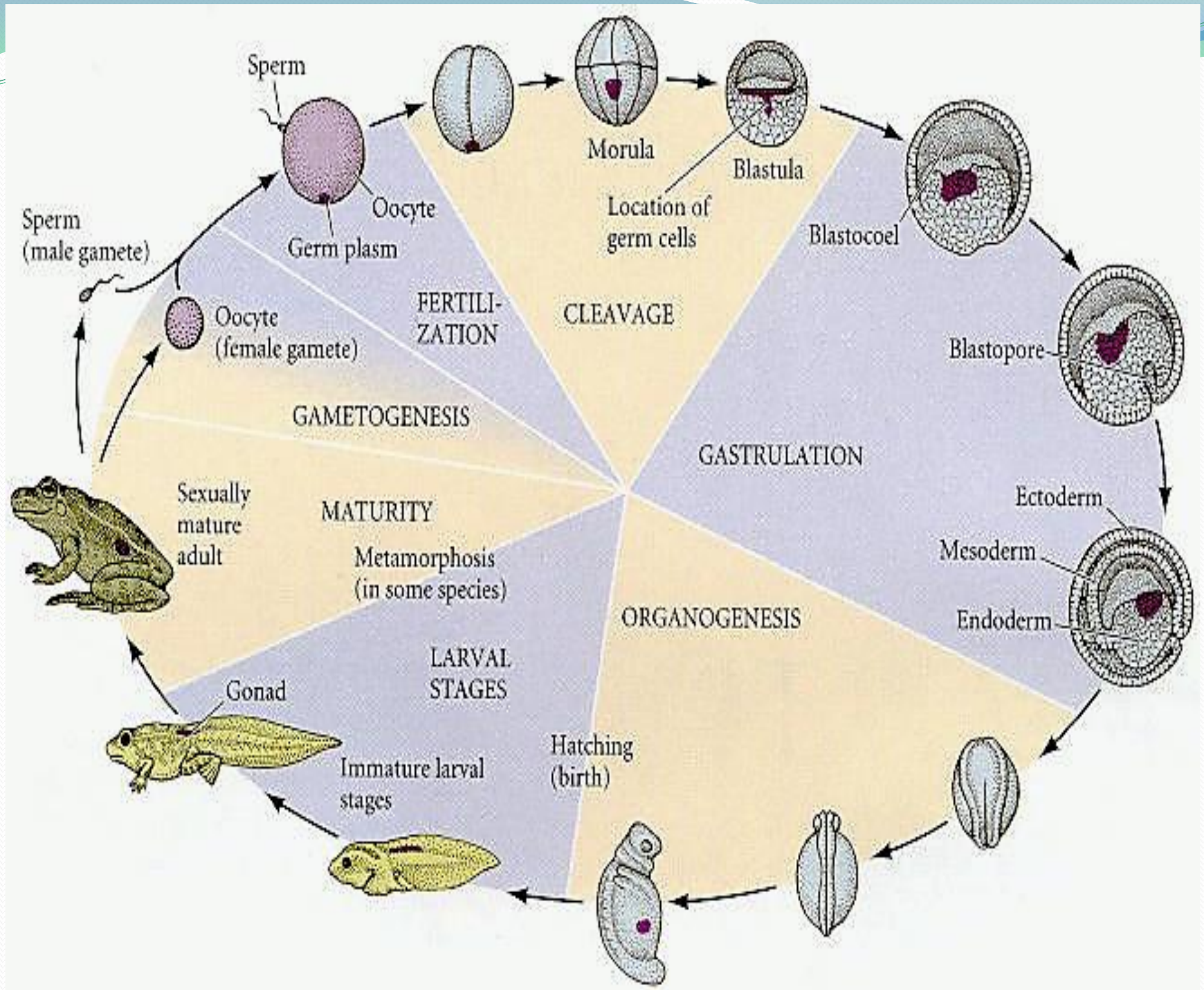
3- Cleavage: series of mitotic division of the fertilized ovum giving rise a large number of small cells (blastomeres) forming the morula. These cells are then arranged in a hollow spherical body forming the blastula with a layer of cells (blastoderm).

4- Gastrulation or differentiation: process by which the cells of the blastula (blastoderm) differentiate to form 3 germinal layers (ectoderm, mesoderm and endoderm).

5- Formation of the fetal membranes: include amnion, chorion, yolk sac and allantois. They are developed from zygote but not form part of embryo itself.

6. Organogenesis: subdivision of embryo into groups of cells to form certain tissue or organ.


Sperm (1N)
Oocyte (1N)
Fertilization
Zygote (2N)
Cleavage
Morula
Cleavage
Blastula (blastocyst/ blastoderm)
Gastrulation
Gastrula
Neurulation
Neurula
Differentiation
Fetus



Circle of life: Stages of animal development

Developmental biology, 7th edition, Scott F. Gilbert

Cell division (Proliferation)

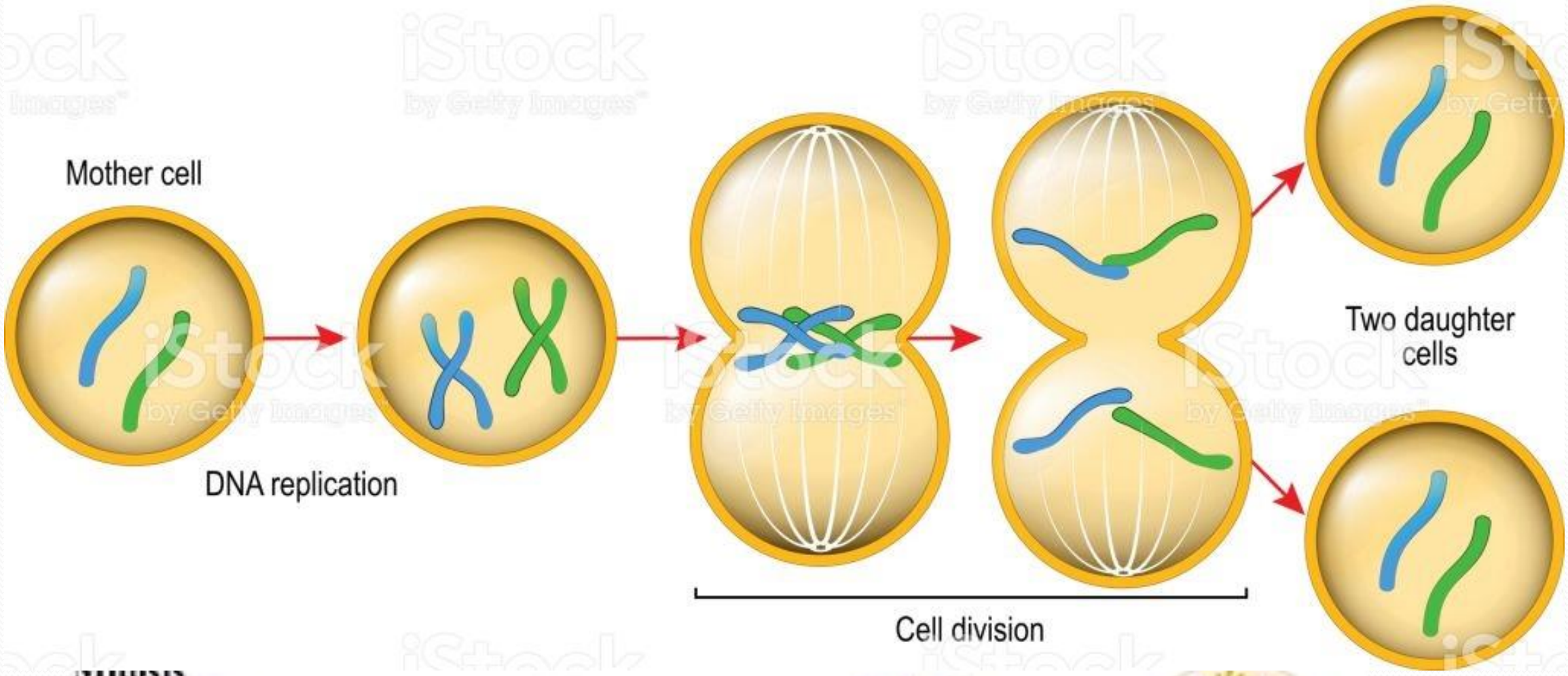
A. Mitosis:

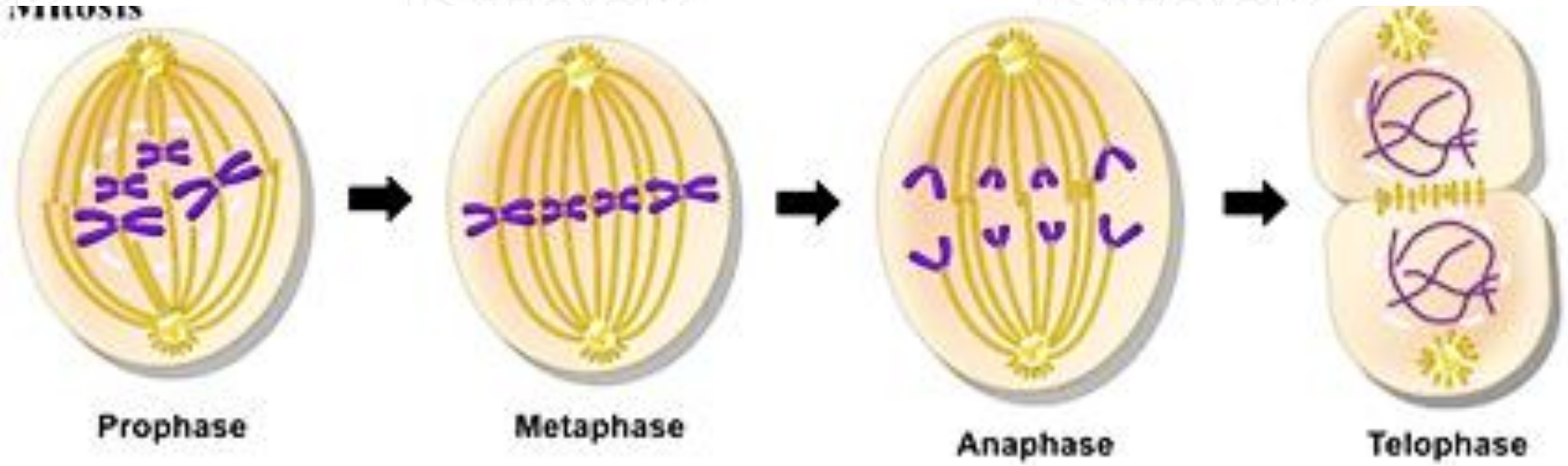
- This type occurs in all somatic cells and results in 2 new (daughter) diploid (2N) cells genetically identical to each other and to the parent.
- There are 4 phases for mitosis: prophase, metaphase, anaphase, telophase.

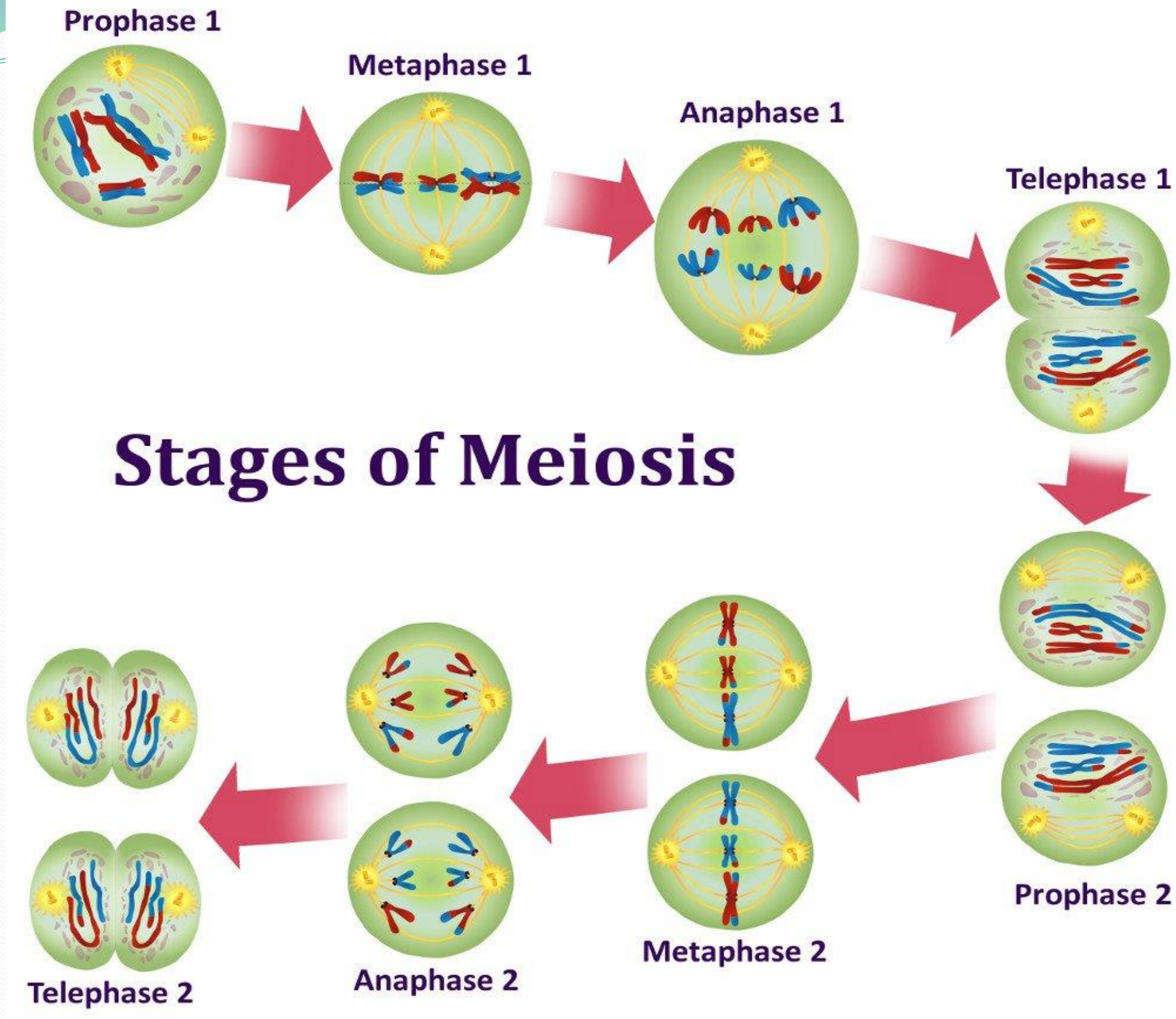
B. Meiosis: (Reduction division)

- It occurs in germ (sex) cells only necessary for sexual reproduction.
- It results in formation of haploid (1N) gametes (sperm and oocyte).
- There are 2 successive meiotic divisions: meiosis I (prophase I, metaphase I, anaphase I, telophase I) and meiosis II (prophase II, metaphase II, anaphase II, telophase II).

MITOSIS


Mother cell
DNA replication
Two daughter cells
Cell division

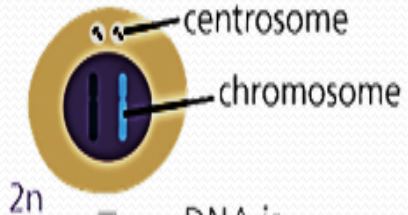

Prophase
Metaphase
Anaphase
Telophase


Prophase 1
Metaphase 1
Anaphase 1
Telephase 1
Stages of Meiosis
Prophase 2
Metaphase 2
Anaphase 2
Telephase 2

Meiosis I

Interphase

2N



DNA is copied

Prophase I

Chromosomes pair up

Recombination occurs

Metaphase I

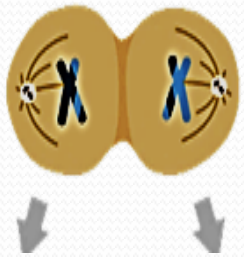
Chromosomes line up at equator

meiotic spindle

Anaphase I

Chromosomes pulled apart

Telophase I & Cytokinesis



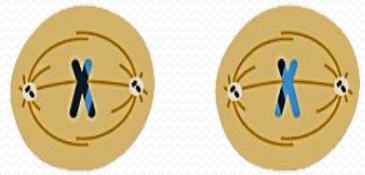
Cell pinches in the middle

Meiosis II

Prophase II

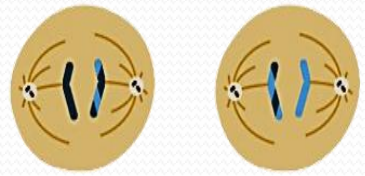
Two daughter cells

Metaphase II



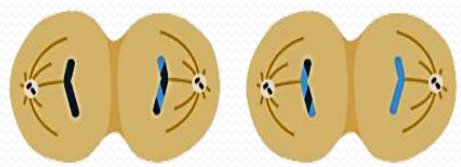
Chromosomes line up at equator

Anaphase II



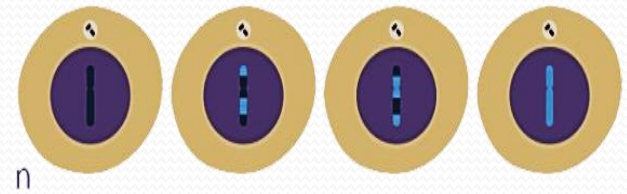
Sister chromatids pulled apart

Telophase II & Cytokinesis



Cell pinches in the middle

N



Four granddaughter cells

n – haploid 2n – diploid

I- Gametogenesis

♀ **Oogenesis** **Spermatogenesis** ♂

- It is the process of formation and development of male gamete (sperm = spermatozoon) and female gamete (oocyte = ovum = egg).
- Gametogenesis is known as **oogenesis** in female and **spermatogenesis** in male.

- It is the first phase in the sexual reproduction of animals during which transformation of certain cells in the parents into specialized cells, the eggs or ova in the female and the spermatozoa in the male occurs.

- The gametes are originated from **primordial germ cells (PGCs)** which are diploid (2N) cells that originate from the primary ectoderm الأديم الظاهر (epiblast) and terminate in the gonadal or genital ridge.

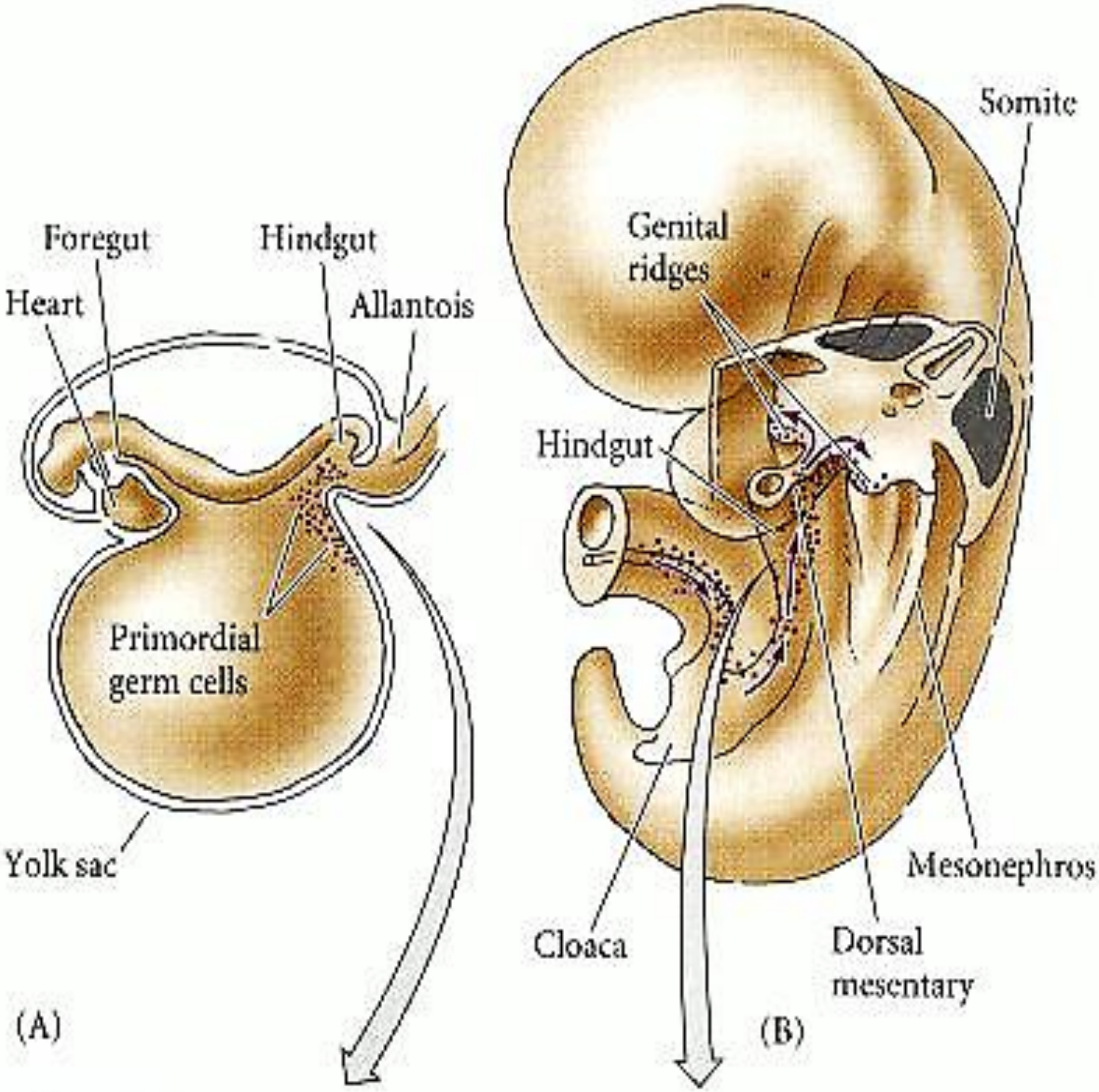
Migration of PGCs:

➢ In mammals:

- PGCs move (by pseudopodia in amoeboid manner) from the **primary ectoderm** into endoderm of yolk sac near hindgut then migrate through dorsal mesentery to finally localize in **the genital ridge**.
- The genital ridge together with PGCs form **the gonad** which is the primordium of either the testis or ovary.

➢ In birds:

- PGCs have **no** pseudopodia but they enter the blood of yolk sac then reach the genital ridge through **blood circulation**.



Primordial germ cells migration in mammals

Developmental biology, 7th edition, Scott F. Gilbert

Time of gametogenesis:

- **In male:** it starts from puberty until death.
- **In female:** it starts in the fetal ovary and progresses to primary oocyte stage before birth and then become matured after puberty and at fertilization and finally stop at senility or menopause.

Gametogenesis includes 3 stages:

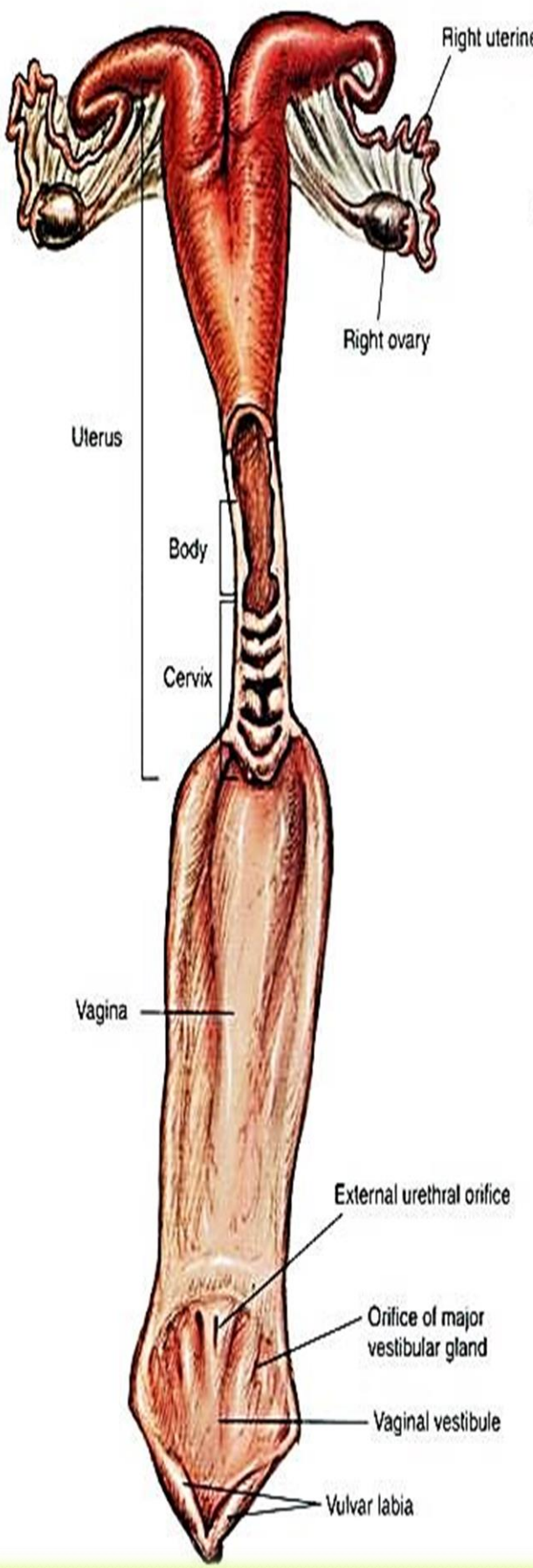
1- Stage of proliferation.

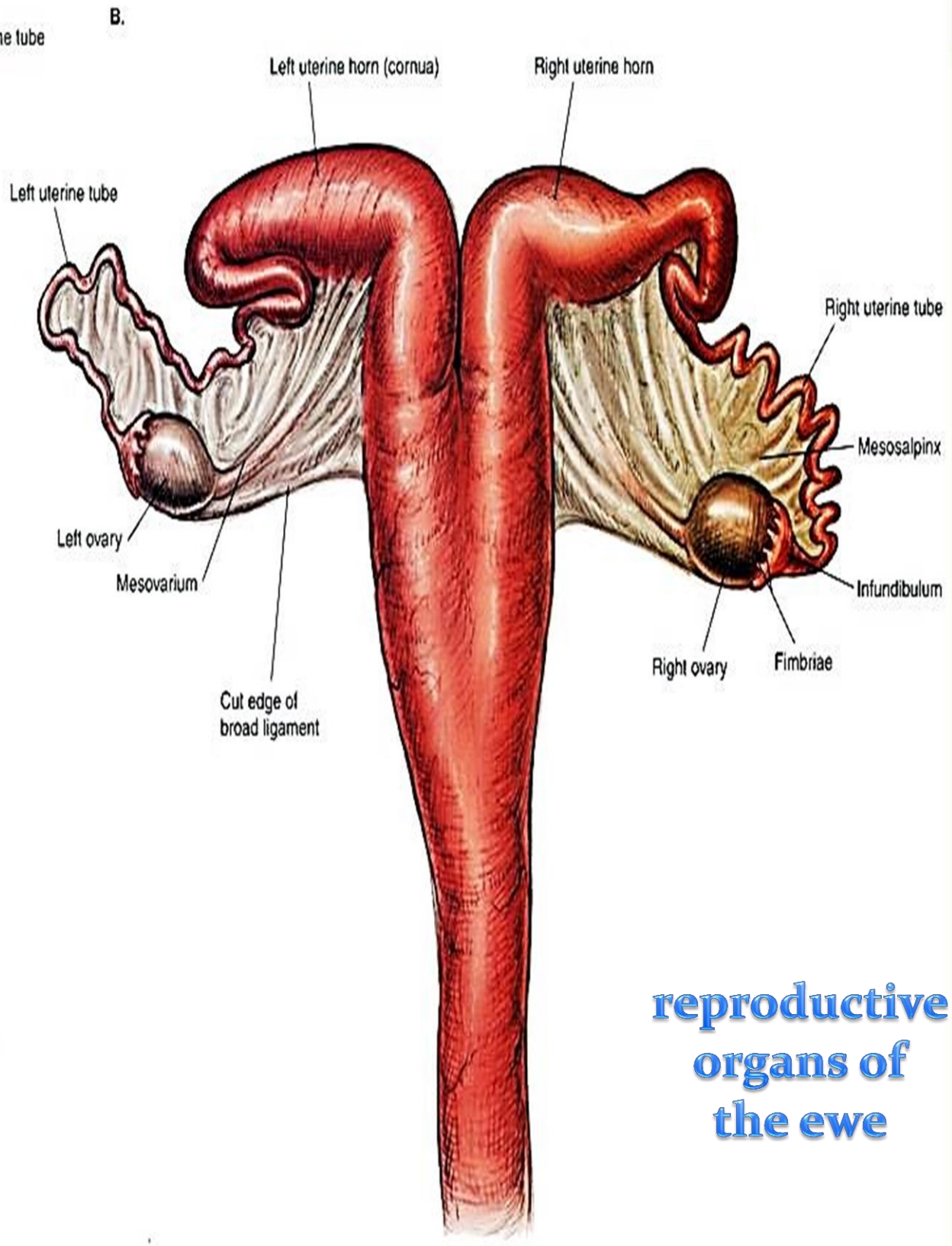
2- Stage of growth.

3- Stage of maturation.

A- Oogenesis

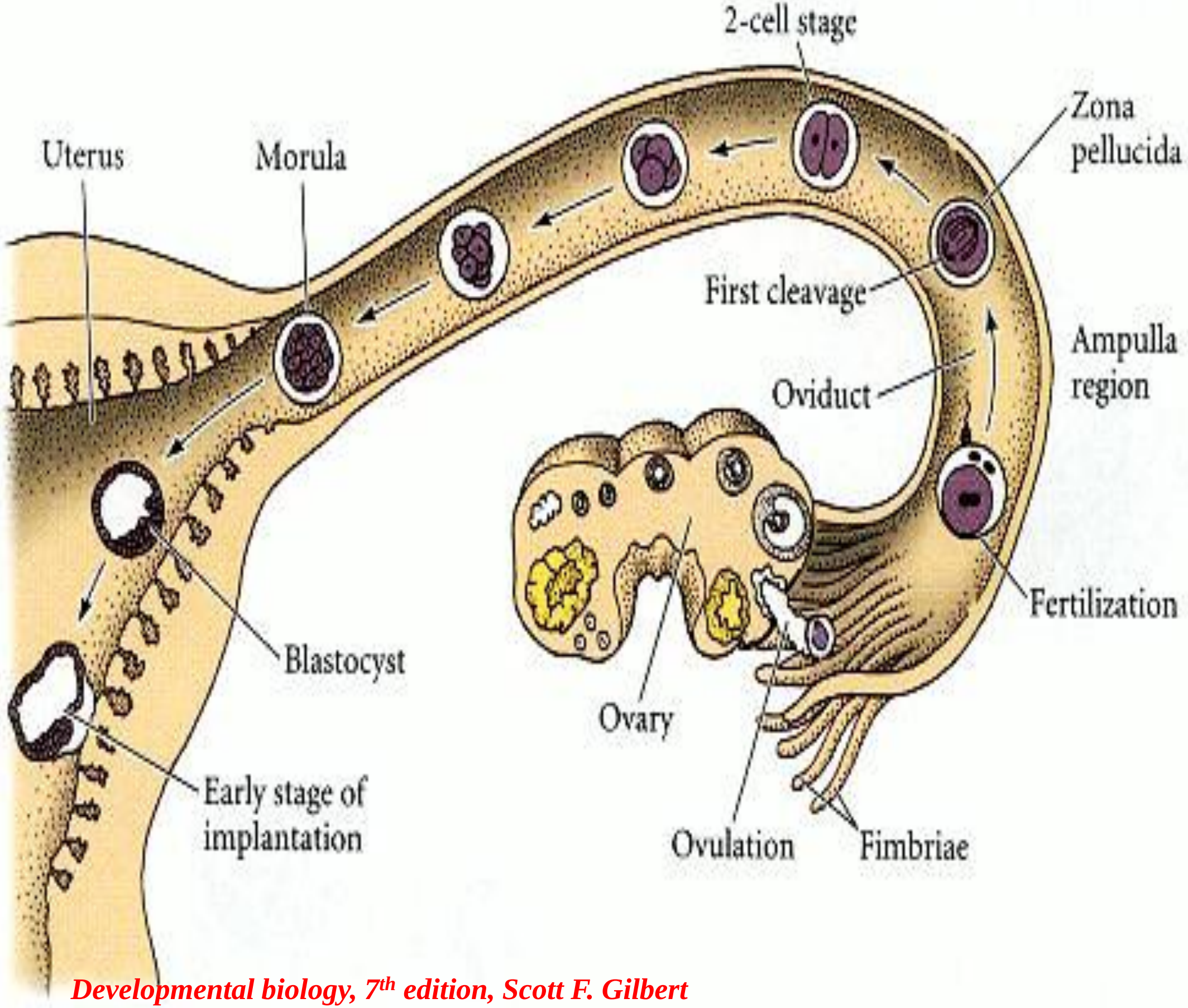
- It means formation and maturation of female gametes (oocyte or ovum or egg).



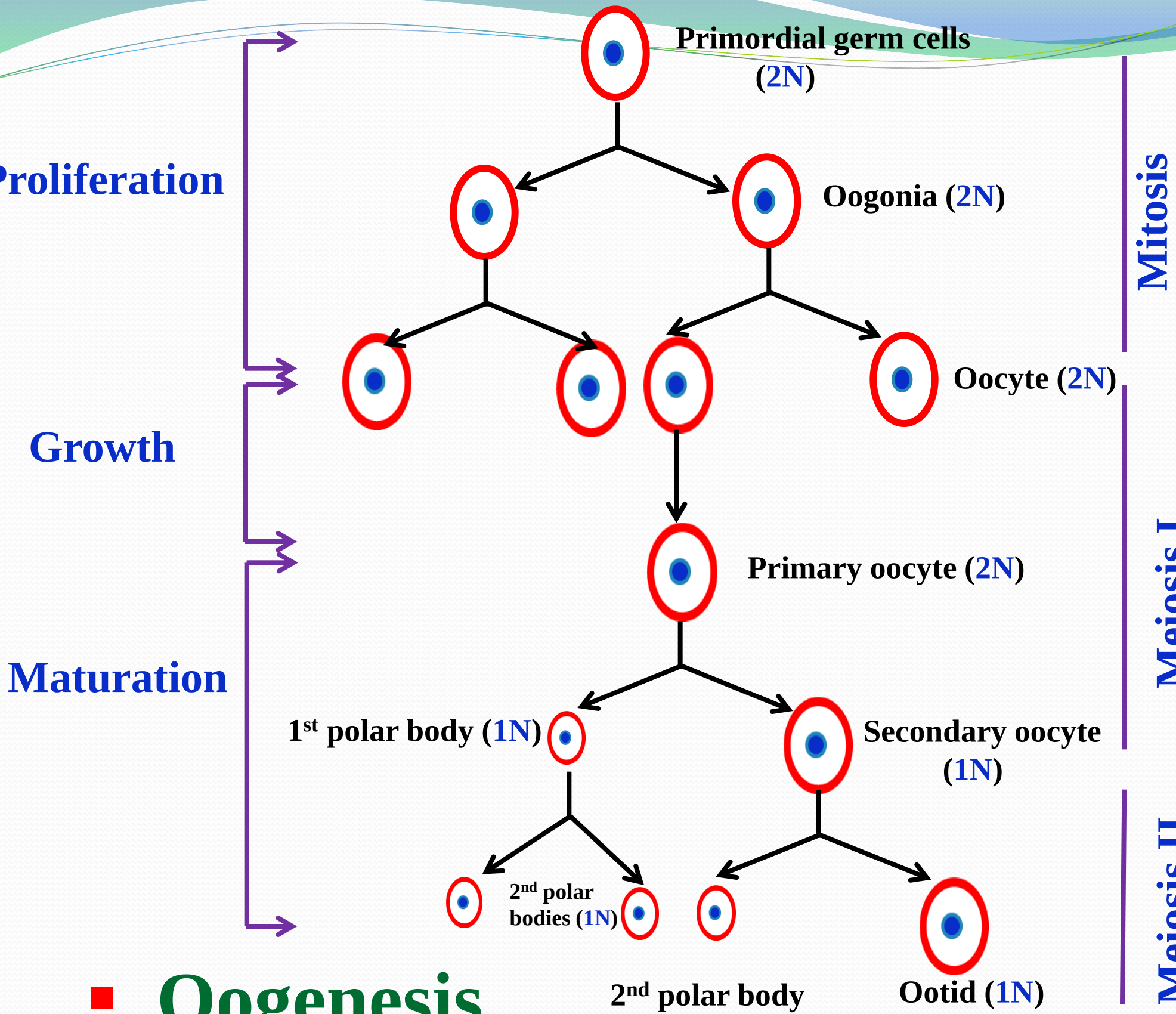


Female genital organs

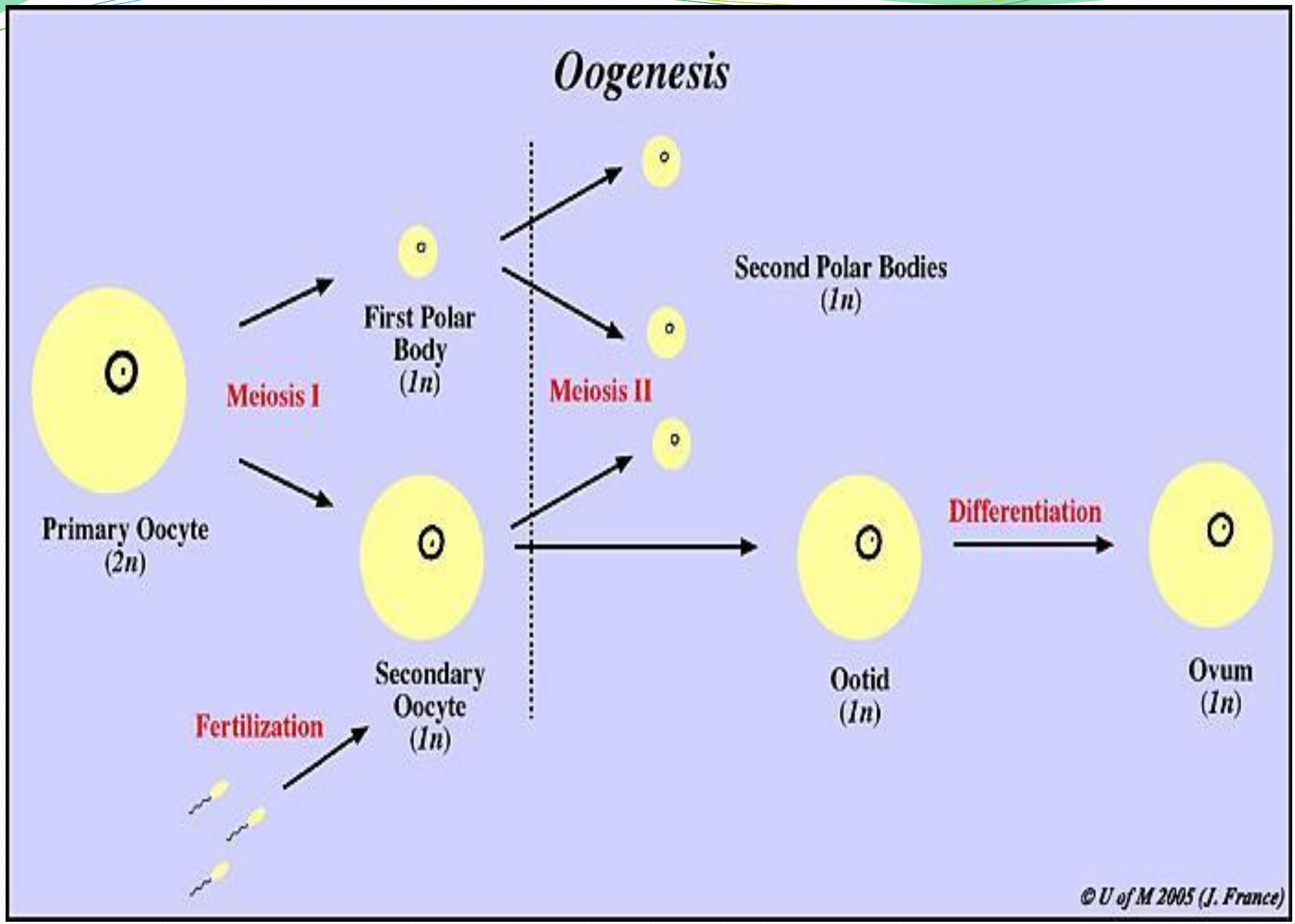
reproductive organs of the ewe

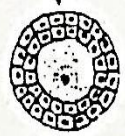
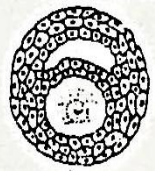
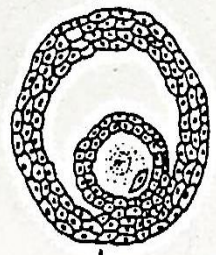


Developmental biology, 7th edition, Scott F. Gilbert


Primordial germ cells
(2N)
Proliferation
Oogonia (2N)
Mitosis
Oocyte (2N)
Growth
Primary oocyte (2N)
Meiosis I
Maturation
1st polar body (1N)
Secondary oocyte
(1N)
2nd polar
bodies (1N)
Meiosis II
2nd polar body
Ootid (1N)

- **Oogenesis**


Oogenesis
Primary Oocyte
(2n)
Meiosis I
First Polar
Body
(1n)
Meiosis II
Second Polar Bodies
(1n)
Secondary
Oocyte
(1n)
Fertilization
Ootid
(1n)
Differentiation
Ovum
(1n)
© U of M 2005 (J. France)

AGE	FOLLICULAR HISTOLOGY		MEIOTIC EVENTS IN OVUM	CHROMOSOMAL COMPLEMENT
Fetal period	No follicle		Oögonium (Mitosis)	2N, 2C
Before or at birth	Primordial follicle		Primary oöcyte (Meiosis in progress)	2N, 4C
After birth	Primary follicle		Primary oöcyte (Arrested in diplotene stage of first meiotic division)	2N, 4C
After puberty	Secondary follicle		Primary oöcyte (First meiotic division completed, start of second meiotic division)	2N, 4C
	Tertiary follicle		Secondary oöcyte + polar body I (Ovulation)	1N, 2C
	Ovulated ovum		Secondary oöcyte + polar body I (Arrested at metaphase II) (Fertilization – second meiotic division completed)	1N, 2C
	Fertilized ovum		Fertilized ovum + polar body II	1N, 1C + Sperm

Summary of the major events in human oögenesis.

Stages of oogenesis:

1) Stage of proliferation:

- Proliferation of oogonia is restricted to **intra-uterine** or prenatal period of life.
- Starts with **PGCs** (2N) which divide **mitotically** to give rise to **oogonia** (2N).
- Oogonia proliferate by **mitosis** and when enlarge, they form **primary oocytes** (2N).

2) Stage of growth:

- The period of growth is **very prolonged** and the increase in size is very considerable.

- Primary oocytes begin **meiosis I** before birth but **arrested in prophase I**.

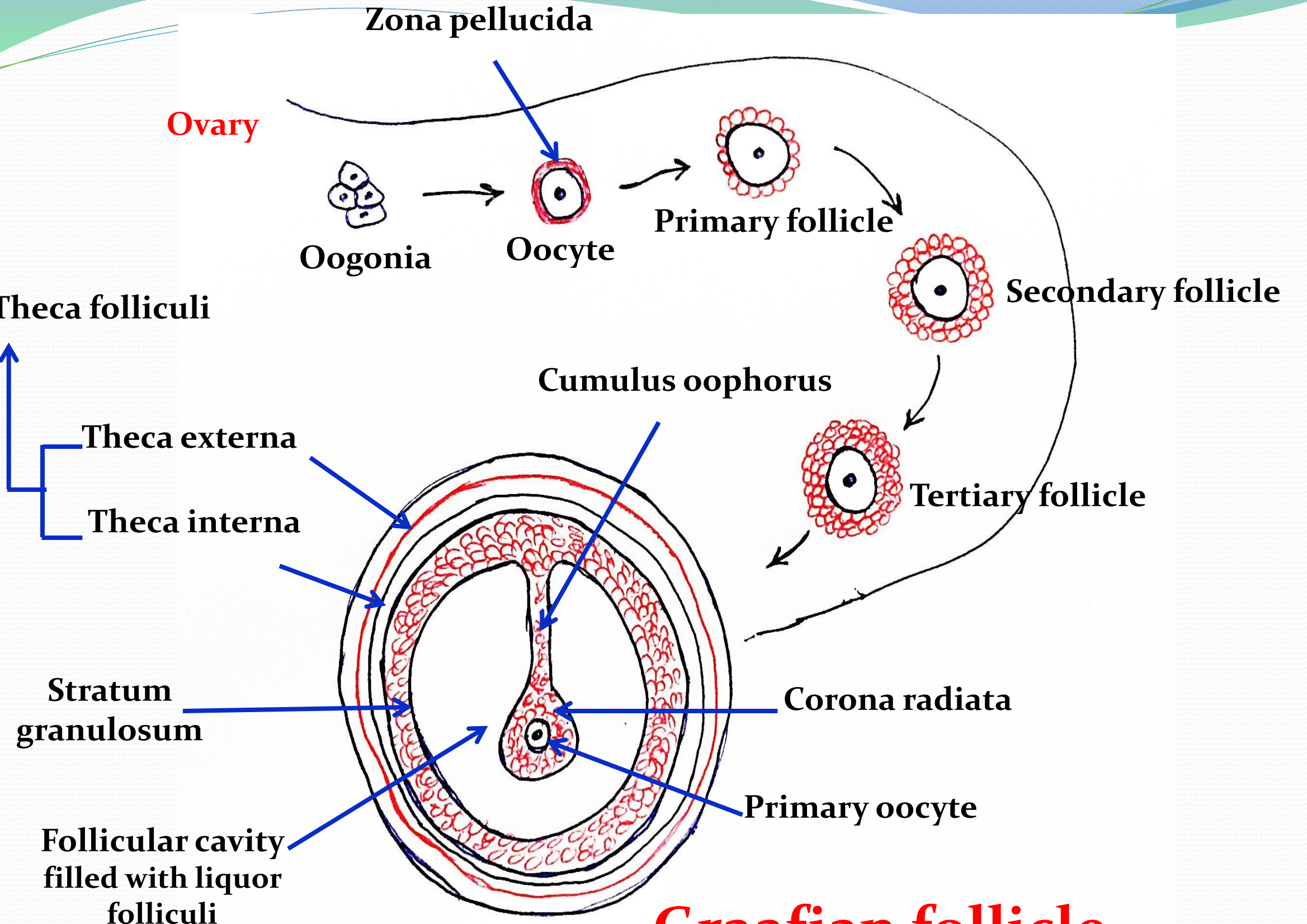
- In contrast to continuous production of primary spermatocytes in males, ***no primary oocytes formed after birth in females*** and so female is born with limited number of primary oocytes.

- The primary oocyte increases in size several times with stored food material in its cytoplasm and is surrounded by the **vitelline membrane** and also with a membrane known as **zona pellucida (oolemma)** which is produced by the follicular cells.
- The oocyte is surrounded by one layer of follicle cells and the number of follicle cells increases greatly and become arranged in several rows.

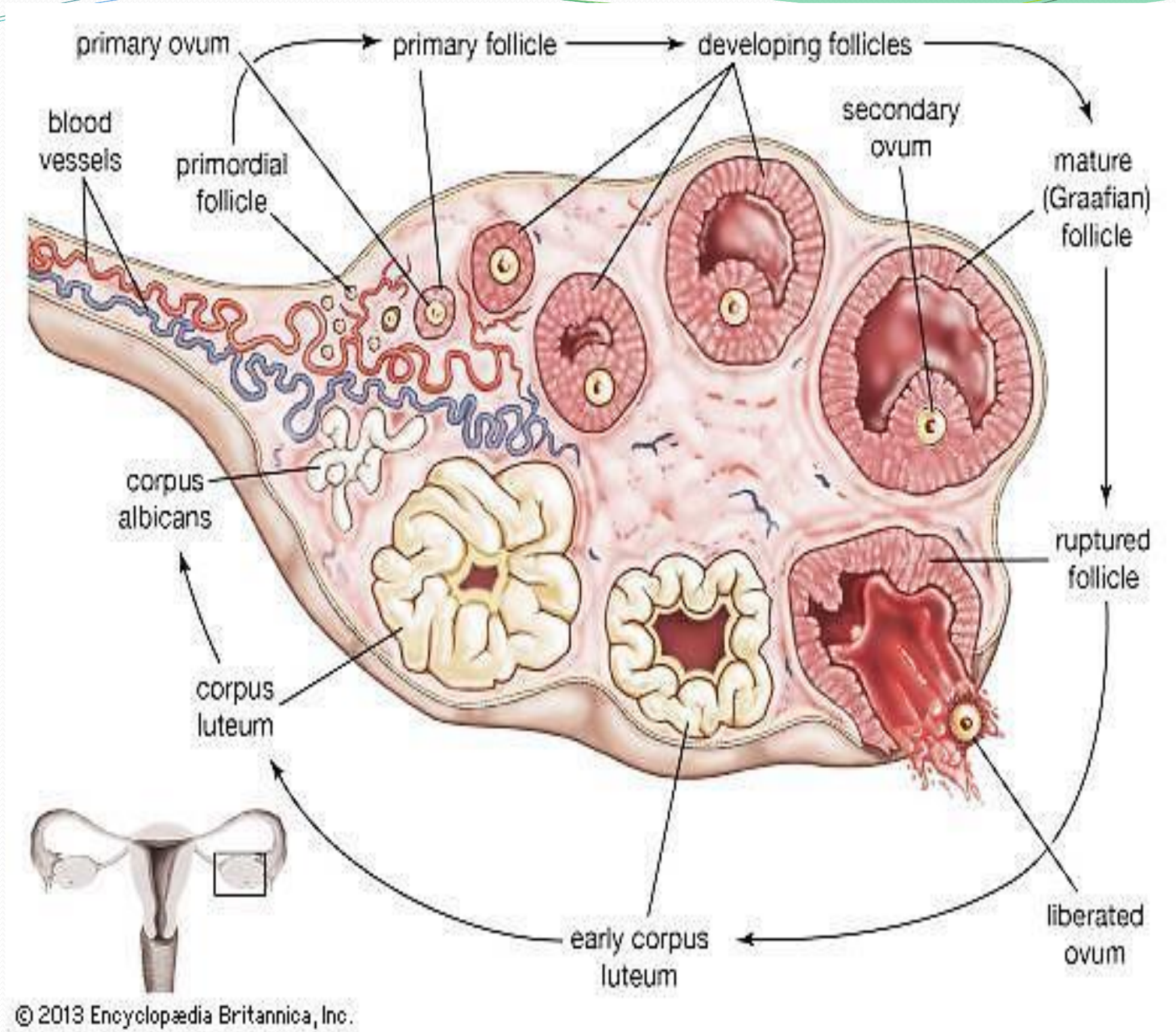
- An eccentric cavity **(antrum)** appears in the mass of the follicular cells. This cavity is filled with fluid termed the **liquor folliculi**, which is secreted by the follicular cells.

- The oolemma of the ovum is surrounded by radially arranged follicular cells known as **corona radiata**.

- The follicle now is known as **Graafian follicle** which moves towards the surface of ovary.



Graafian follicle


primary ovum
primary follicle
developing follicles
blood vessels
primordial follicle
secondary ovum
mature (Graafian) follicle
corpus albicans
ruptured follicle
corpus luteum
early corpus luteum
liberated ovum
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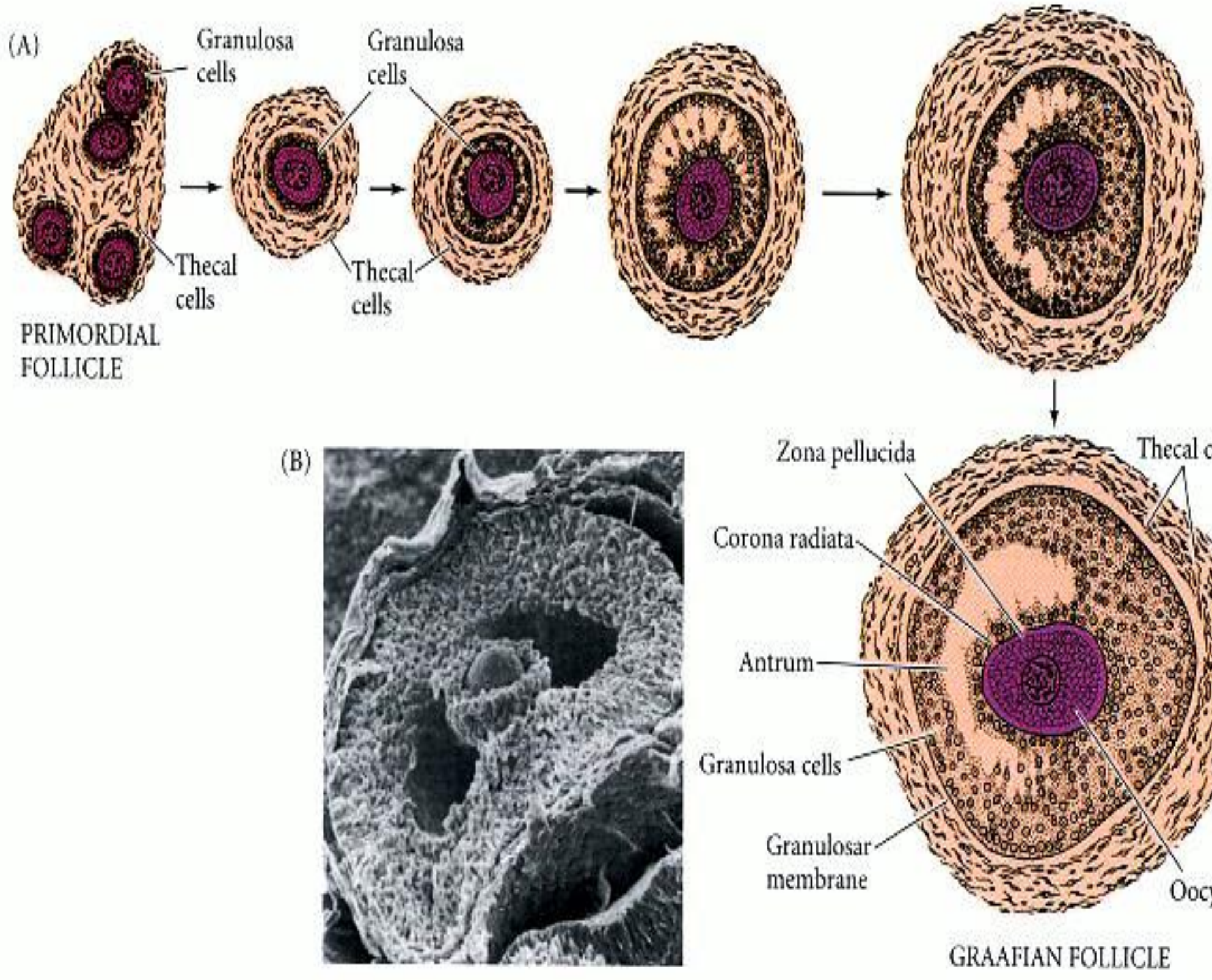
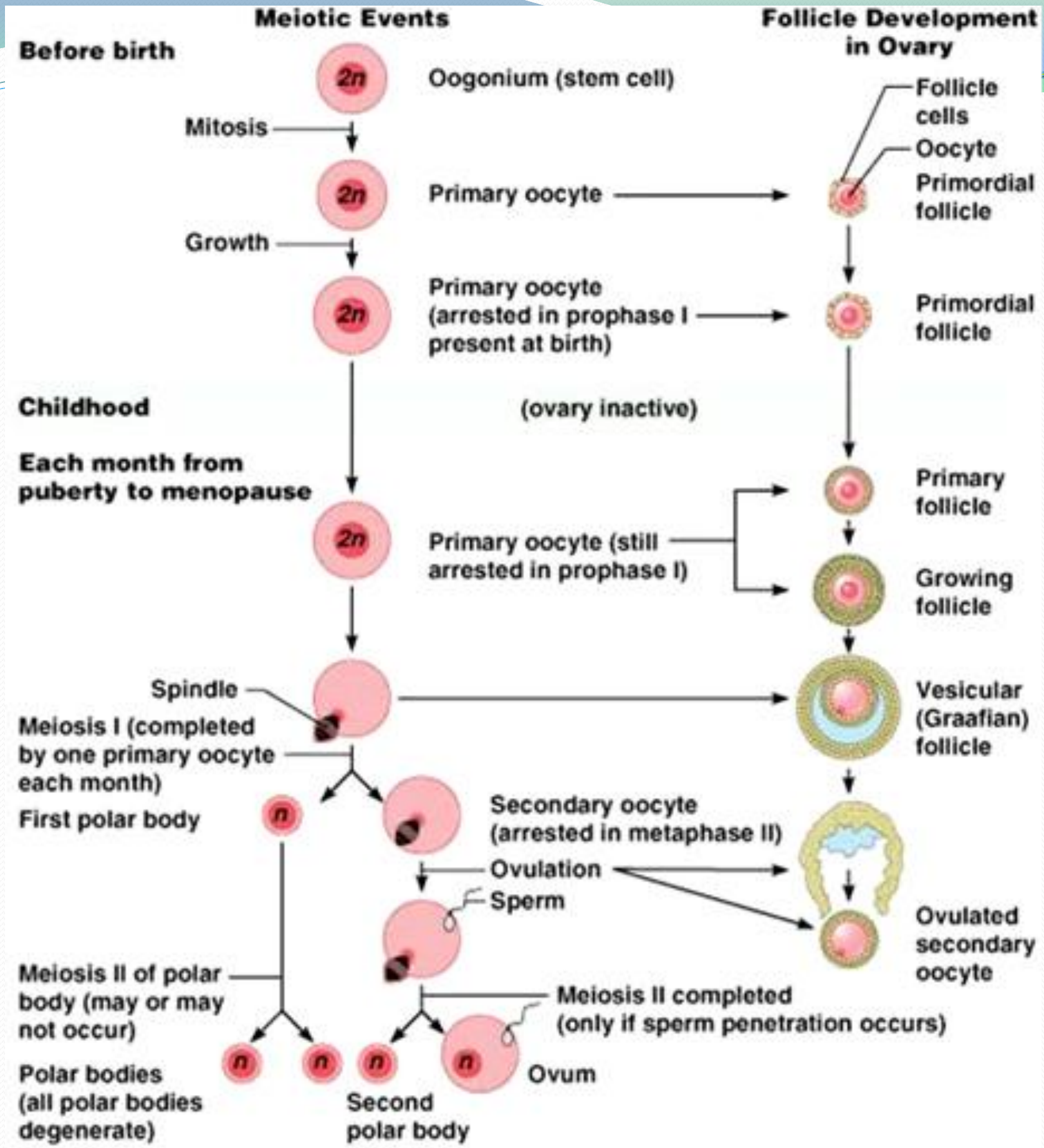

(A)
Granulosa cells
Granulosa cells
Thecal cells
Thecal cells
PRIMORDIAL FOLLICLE
(B)
Zona pellucida
Thecal cells
Corona radiata
Antrum
Granulosa cells
Granulosar membrane
Oocyte
GRAAFIAN FOLLICLE

3) Stage of maturation:

-The maturation occurs **postnatally** through 2 meiotic divisions.

-**In the first meiosis**: primary oocyte completes Meiosis I **just before ovulation** giving a **secondary oocyte** (1N, large) and **first polar body** (1N, small, soon degenerates).

-**In the second meiosis**: secondary oocyte begins Meiosis II **at time of ovulation** but arrested at Metaphase II. **After fertilization**, secondary oocyte completes Meiosis II forming **ootid** (1N) and **second polar body** (1N, small).


Meiotic Events
Follicle Development in Ovary
Before birth
2n
Oogonium (stem cell)
Follicle cells
Oocyte
Mitosis
2n
Primary oocyte
Primordial follicle
Growth
2n
Primary oocyte (arrested in prophase I present at birth)
Primordial follicle
Childhood
(ovary inactive)
Each month from puberty to menopause
2n
Primary oocyte (still arrested in prophase I)
Primary follicle
Growing follicle
Spindle
Vesicular (Graafian) follicle
Meiosis I (completed by one primary oocyte each month)
First polar body
n
Secondary oocyte (arrested in metaphase II)
Ovulation
Sperm
Ovulated secondary oocyte
Meiosis II of polar body (may or may not occur)
Meiosis II completed (only if sperm penetration occurs)
n
n
n
n
Polar bodies (all polar bodies degenerate)
Second polar body
Ovum

Results of oogenesis:

- **Reduction of number of chromosomes into half by meiotic division.**
- **Accommodation of the ovum to be ready for fertilization.**

Folliculogenesis:

-It means the growth and development of ovarian follicles from primordial to ovulatory stages.

Developmental Stages of folliculogenesis:

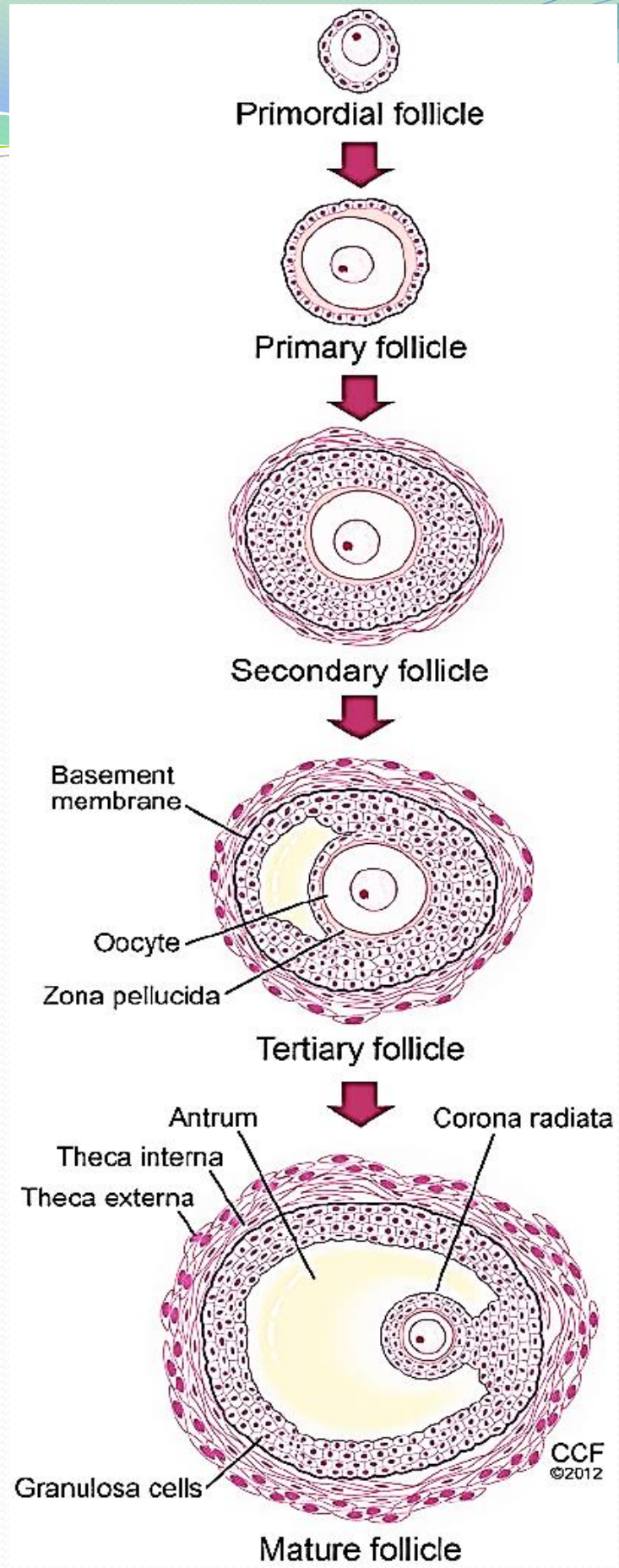
1- Primordial follicle.

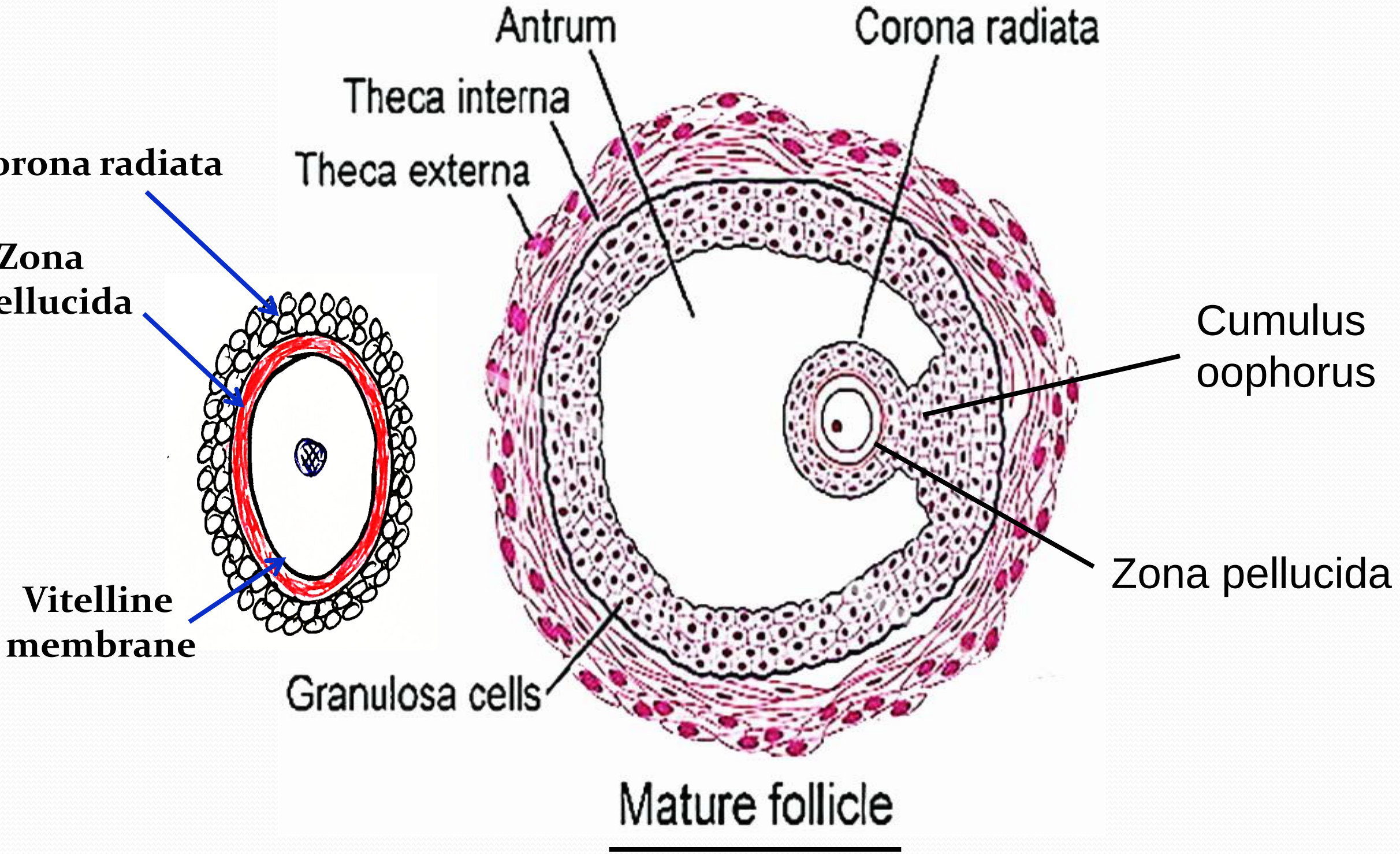
2- Primary follicle.

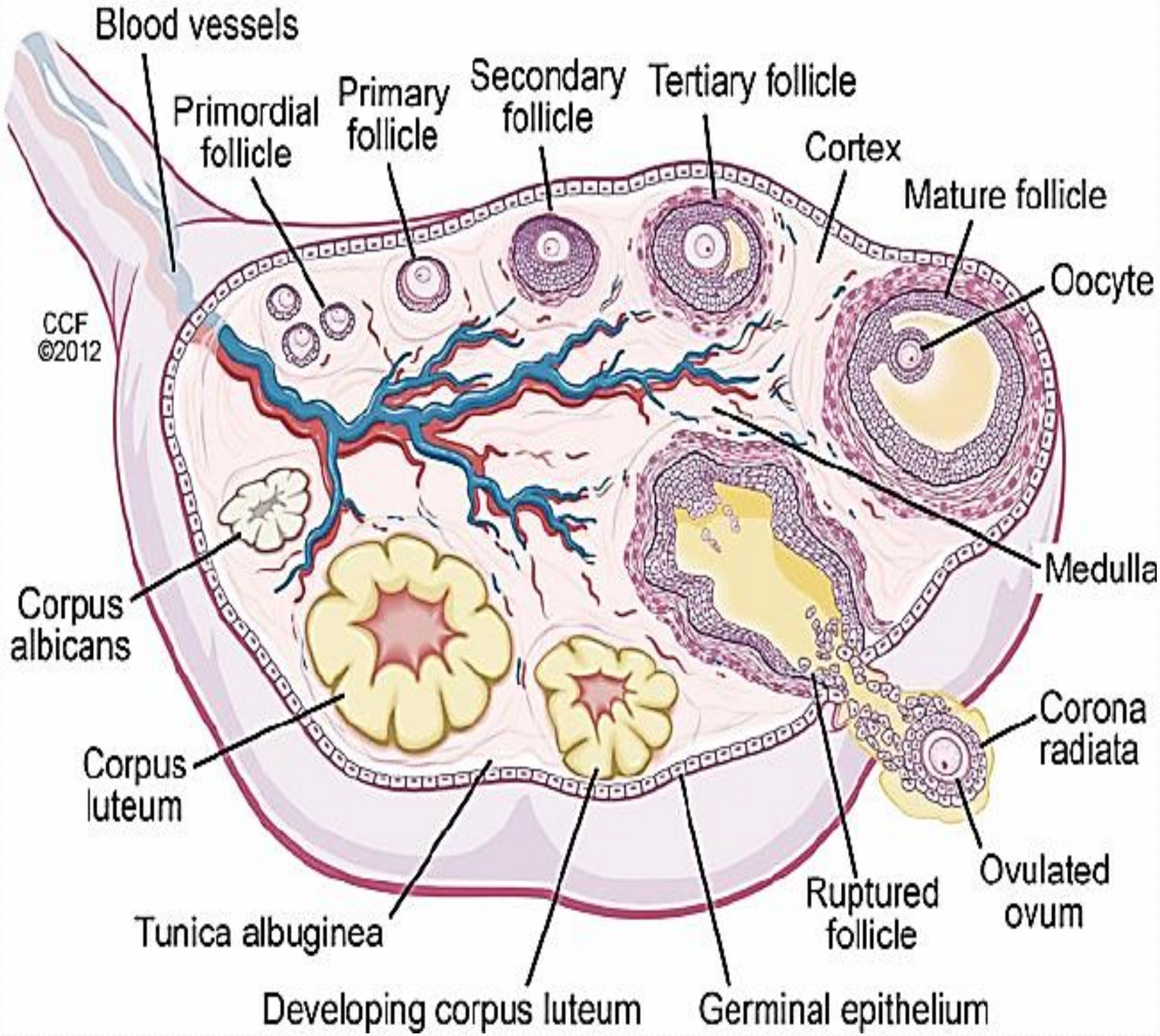
3- Secondary follicle.

4- Tertiary (antral) follicle.

5- Graafian (mature) follicle.




Antrum
Corona radiata
Theca interna
Theca externa
Corona radiata
Zona pellucida
Vitelline membrane
Cumulus oophorus
Zona pellucida
Granulosa cells
Mature follicle


Blood vessels
Primordial follicle
Primary follicle
Secondary follicle
Tertiary follicle
Cortex
Mature follicle
Oocyte
CCF ©2012
Medulla
Corpus albicans
Corpus luteum
Corona radiata
Tunica albuginea
Ruptured follicle
Ovulated ovum
Developing corpus luteum
Germinal epithelium

Menstruation (human) and estrous (animals) cycle

- **Menstruation cycle in human has 4 successive phases: menstrual, proliferative, luteal and ischemic phases.**
- **Similarly, estrous cycle in animals has 4 successive phases:**

1) **Proestrous: includes menstrual and proliferative phases.**
2) **Estrous (heat): 1st period of luteal phase in which ovulation occurs.**
3) **Metestrous: middle period of luteal phase.**
4) **Diestrous: last luteal phase and ischemic phase.**

Ovulation:

-It means the rupture of the graafian follicle and releasing of the ovum.

Predisposing factors which may induce ovulation:

1-Increasing the **intrafollicular pressure** resulted from muscular contraction of theca layer and increased secretion of the liquor folliculi.

2-Hormones: Follicle stimulating hormone (FSH) and Luteinizing hormone (L.H) released by the anterior pituitary gland.

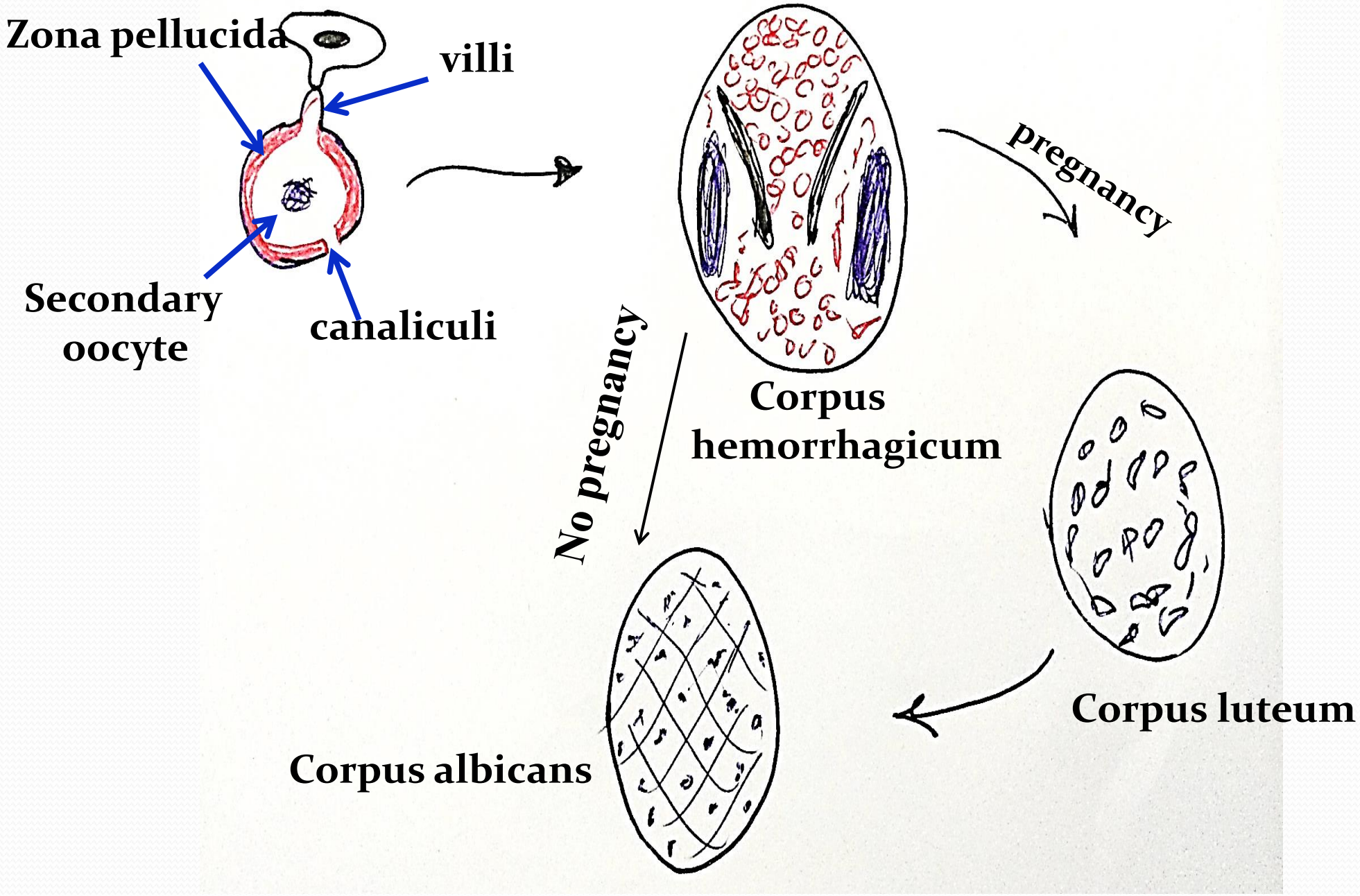
3-**Enzymatic action**: follicular cells secrete enzymes causing retardation of blood supply and thinning of the wall **(stigma)** and local lytic enzyme activity.

- Shortly before the ovulation, the first meiosis takes place.

- The second reduction division is not completed unless the oocyte has been penetrated by the sperm.

- The ovulation is followed by the formation of **corpus hemorrhagicum** followed by formation of **corpus luteum (C.L)** which maintains the pregnancy.

- During the 2nd half of pregnancy, C.L is regressed and phagocytized followed by formation of **corpus albicans**.



***N.B**: Ovulation occurs periodically in most animals and human (monthly) but it is induced by incidence of copulation in some animals like rabbit and cat.*

Types of Ova

- The ova can be classified according to:

A) The relative amount of yolk:

1- Microlecithal or minolecithal: This ovum contains a **little** amount of yolk.

- e.g mammals and amphioxus.

2- Mediolecithal: This ovum contains a **moderate** amount of yolk.

- e.g amphibian.

3- Megalecithal (Macrolecithal): This ovum contains a huge or **large** amount of yolk.

- e.g birds and arthropods or insects.

B) The distribution of yolk in the cytoplasm:

1- Isolecithal: in which the yolk is distributed **uniformly** in the cytoplasm.

- e.g mammals and amphioxus.

2- Telolecithal: in which the yolk is concentrated in **one pole** known as vegetal pole.

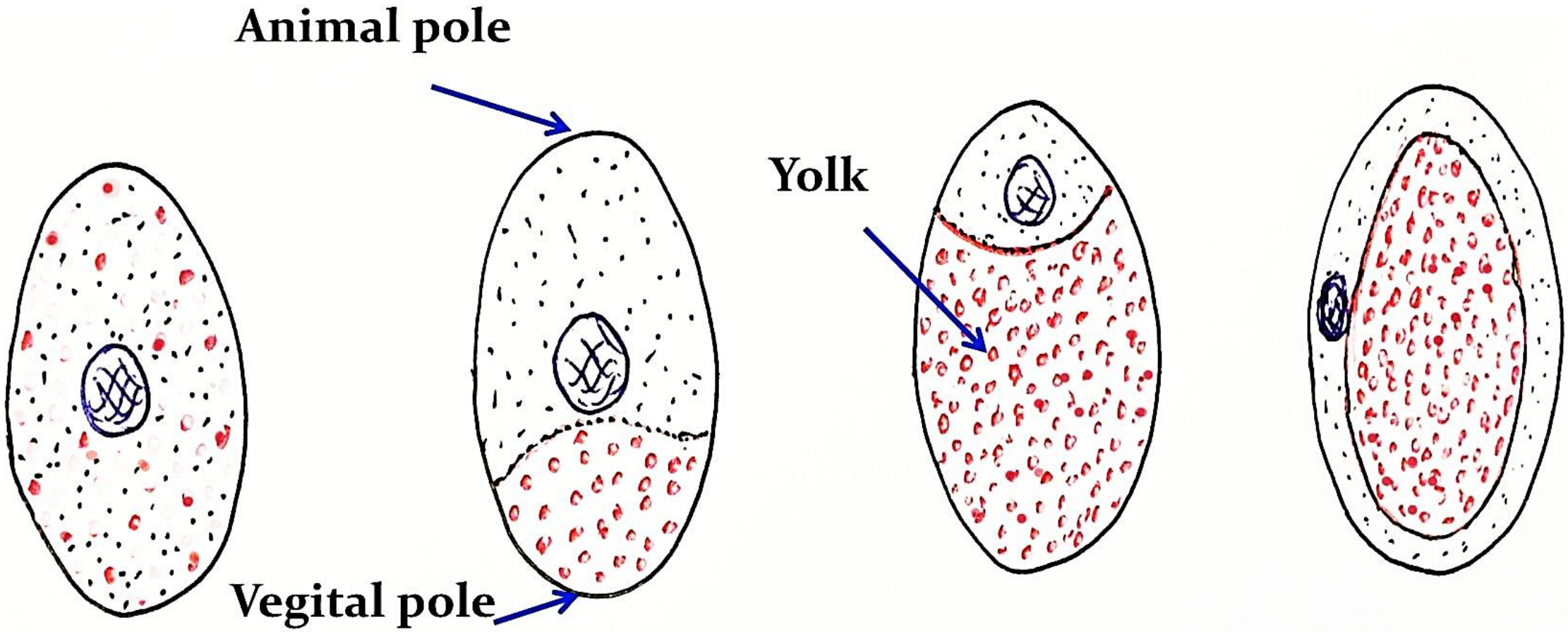
- e.g amphibian and birds.

3- Centrolecithal: in which the yolk is massed **centrally** surrounded by a peripheral shell of clear cytoplasm.

- e.g Arthropods or insects.

Therefore, on these two bases of classification, the ovum of:

- **Mammals and amphioxus** is ***isolecithal minolecithal.***
- **Amphibian** is ***telolecithal mediolecithal***.
- **Birds** is ***telolecithal megalecithal***.
- **Arthropods or insects** is ***centrolecithal megalecithal.***



Isolecithal
Minolecithal
- **mammals, amphioxus**

Telolecithal
Mediolecithal
- **amphibians**

Telolecithal
Megalecithal
- **birds**

Centrolecithal
Megalecithal
- **Arthropods**

Types of Ova

Membranes of Ovum

1) Primary membrane:

- It is produced by the cytoplasm of the ovum and known as the **cell or Vitelline membrane**.

2) Secondary membrane:

- It is a membrane known as **oolemma or zona pellucida** produced by follicular cells.

- Out side the oolemma, the ovum is surrounded by radially arranged follicle cells known as **corona radiate**. Extensions of the follicle cells pass through radial canals in zona pellucida and reach the surface of the ovum.

3) Tertiary membranes:

- They are added by the oviduct when the egg passes through it such as:

* jelly around the frog egg.

* albumen around the rabbit's egg.

* albumen, shell membrane and shell in the hen's egg.

Vitelline membrane

Zona pellucida (oolemma)

Corona radiata

Cytoplasm

Primary membrane

Secondary membrane

Air sac

Shell

Outer shell membrane

Inner shell membrane

Albumin

Vitelline membrane

Yolk

Birds

Jelly material

Tertiary membrane

Albumin

Frog

Rabbit

Oogenesis in mammals

The main characters of oogenesis in mammals are:

1- The oogonia arise from **mitotically** dividing primordial germ cells in the embryonic ovary.

2- The proliferation stage of the oogonia is restricted only to the intra-uterine period of life (**prenatal period**).

3- By the time of birth, the oogonia have begun the **long slow** growth period that makes their transition to primary oocytes.

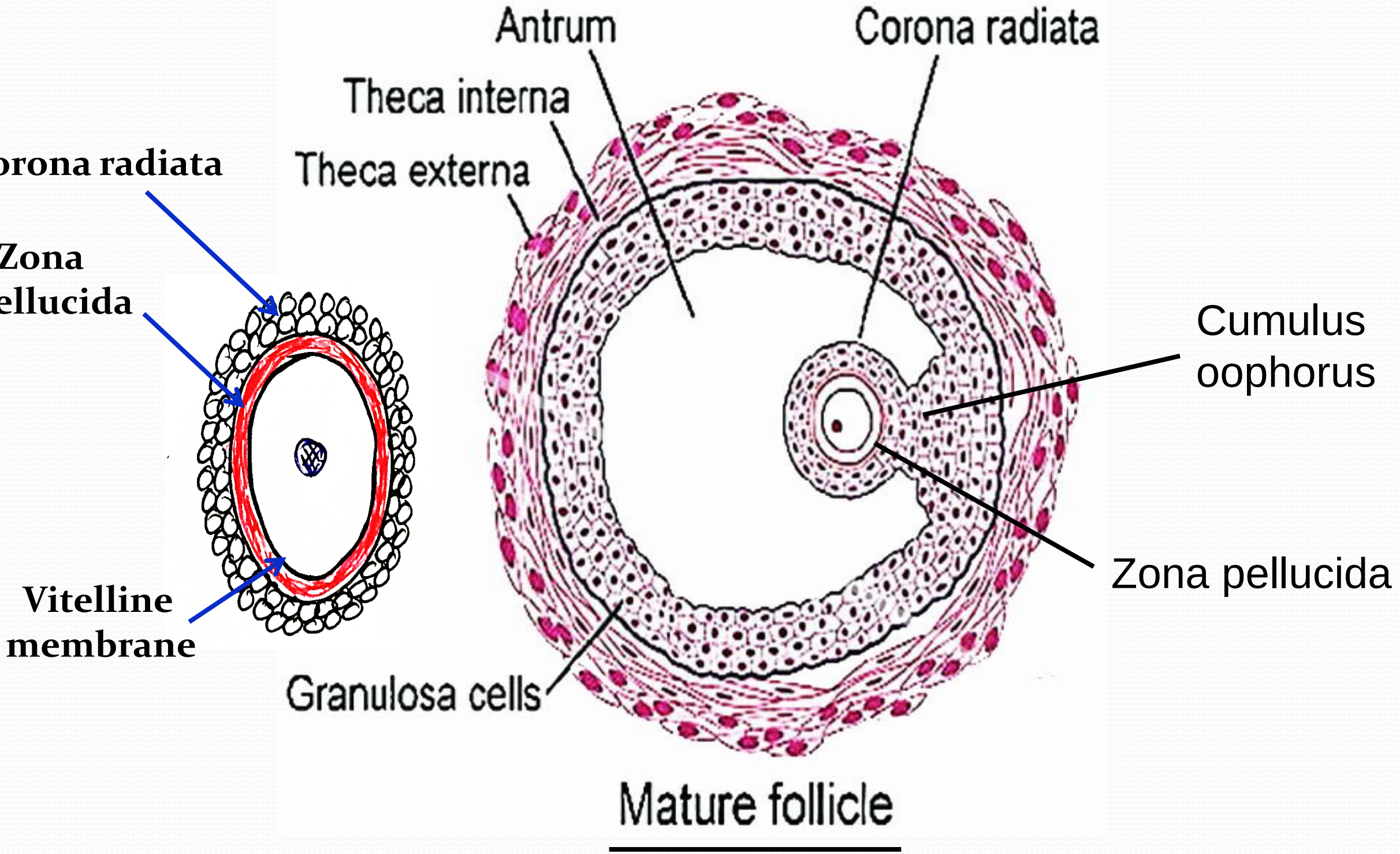
4-As sexual maturity approaches, the primary oocyte further increases in size, surrounded by several layers of follicular cells and an antrum begins to develop in the mass of follicular cells filled with **liquor folliculi** which is secreted by the follicular cells.

5-The enlarging growing follicle **(Graafian follicle)** moves towards the surface of the ovary and the increasing liquor folliculi causes it to protrude above the surface of the ovary.

6- The yolk content in mammalian ova is relatively small and uniformly distributed **(Isolecithal, Microlecithal)**. The ovum has vitelline membrane and the zona pellucida or oolemma which surrounded by radially arranged corona radiate cells.

7- With increase in liquor folliculi, most of the follicular cells are crowded peripherally to constitute **the stratum granulosum** which surrounded by condensation of ovarian C.T forming **theca folliculi.**

8- The follicular cells form a hillock projecting from the stratum granulosum into the antrum, known as **the cumulus oophorus**.


Antrum
Corona radiata
Theca interna
Theca externa
Corona radiata
Zona pellucida
Vitelline membrane
Cumulus oophorus
Zona pellucida
Granulosa cells
Mature follicle

Oogenesis in birds

The main characters of oogenesis in birds are:

1- The female sex cell is **large** in size as compared with the other cells due to accumulated food materials in its cytoplasm.

2- The **yolk** is synthesized **in the liver** and transported via the blood to the follicular cells which transfer the yolk materials to the ovum.

3- The region of the ovum containing the nucleus and the active cytoplasm is known as **animal pole** while the opposite region is called the **vegetal pole**.

4- The bird egg is **telolecithal megalecithal**. When the full amount of yolk has accumulated in the ovum, the theca layer is ruptured and the ovum is liberated into the oviduct.

5-The **first** maturation division occurs **at time of ovulation** (but in mammals, completed before ovulation) while the second one does not usually occurs unless the ovum is penetrated by a sperm cell.


Thank
You