EMBRYOLOGY

PRESENTED BY

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Embryology derived from *Greek* word *embryon* (“the unborn’’) and *logia* (study).

Embryology is the study of the formation and development of the embryo or fetus from the moment of its conception upto the time when it is born as infant.

The growth and development of such an organism stipulated within a specific period-

1. Embryonic development
2. Fetal development

Total period of development is of nine months i.e. 38 weeks or 266 days.

During the embryonic period (first eight weeks after fertilization), the single cell, i.e. zygote is converted into a form that externally resembles the adult and all the primitive organs and systems are formed. During these two months we call the developing individual an embryo.

Further development and functional maturation of various organs and systems which take place in fetal period. From third month until birth we call it a fetus.

Branches of Embryology

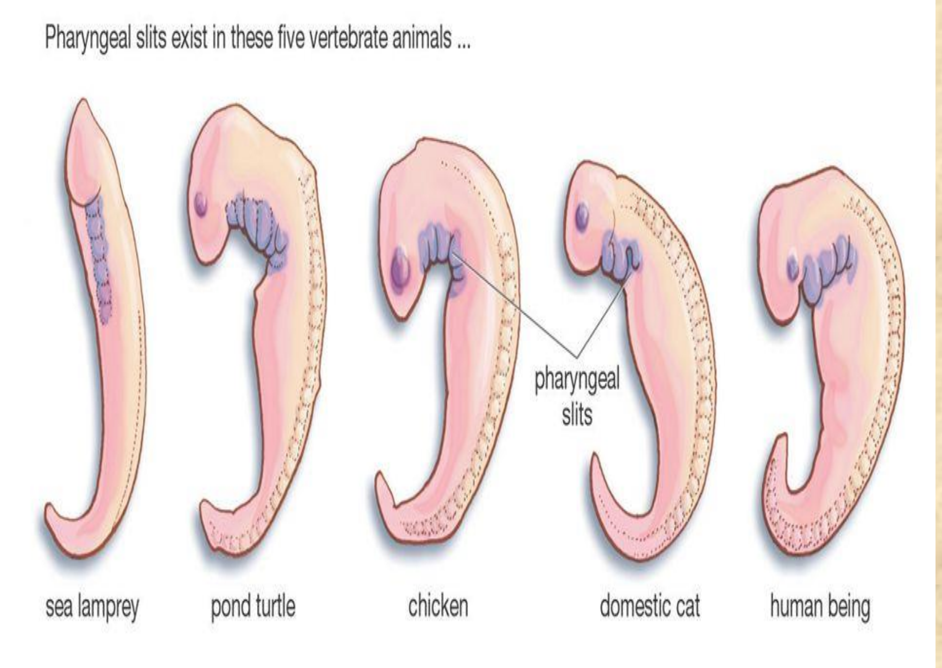
- Descriptive Embryology
- Comparative Embryology
- Experimental Embryology
- Chemical Embryology
- Teratology
- Developmental Embryology

Descriptive Embryology

The study of the changes that occur in cells, tissues & organs during the progressive stages of prenatal development

Comparative Embryology

- It is the branch of embryology that compare us and contrasts embryos of different species.
- It is used to show how all animals are related

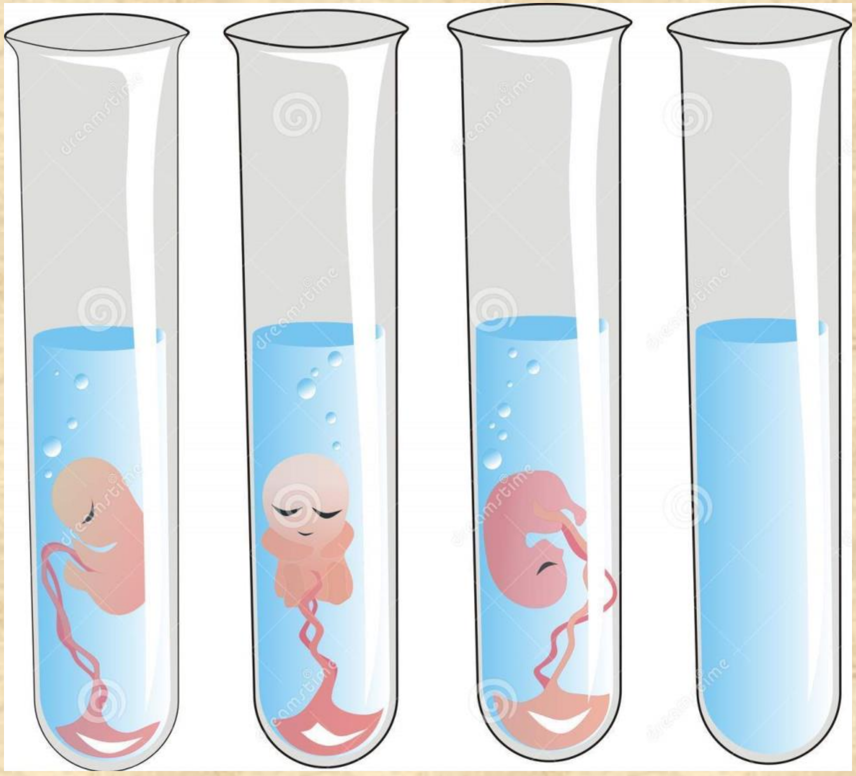


Experimental Embryology

Experiments are used for studying developmental stages.

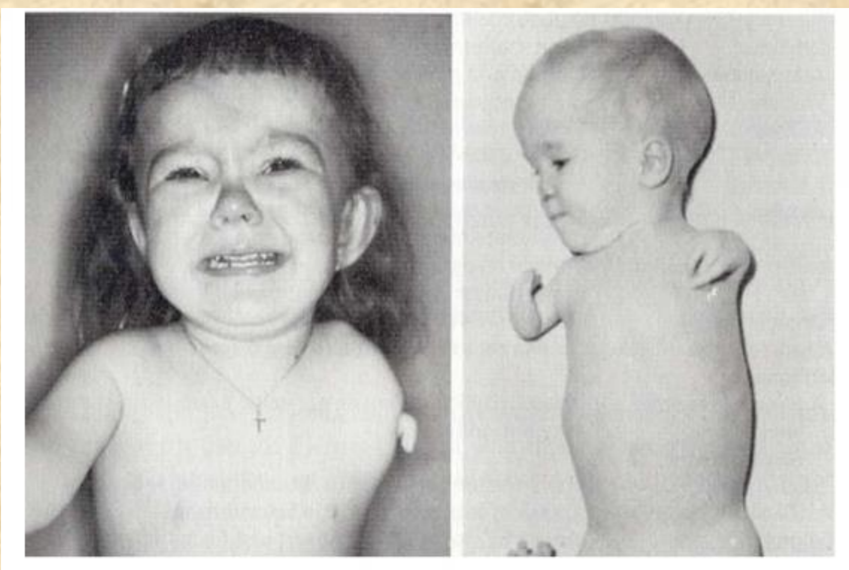
Chemical Embryology

- Developmental stages are studied by bio-chemical physiological techniques, also called Physiological or Bio-Chemical Embryology



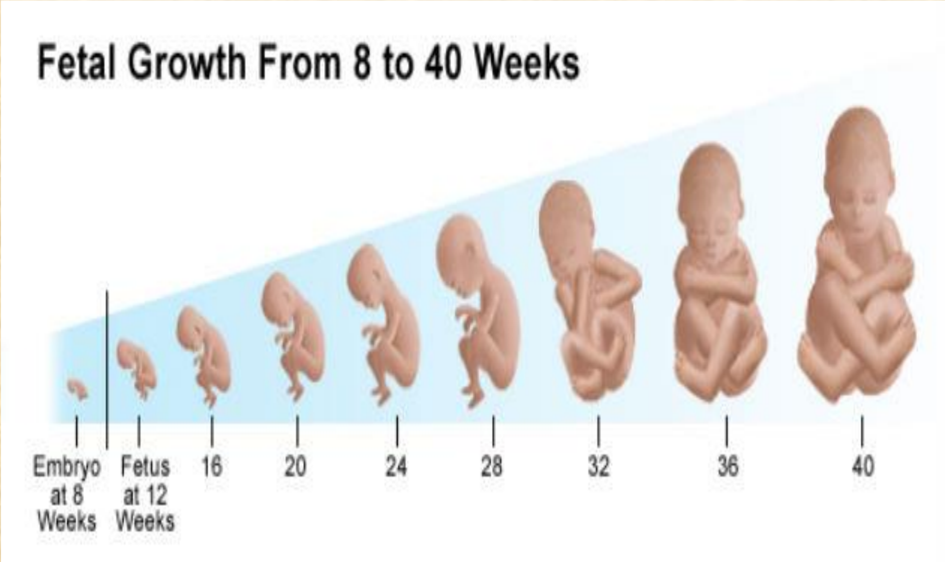
Teratology

It concerned with the study of malformations or abnormal development



Developmental Embryology

It includes not only embryonic development but also postnatal process such us normal & neoplastic growth, metamorphosis, regeneration & tissue repair in both animals & plant.

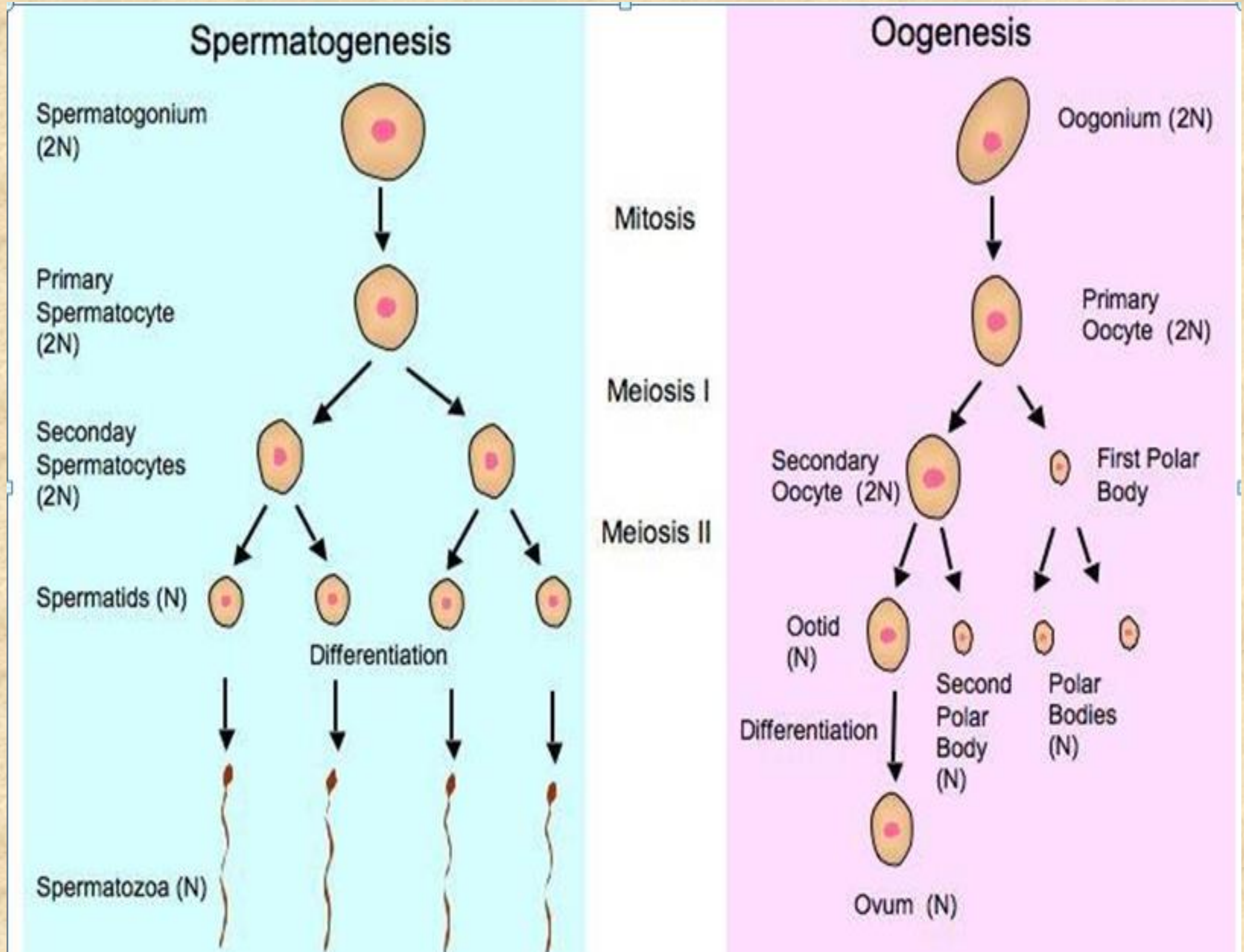


GAMETOGENESIS

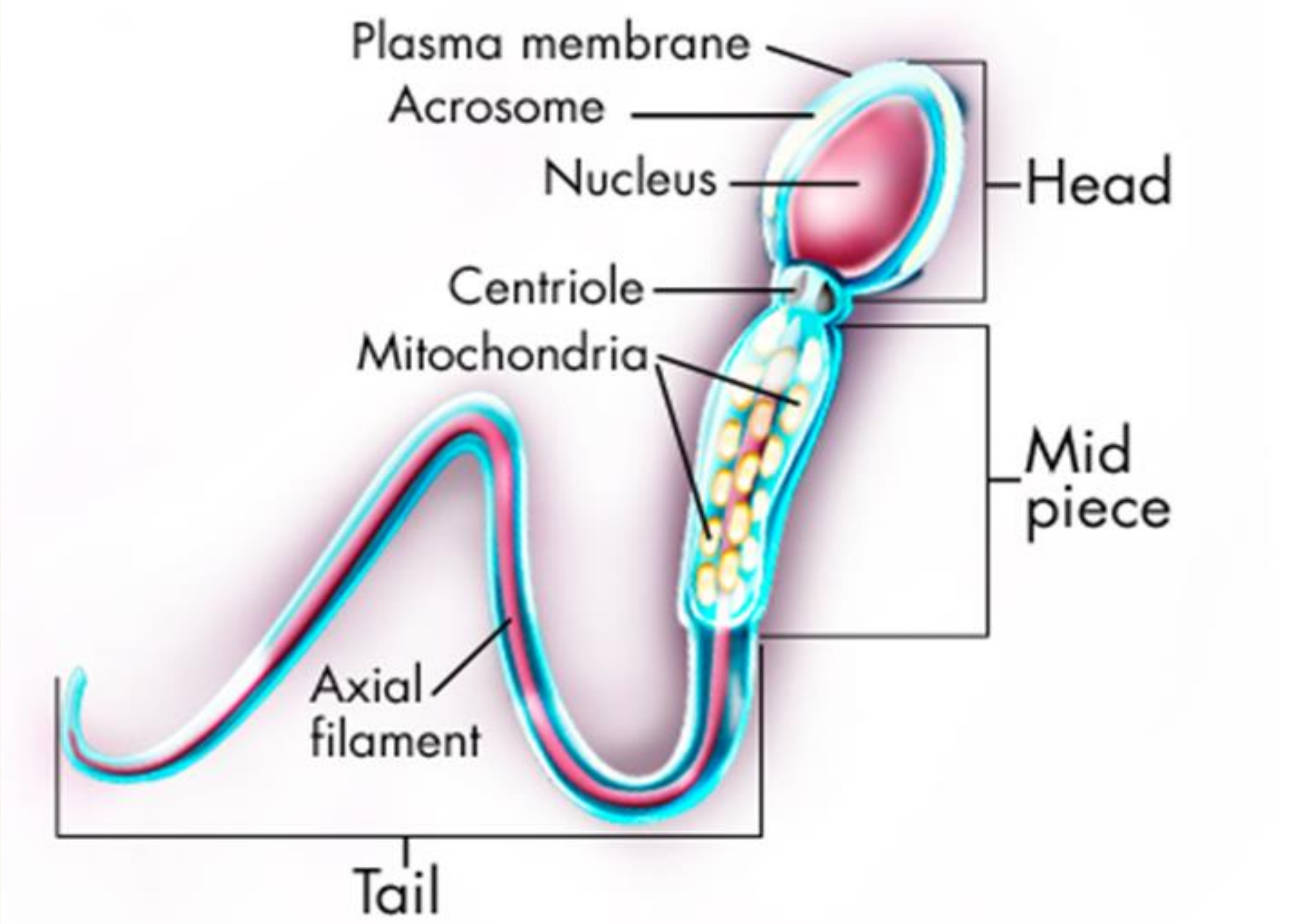
Gametogenesis is the process of formation and development of gametes (oocytes or sperms) from the germ cells in the testes and ovaries.

- Spermatogenesis is the process by which male primordial germ cell called spermatogonia undergo meiosis, and produce a number of cells termed spermatozoa.

- Oogenesis is the sequence of events by which oogonia are transformed into mature oocytes.


Spermatogenesis
Oogenesis
Spermatogonium (2N)
Oogonium (2N)
Mitosis
Primary Spermatocyte (2N)
Primary Oocyte (2N)
Meiosis I
Seconday Spermatocytes (2N)
Secondary Oocyte (2N)
First Polar Body
Meiosis II
Spermatids (N)
Ootid (N)
Differentiation
Second Polar Body (N)
Polar Bodies (N)
Differentiation
Spermatozoa (N)
Ovum (N)

STRUCTURE OF A SPERM



Mature sperms are free-swimming, actively motile cells consisting of a head, middle piece and a tail.

-Head region serves two functions:

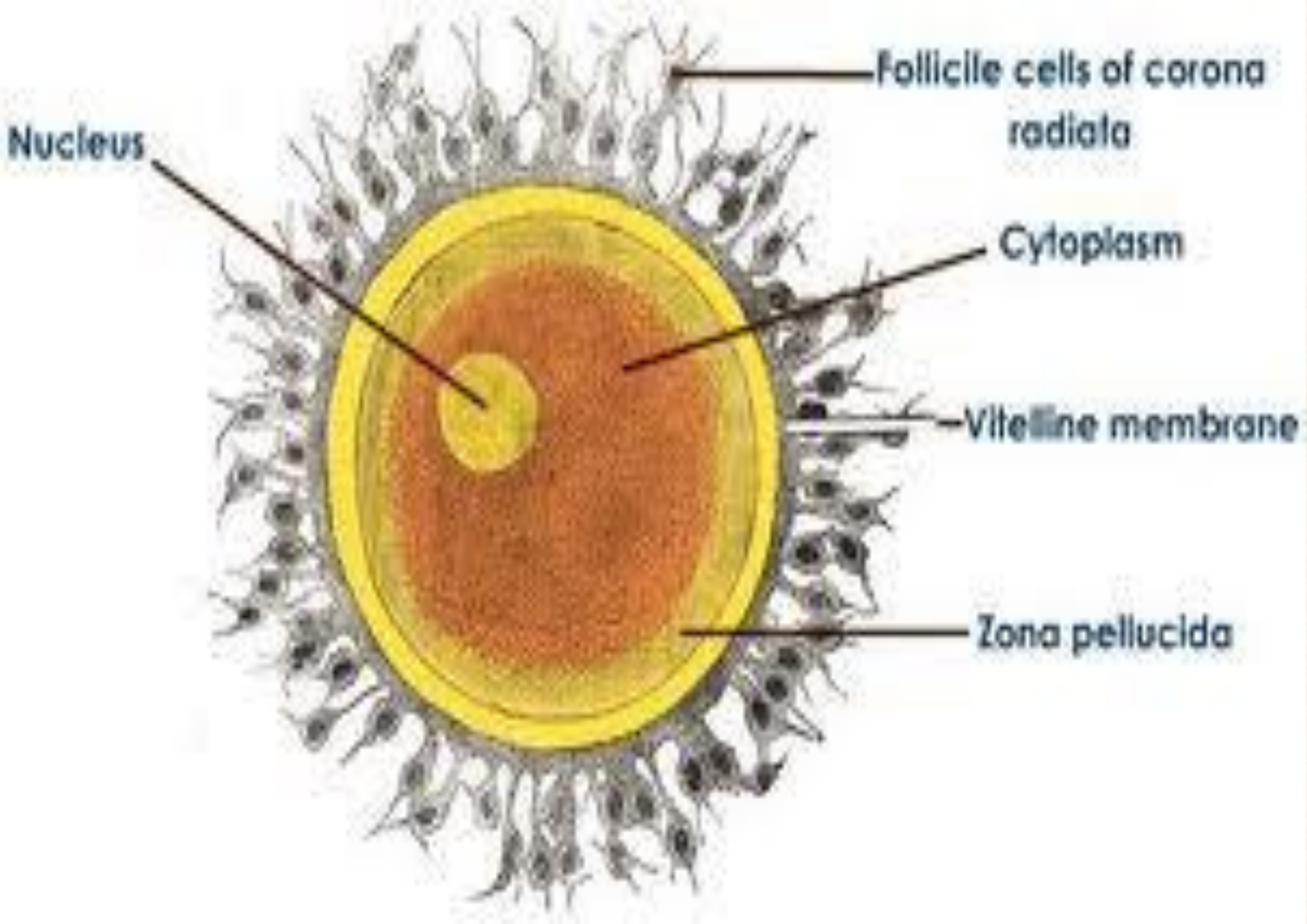
1. Contains haploid nucleus (genetic function)
2. Acrosomal cap = contains enzymes that allow sperm to break down membranes around egg and fertilize egg.

Neck- basal body and centriole

-Tail = provides motility of the sperm

-Mid piece between head and tail contains mitochondria, which provides ATP necessary for activity.

STRUCTURE OF AN OVUM

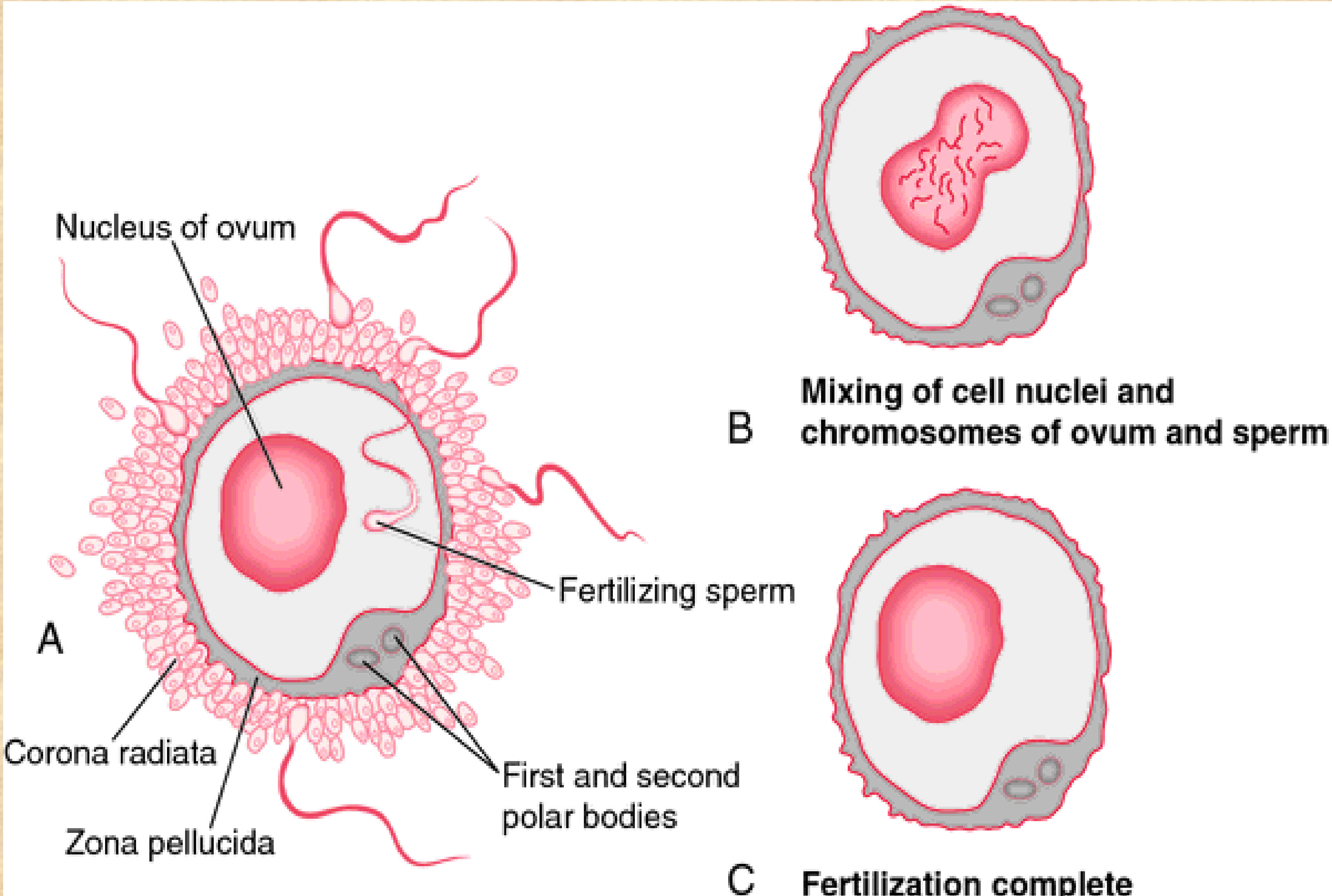


The cell substance is known as the yolk or ooplasm, the nucleus as the germinal vesicle, and the nucleolus as the germinal spot. The ovum is enclosed within a thick, transparent envelope, the zona striata or zona pellucida, adhering to the outer surfaces of which are several layers of cells, constituting the corona radiata.

The shedding of the ovum from the ovary is called ovulation. At the time of ovulation the ovum is not fully mature. It is in fact a secondary oocyte that is undergoing division to shed off the second polar body.

Characters	oocyte	sperm
cell volume	+++	---
condensation of DNA	---	+++
Mobility	---	+++
total number of produced cells	400	Numerous +++
localization in the abdomen	Inside	Outside
temperature needed for differentiation	Warm	Cool

Fertilization



The process by which male and female gametes fuse, occurs in the ampullary part of uterine tube. Only 1% of sperm deposited in the vagina enter the cervix.

Movement of sperm from the cervix to the uterine tube occurs by muscular contraction of uterus and uterine tube and by their own propulsion. Muscular contraction is promoted by the prostaglandins, present in the semen and oxytocin released from the neurohypophysis.

Spermatozoa are not able to fertilize the oocyte immediately upon arrival in the female genital tract but must undergo (1) capacitation and (2) acrosome reaction to acquire this capability.

Capacitation is a period of conditioning in the female reproductive tract that in the human lasts approximately 7 hours. During this time, a glycoprotein coat and seminal plasma protein are removed from the plasma membrane that overlies the acrosomal region of the spermatozoa. Only capacitated sperm can pass through the corona cells and undergoes the acrosome reaction.

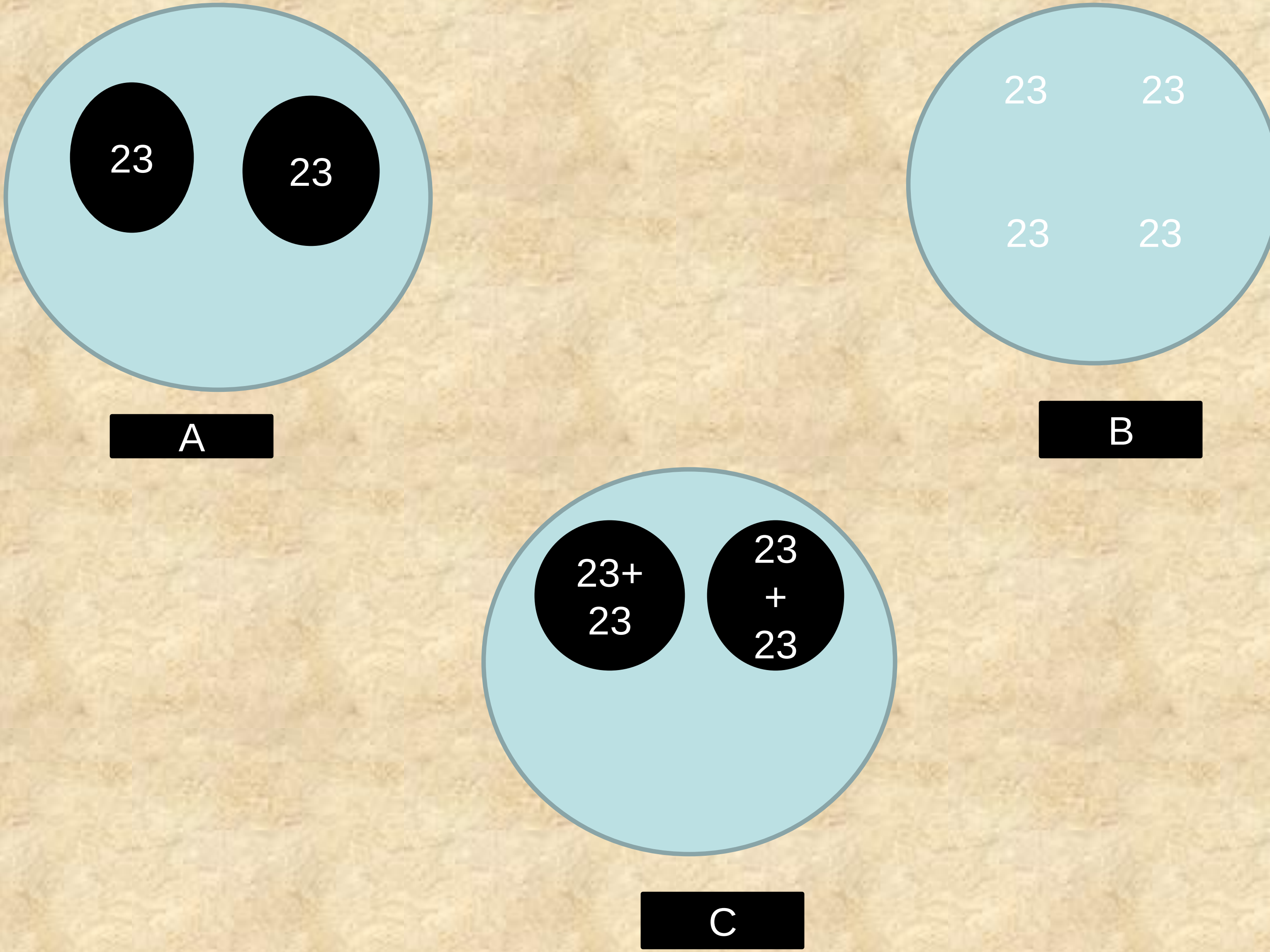
The acrosome reaction, which occurs after binding to the zona pellucida, is induced by zona proteins. This reaction culminates in the release of enzymes needed to penetrate the zona pellucida, including acrosin and trypsin like substances.

Alterations taking place in the plasma membrane of the oocyte and in the ZP, ensure that no other sperm can enter the oocyte.

ZP is altered due to release of lysosomal enzymes by the plasma memb. of the oocyte. This process is called zona reaction.

The phases of fertilization –

1. Penetration of the corona radiate; phase
2. Penetration of the zona pellucida; phase
3. Fusion of the Oocyte and Sperm Cell Membranes- The oocyte finishes its second meiotic division and producing second polar body immediately after entry of the sperm. The oocyte is now considered to be a definitive oocyte. The chromosomes of the oocyte and sperm are then respectively enclosed within female and male pronuclei. These pronuclei fuse with each other to produce the single, diploid, 2N nucleus of the fertilized zygote.


23
23
A
23
23
23
23
B
23+
23
23
+
23
C

Cleavage

Cleavage consists of repeated mitotic divisions of the zygote, resulting in a rapid increase in the number of cells (blastomeres). These embryonic cells become smaller with each successive cleavage division.

Division of the zygote into blastomeres begins approximately 30 hours after fertilization.

Stages of cleavage of human zygote takes place in the following period:

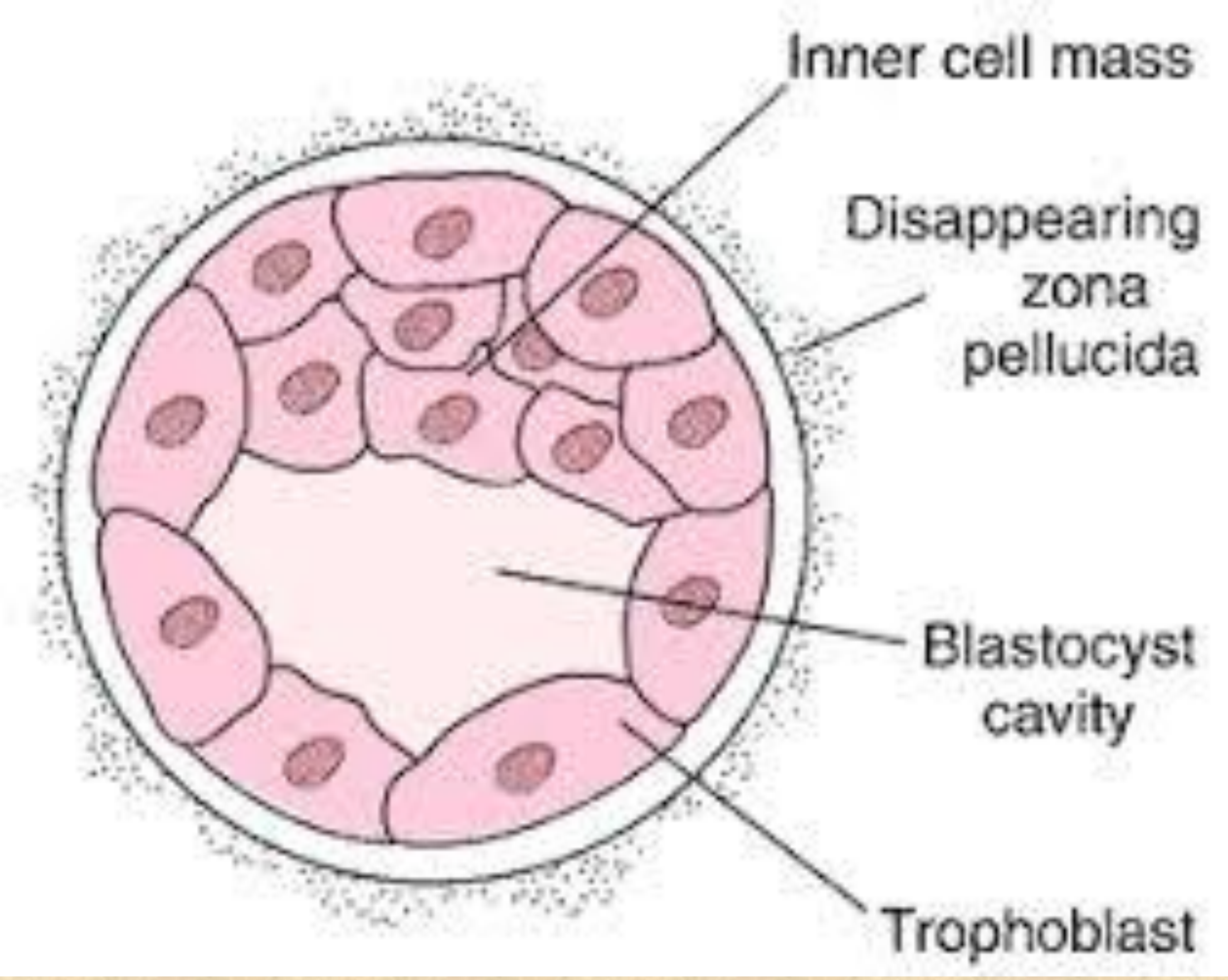
- 2 cell stage approximately 30 hours after fertilization.
- 4 cell stage 40-50 hours after fertilization.
- By 3 days, the embryo consists of 12 to 16 cells (morula).
- By 4 days, the embryo consists of 16 to 32 cells (advanced morula stage).

If we cut a section across the morula, we see that inner cell mass is completely covered by an outer layer i.e. called trophoblast.

Inner cell mass- embryo proper (embryoblasts)

Trophoblast- provide nutriotion to the embryo

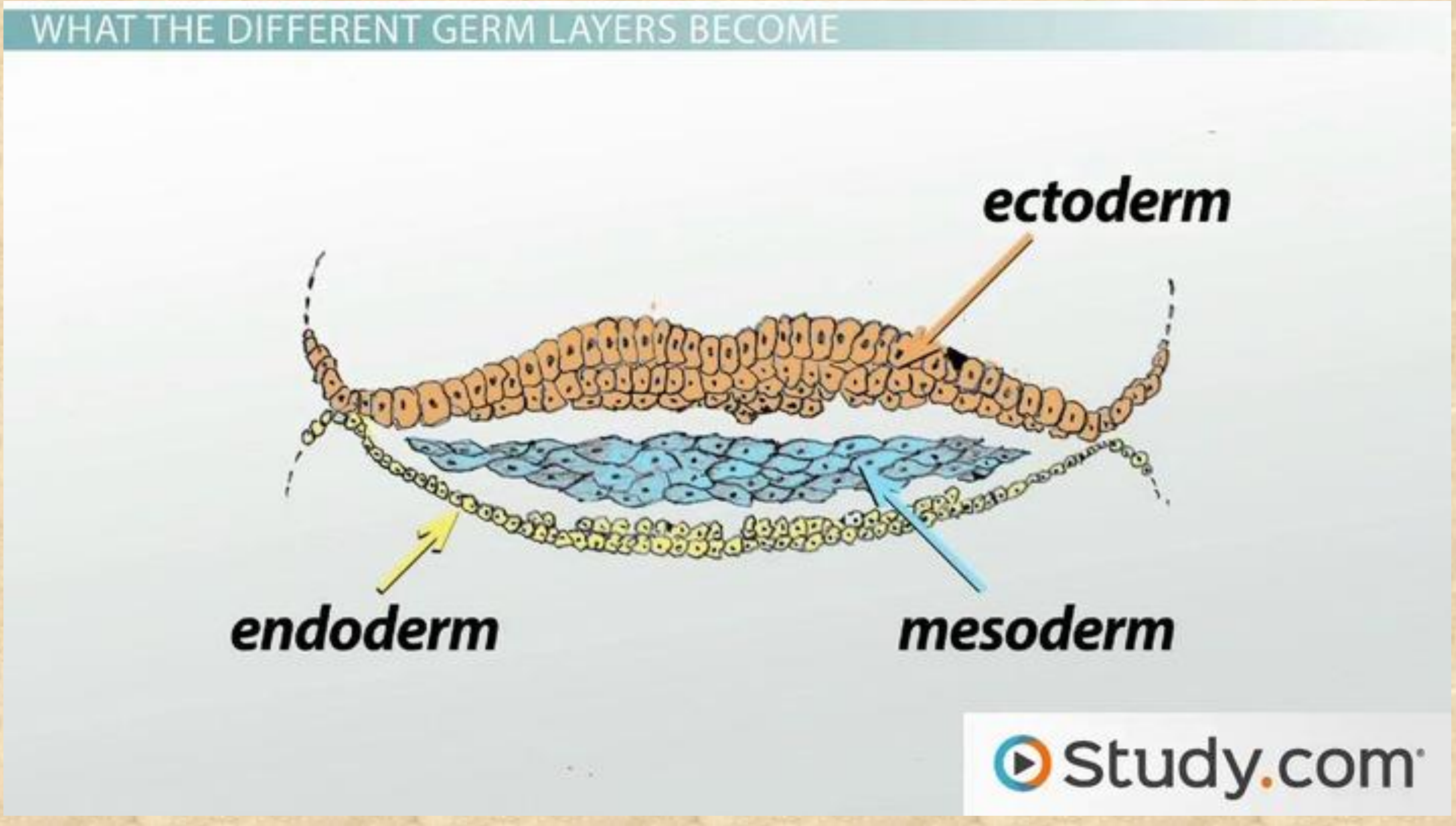
Some fluid now passes into the morula from the uterine cavity and partially separates the cells of the ICM from those of trophoblast. As the quantity of fluid increases, the morula acquires the shape of cyst. Now ICM gets attached to the inner side of trophoblast on one side only (embryonic pole or animal pole) . Morula now become blastocyst. The cavity of the blastocyst is blastocole.


Inner cell mass
Disappearing zona pellucida
Blastocyst cavity
Trophoblast

Germ layer formation

The process that establishes all three germ layers in the embryo is called gastrulation. Gastrulation begins with formation of the primitive streak.

These layers form all of tissues and organs.


WHAT THE DIFFERENT GERM LAYERS BECOME
ectoderm
endoderm
mesoderm
Study.com

Derivatives of germ layers

ECTODERM	MESODERM	ENDODERM
Epidermis of skin, Sweat and sebaceous glands, Mammary gland, Hair, Nail, Enamel of teeth Lens of eye, Anterior pituitary gland, Internal ear, Epithelium of cornea, conjunctiva, ciliary body & iris Brain & spinal cord, Retina, Pineal body Bones of skull	Muscle of head, trunk and limbs, Dermis of skin, Connective tissues, Gonads and gametes, Kidney, Vagina, uterus and uterine tubes, Pleura, pericardium and peritoneum, mesenteries Endocardium and Myocardium	Gut, Liver, Gall bladder Pancreas, Urinary bladder, Urethra, Trachea Bronchi, Lung alveoli Pharynx, Thyroid gland Auditory tube, Tonsils Thymus , Parathyroid

Laws of Heredity

The variety prevalent in mankind as a whole will be attended in view of their nature, size and shape, complexion, voice and psychic attributes etc. irrespective of their species, race and regional involvement.

The progeny resulting out from its parents does not resemble in to its mother and father. The changes in respect of voice, body, structure, complexion etc. are unavoidable. The diversity in respect of health of an individual throughout life period and even the time of departure etc. from this world are variable from man to man and from progeny to progeny from the same parents.

These above said queries are still unreplied to its highest level of satisfaction. The modern science does not hold any satisfactory answer except considering them due to **genetic involvement.** The types of gene responsible in bringing out the change in size, shape, nature, voice, complexion, face cutting etc.

Gregor Mendel, an Austrian monk, in 1865 carried out important studies of heredity. Mendel discovered the basic principles of heredity.

What is Heredity??

Passing of characteristics (traits) from parents to the offspring is called Heredity .

Mendel was the first person to succeed in predicting how traits are transferred from one generation to the next.

Traits - characteristics that are inherited.

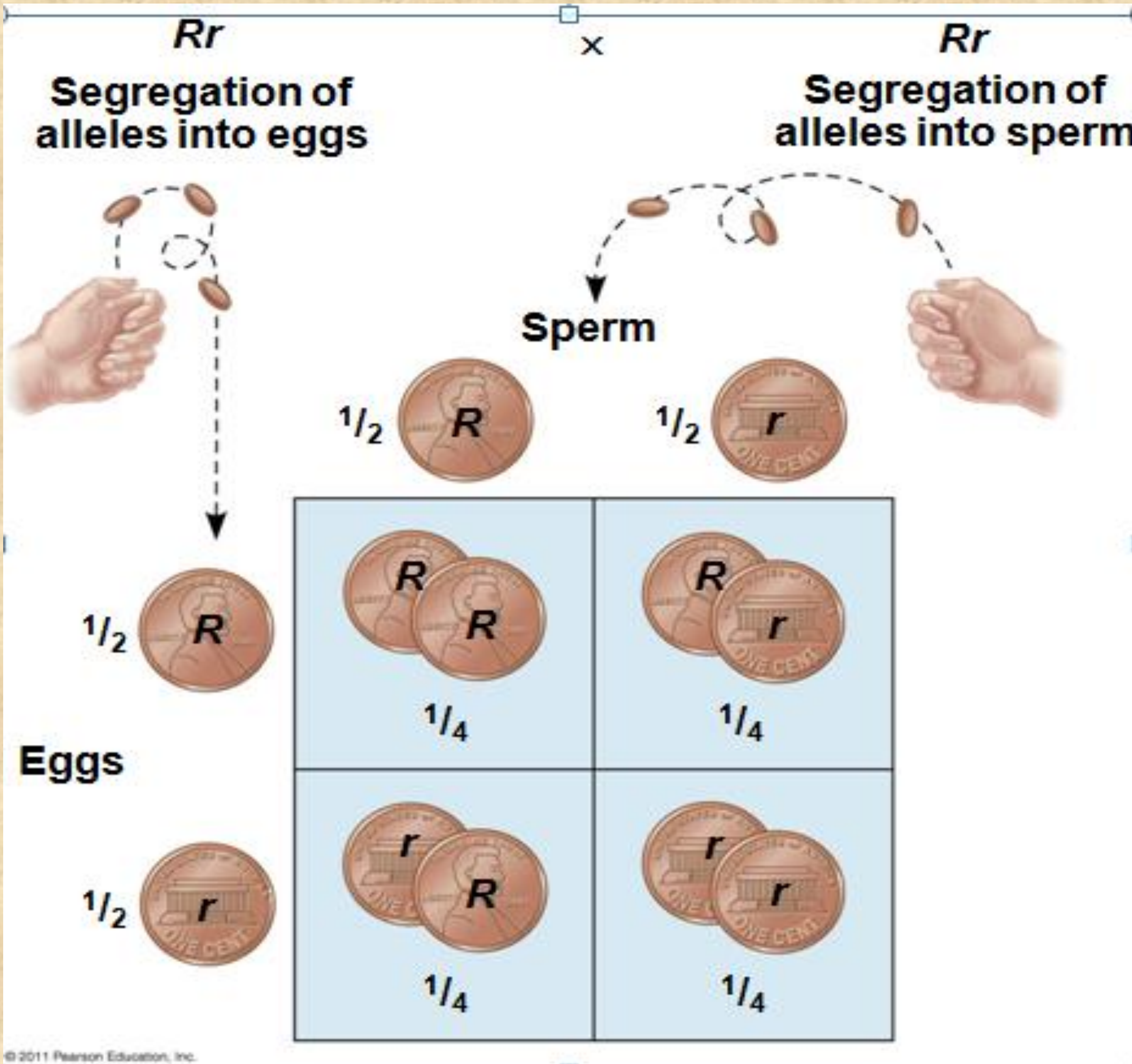
genetics – the study of heredity is called genetics.

Mendal's law-2

1. **The law of segregation:-** every individual has two factors for each trait, and when gametes are produced, each gamete receives one of these factors.

- During fertilization, these gametes randomly pair to produce four combinations of factors.

2. **The law of independent assortment:-** **E**ach pair of factor segregates independently of each other pair of factor during gamete formation.


Rr
×
Rr
Segregation of alleles into eggs
Segregation of alleles into sperm
Sperm
1/2 R
1/2 r
Eggs
1/2 R
1/2 r
R R
1/4
R r
1/4
r R
1/4
r r
1/4

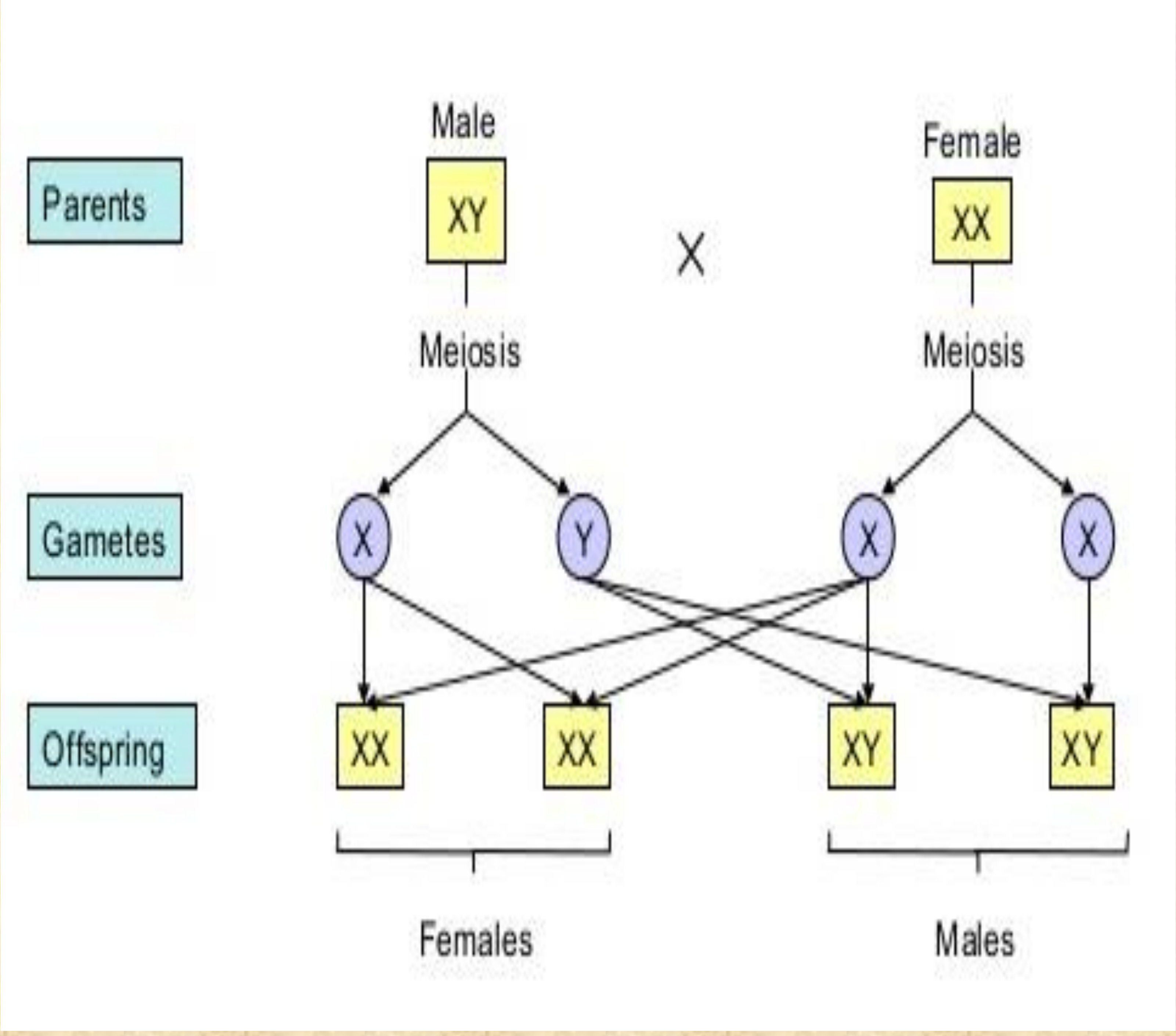
SEX DETERMINATION

The germ cells or gametes are generated within the sex glands of the male and female parents and are termed spermatozoon and ovum, respectively. The cells of every animal species contain a definite and characteristic number of chromosomes. The total number of chromosomes in each human cell has been revised as 46 for both men and women.

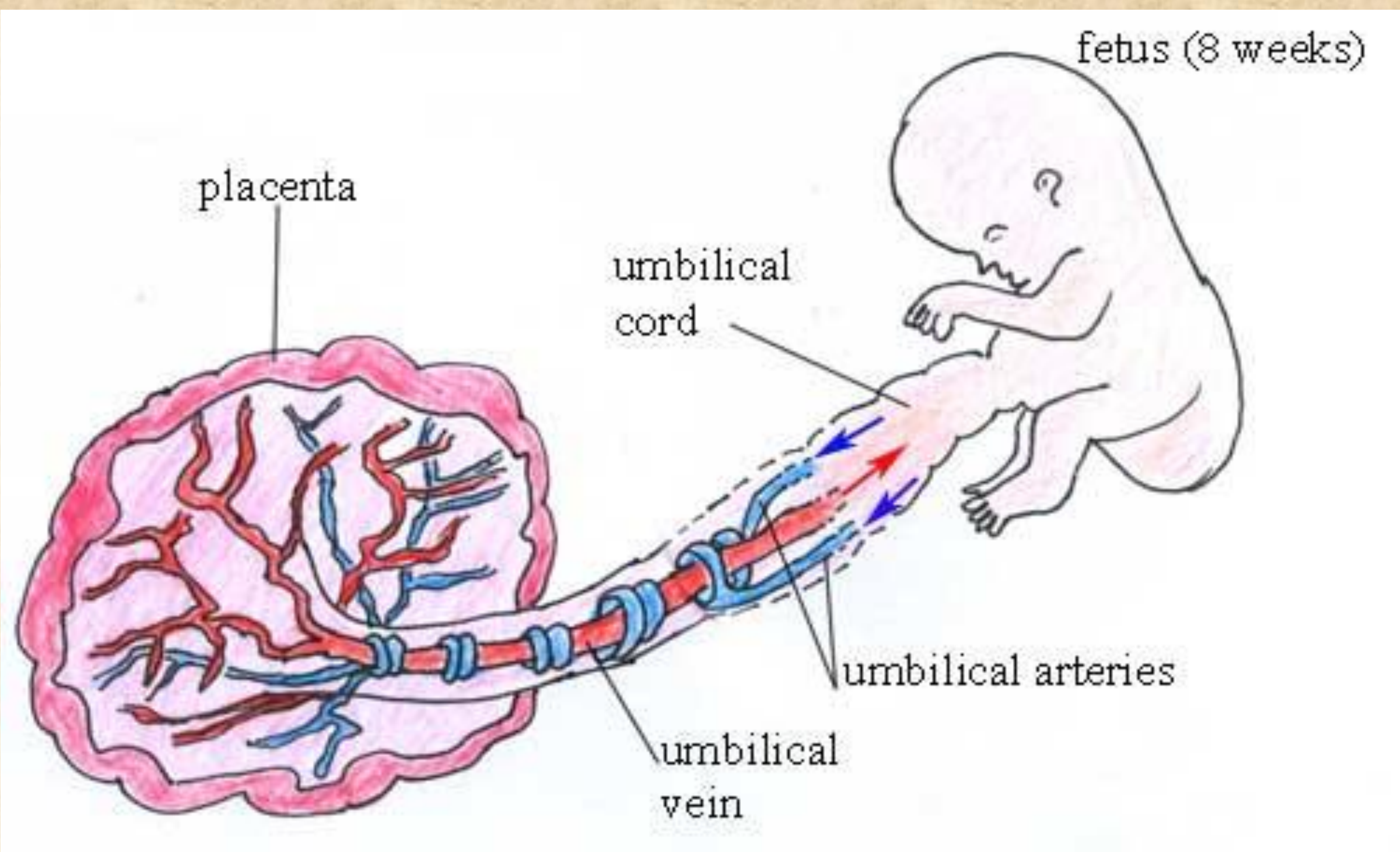
There is a double set of chromosomes in each cell; hence the human assortment contains 23 pairs.

In the female, all ova contain 22+X chromosomes. However, in the male the spermatozoon are of two types, half of them have 22+X chromosomes and the other half of them has 22+Y chromosomes.

We speak of these as ‘X-bearing’, or ‘Y-bearing’, spermatozoa. An ovum can fertilised by either type of spermatozoon. If the sperm is ‘X-bearing’, the zygote has 44+X+X chromosomes and the offspring is a girl. If the sperm is Y-bearing’ the zygote has 44+X+Y chromosomes and the offspring is a boy.


Male
Female
Parents
XY
X
XX
Meiosis
Meiosis
Gametes
X
Y
X
X
Offspring
XX
XX
XY
XY
Females
Males

PLACENTA


fetus (8 weeks)
placenta
umbilical cord
umbilical arteries
umbilical vein

After the implantation of the embryo, the uterine endometrium is called the decidua. The portion of the decidua where the placenta is to be formed is called the decidua basalis.

The placenta develops in response to the embryo’s outstripping its ability to gain oxygen and nutrients by simple diffusion.

The essential functional elements of the placenta are very small finger like processes or villi. These villi are surrounded by maternal blood. The trophoblast is at first made up of single layer of cells. As these cells multiply, two distinct layers are formed-

1. Cytotrophoblast
2. Syncytiotrophoblast – near to decidua.

The cytotrophoblast is rest on extra-embryonic mesoderm.

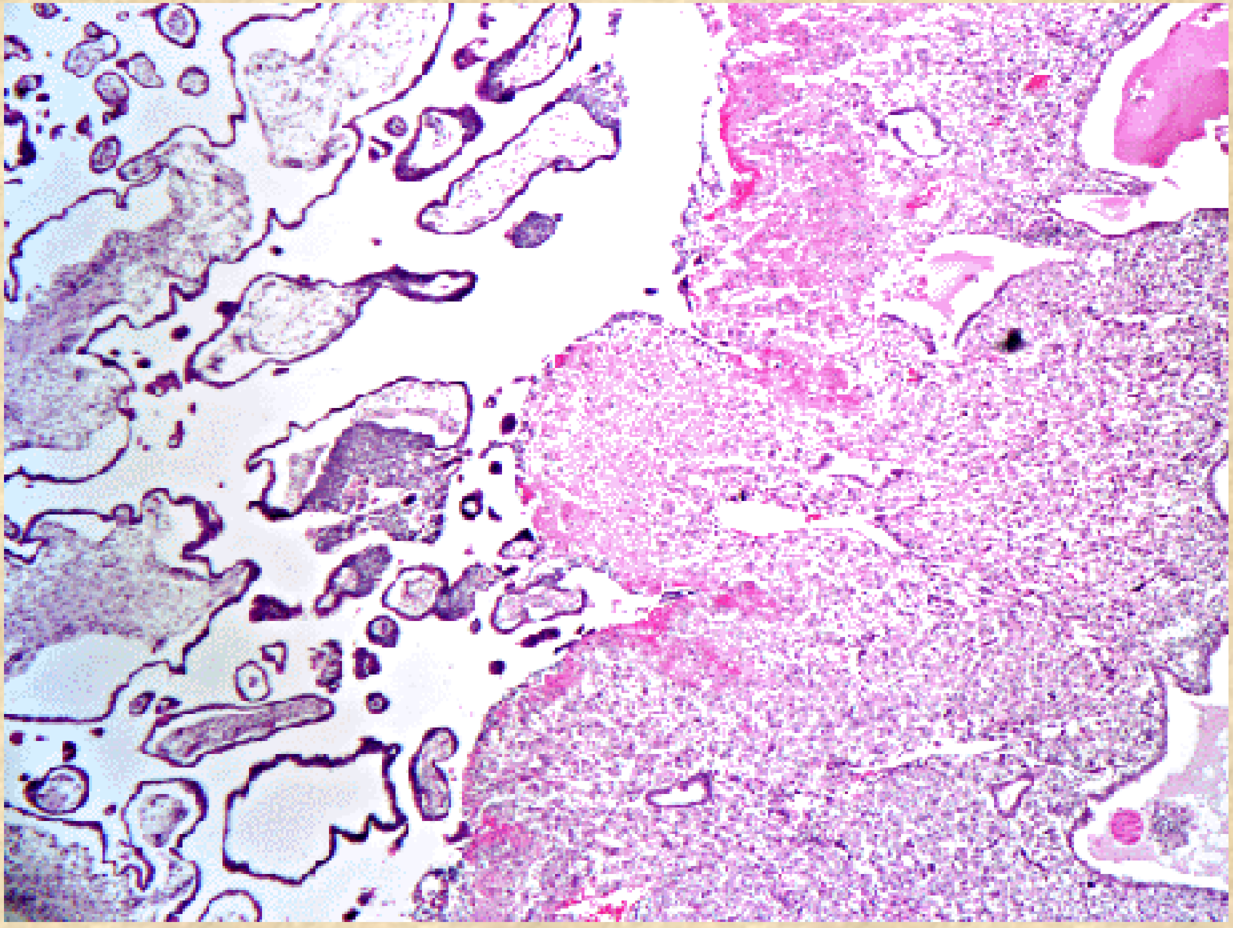
Syncytotrophoblast + Cytotrophoblast + extra-embryonic mesoderm = Chorionic villi

The syncytiotrophoblasts continue to erode the surrounding decidua and its associated capillaries and arterioles until the blastocyst is surrounded by a sea of circulating maternal blood (trophoblastic lacunae). The lacunae gradually communicates with each other, so that eventually one large space is formed.

Broadly, the developing placenta includes (1) chorionic villi (2) a cavernous intervillous space, and (3) decidua basalis with blood vessels

By the beginning of the fourth month, the placenta has two parts-

1. The fetal part- is formed by the villous chorion. The chorionic villi that arise from the chorion project into the intervillous space containing maternal blood.
2. The maternal part- of the placenta is formed by the decidua basalis.



Fetal side **Maternal side**

Functions of placenta

Functioning by end of the 3rd week.

1. Produces hormones that control the basic physiology of the mother and near term mature fetal organs for life outside of the uterus
2. Protects the fetus from immune attack by the mother
3. Removes waste produced by the fetus

4. Placental barrier prevents the mix of maternal blood with fetal blood

Placental Hormones

- Human chorionic gonadotropin (hCG)
- Human placental lactogen (hPL)
- Estrogen, progesterone
- Relaxin

Umbilical cord

- Life line between mother and embryo
- 1 large vein & 2 small arteries **{spiraling or twisting}.**
- Wharton's jelly surrounds the blood vessels preventing compression
- Central insertion site on the placenta

- **covered by amnion**
- **Normal length → 55 cm**
- 1 inch wide
- umbilical vein transports oxygenated blood to the foetal heart while the arteries return oxygen-depleted blood to the placenta.