NÜ Wa

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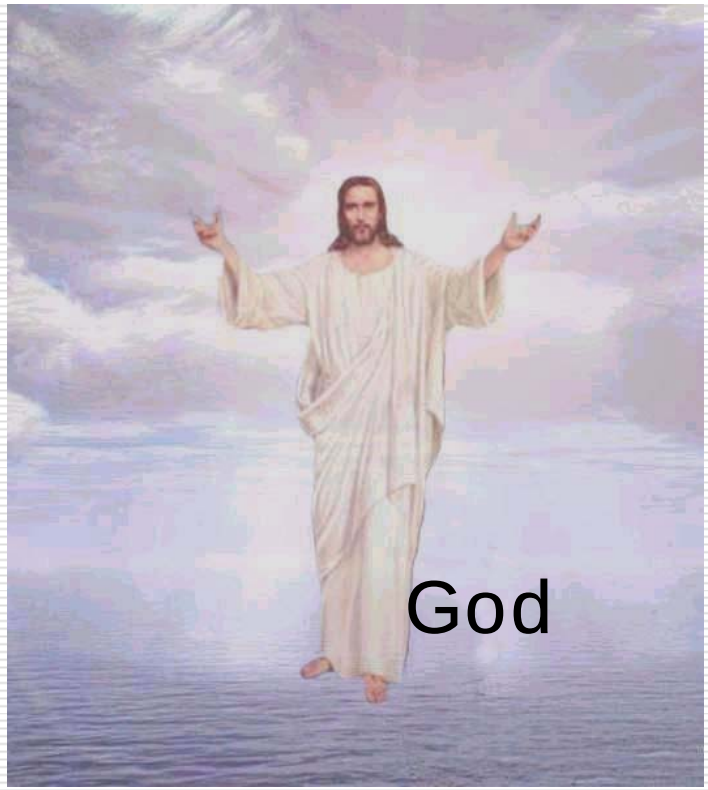
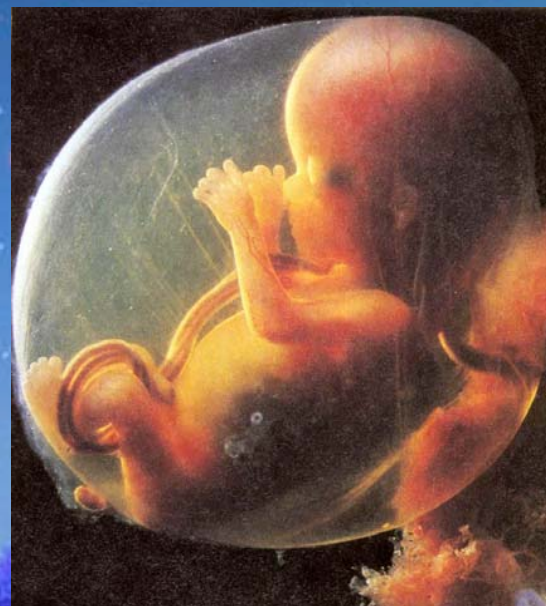


HUMAN EMBRYOLOGY

Department of Histology and Embryology
Jilin University



Chapter 1

Introduction to Human Embryology

1. What is Embryology?

ontogenesis

ovum

sperm

Zygote/fertilized ovum

Nine months

(266 days or 38 weeks to be exact)

in the uterus

fetus

Infant

1. What is Embryology?

- Traditional /descriptive embryology focuses on understanding the basic structural pattern of the embryonic body.
- Teratology is concerned with the reasons, mechanisms and protective measures of malformations.
- Comparative embryology seeks several general rules by comparison the identities or the differences among the development of many species.

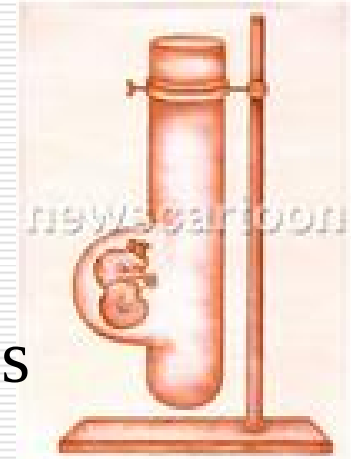
- Experimental embryology researches on the causative factors in development by posing hypotheses and testing them with different experimental techniques.
- Chemical embryology researches on the changes of some chemical materials in cells or tissues and the chemical basis of morphogenesis during the development .
- Molecular embryology focuses on the molecular mechanisms of morphogenesis, and the gene regulation of embryonic development.

- Reproductive biology emphases on normal gametogenesis, endocrinology of reproduction, transport of gametes and fertilization, early embryonic development, and implantation of the mammalian embryo, in addition to more practically oriented problems involving techniques of fertilization and contraception.

- Developmental biology includes not only embryonic development , but also postnatal processes such as normal and neoplastic growth, metamorphosis, regeneration, and tissue repair at levels of complexity ranging from the molecular to the organismal.

2. Embryology in contemporary society

- Test-tube baby (TTB)
- The technique has allowed some childless couples to give birth to children from their own genetic heritage.
- It is used in cases that both the mother and father are capable of producing viable eggs and sperm cells, however, the ovulated eggs are unable to be fertilized in her body and then to be transported to uterus because of a blockage in uterine tube.



Test-tube baby

- First generation TTB

  in vitro fertilization, IVF & embryo transfer
- Second generation TTB

  intracytoplasmic sperm injection, ICSI
- Third generation TTB

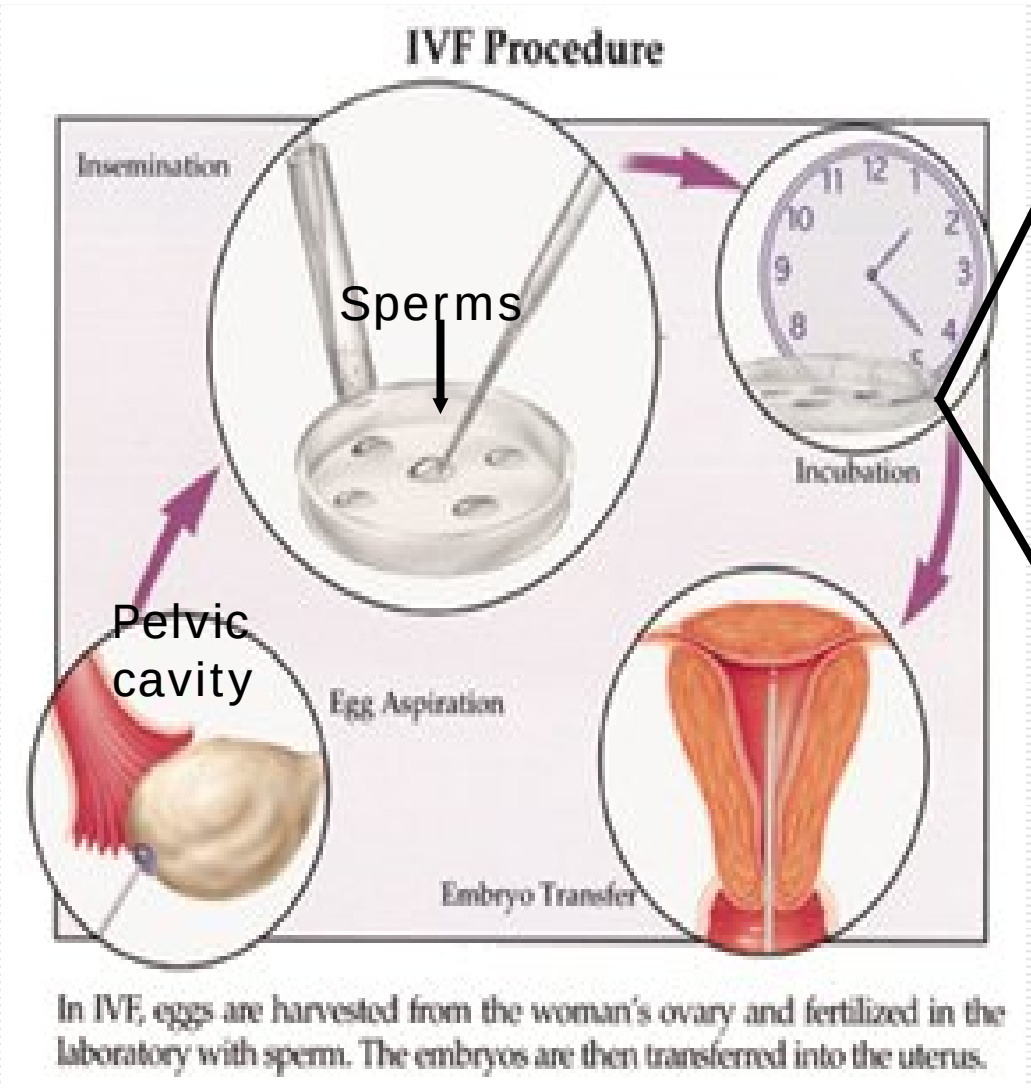
  pre-implantation genetic diagnosis, PGD
- Fourth generation TTB

  Ovoplasm replacement technique

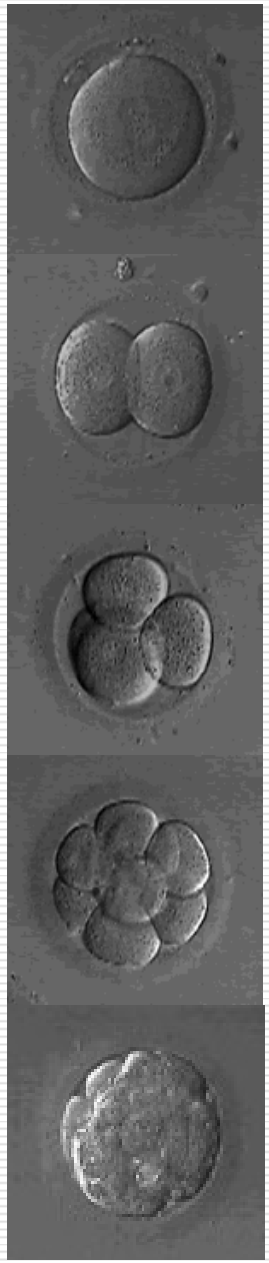
1.superovulation (fertility-enhancing drug)

2.Egg Retrieval (laparoscopy)

3.Artificial fertilization 4.Embryo Transfer

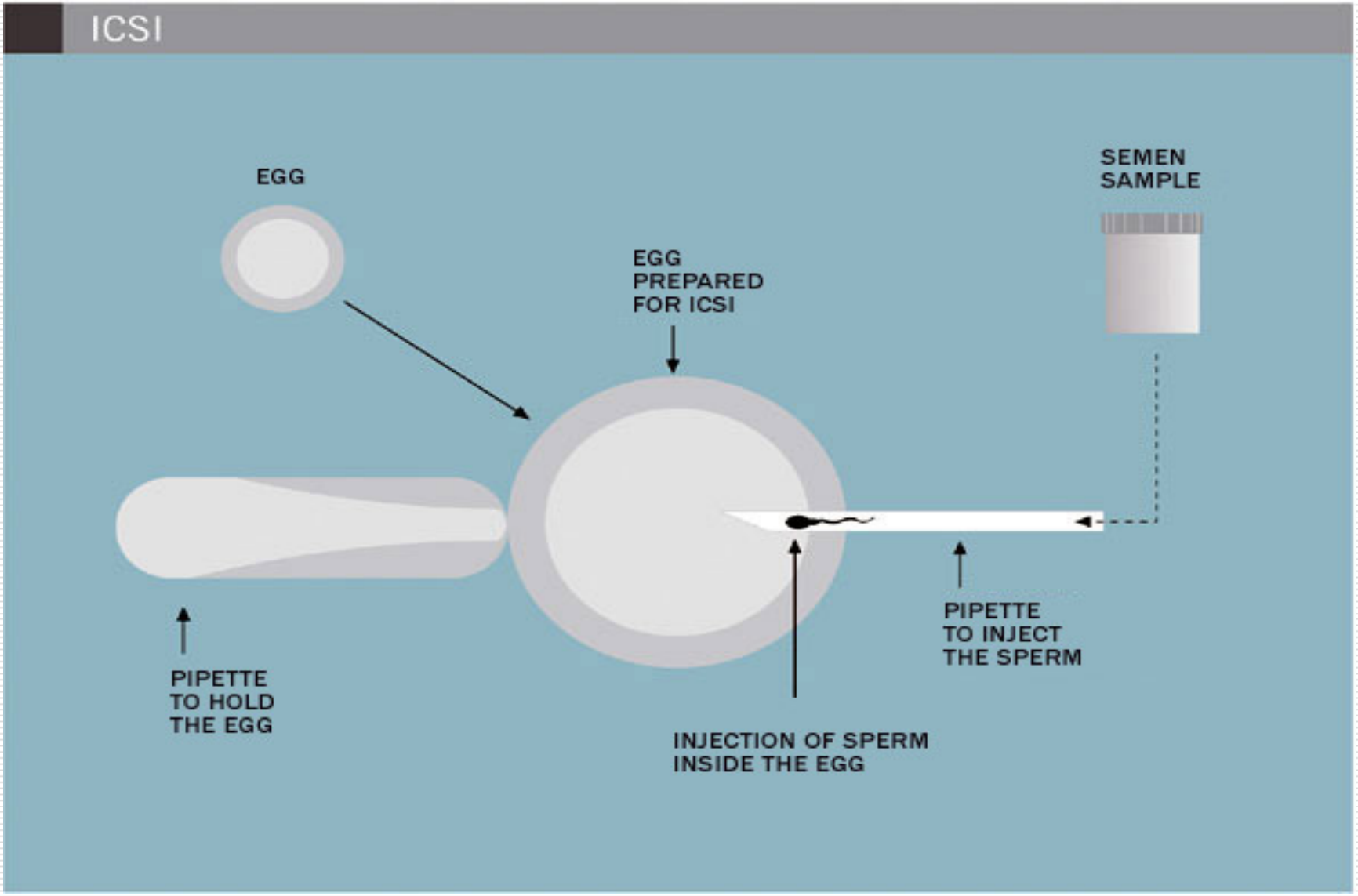


In IVF, eggs are harvested from the woman's ovary and fertilized in the laboratory with sperm. The embryos are then transferred into the uterus.



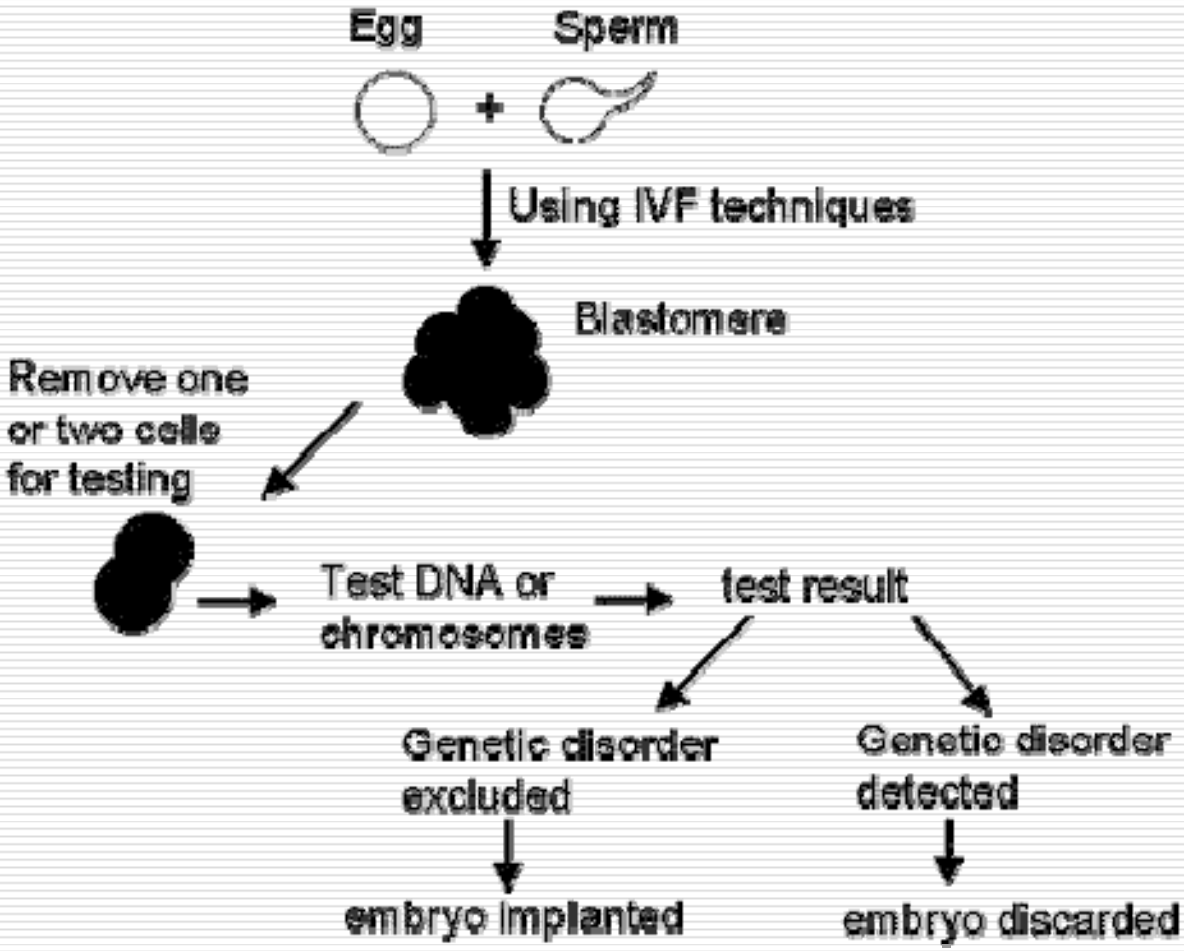
division of zygote

intracytoplasmic sperm injection, ICSI



intracytoplasmic sperm injection, ICSI

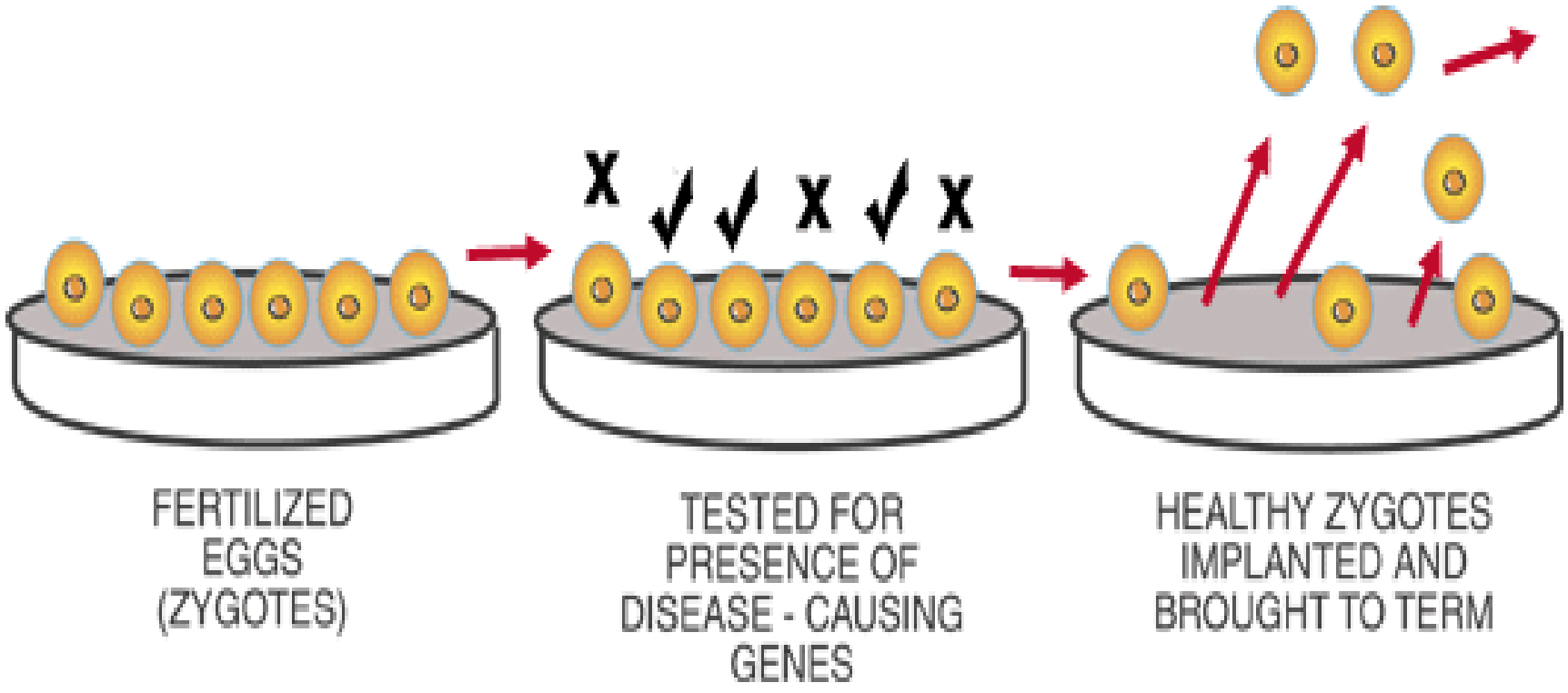
PGD:


Egg
Sperm
Using IVF techniques
Blastomere
Remove one or two cells for testing
Test DNA or chromosomes
test result
Genetic disorder excluded
Genetic disorder detected
embryo implanted
embryo discarded

Viable and Desirable?

advantage: Genetic testing performed prior to embryo transfer, to prevent from the genetic diseases.

"This information is helping parents choose which embryos they want--and which to reject as unhealthy, or merely undesirable."



Ovoplasm replacement technique

- The cytoplasm of her eggs is replaced by that of another healthy woman through microtechnique. Then, her eggs is fertilized in vitro.
- Because the genetic material only exists in the nucleus of sperm or ovum, after ovoplasm replacement, the hereditary feature of ovum still belongs to the woman planning to be pregnant.

Chapter 2

General Embryology

First Week of Development: Fetilization & Blastocyst

Human embryogenesis

Prenatal period

Pre-embryonic period

It extends from fertilization to 14 d.

Embryonic period

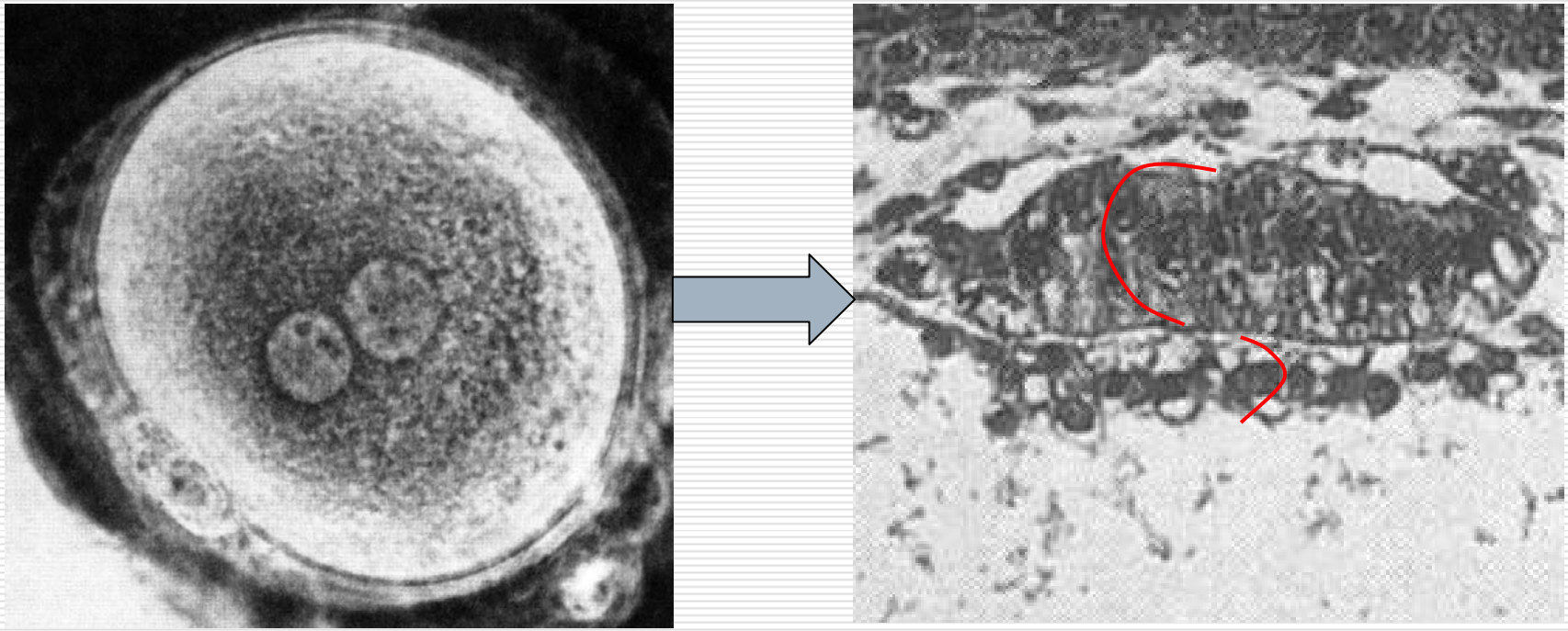
1. It extends from 3rd to 8th week.
2. The developing individual is called an **embryo.**

Fetal period

1. It extends from week 9 until birth.
2. The developing individual is called a **fetus.**

Pre-embryonic period

The fertilized ovum cleaves in mitosis continuously, forming bilaminar germ disc until 14 days.



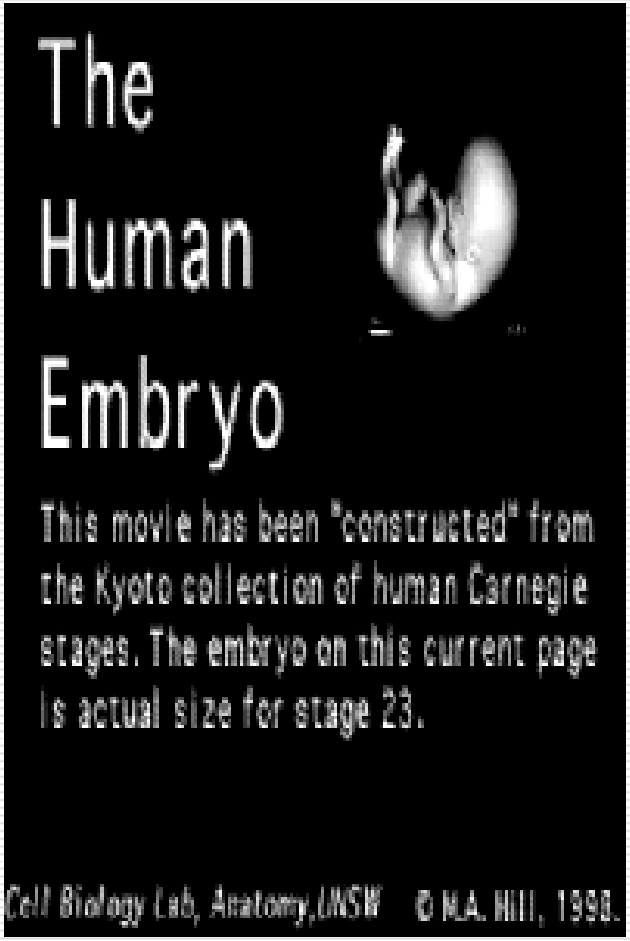
Cross section of embryonic disc

Embryonic period

Through the development of 6 weeks, the embryo begins to have stature of human.

schematic diagram of embryo

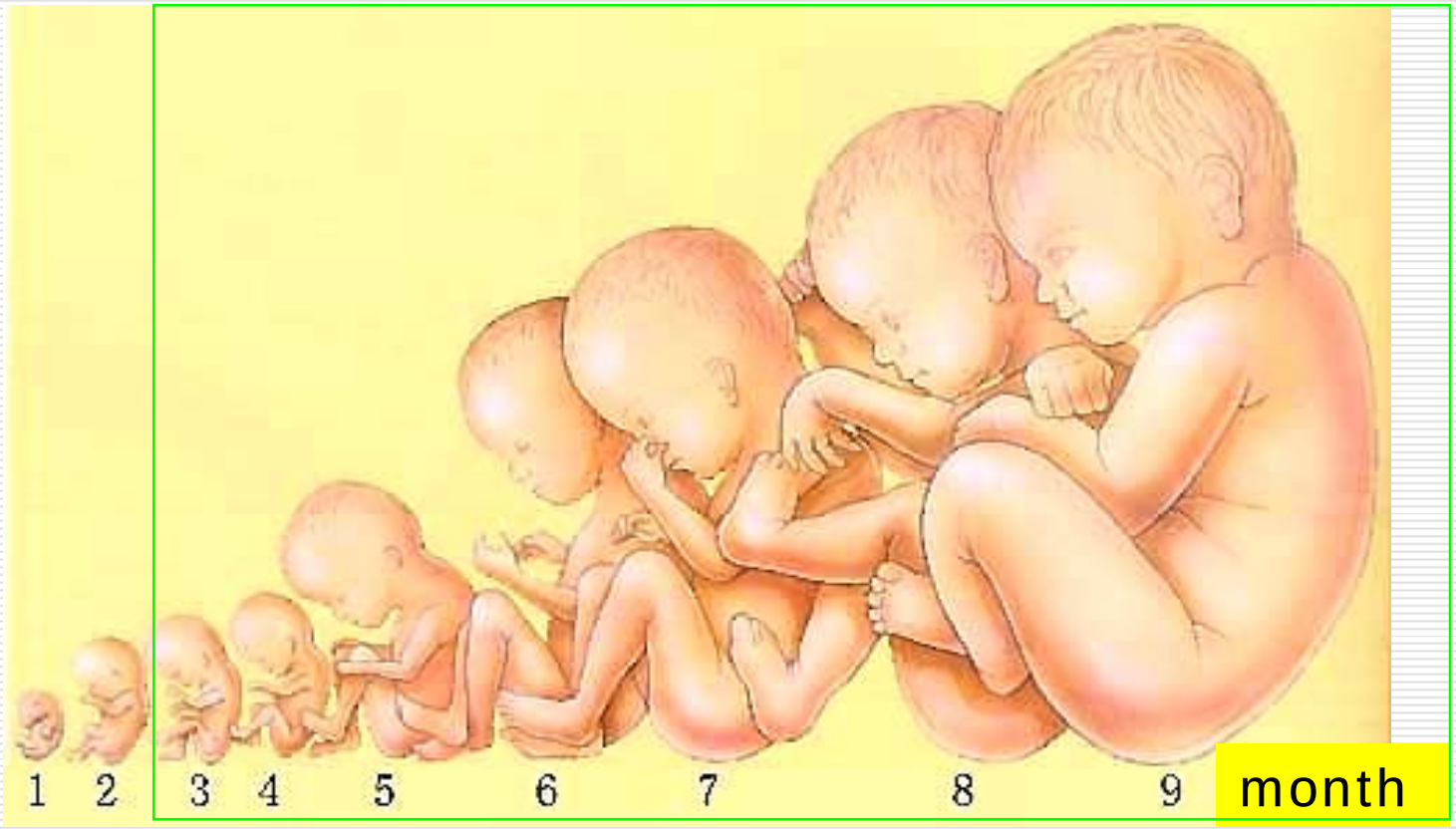
Pre-embryonic and embryonic period



The animation shows the embryonic development from a fertilized cell to a embryo from 12 to 23 stages. Pay more attention to the actual size of embryonic body. The length of the scale is 4 mm.

Fetus period

The tissues and organs are matured and fetus grows quickly in this period.

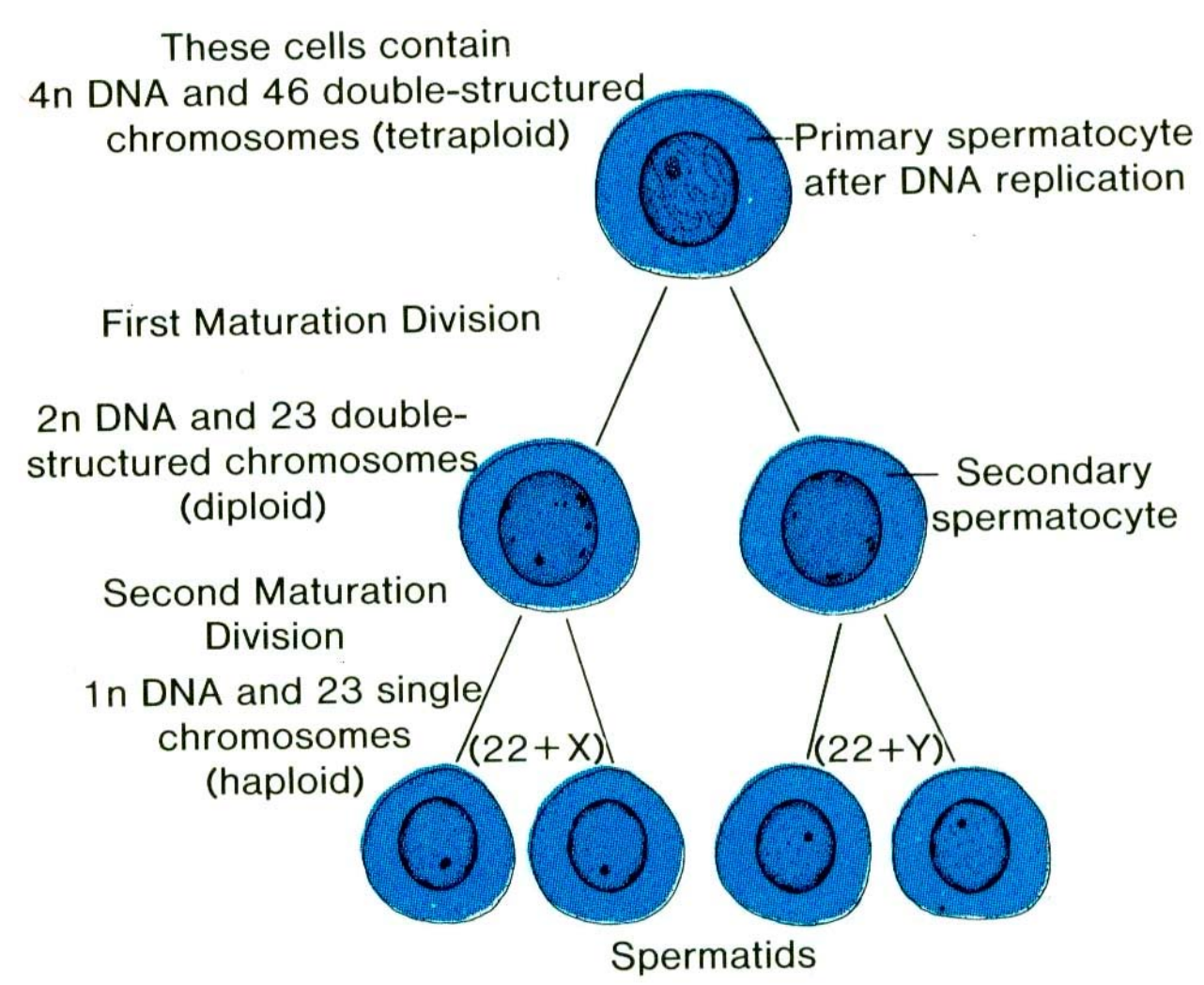


Pre-embryonic period
First Week of Development: Fetilization & Blastocyst

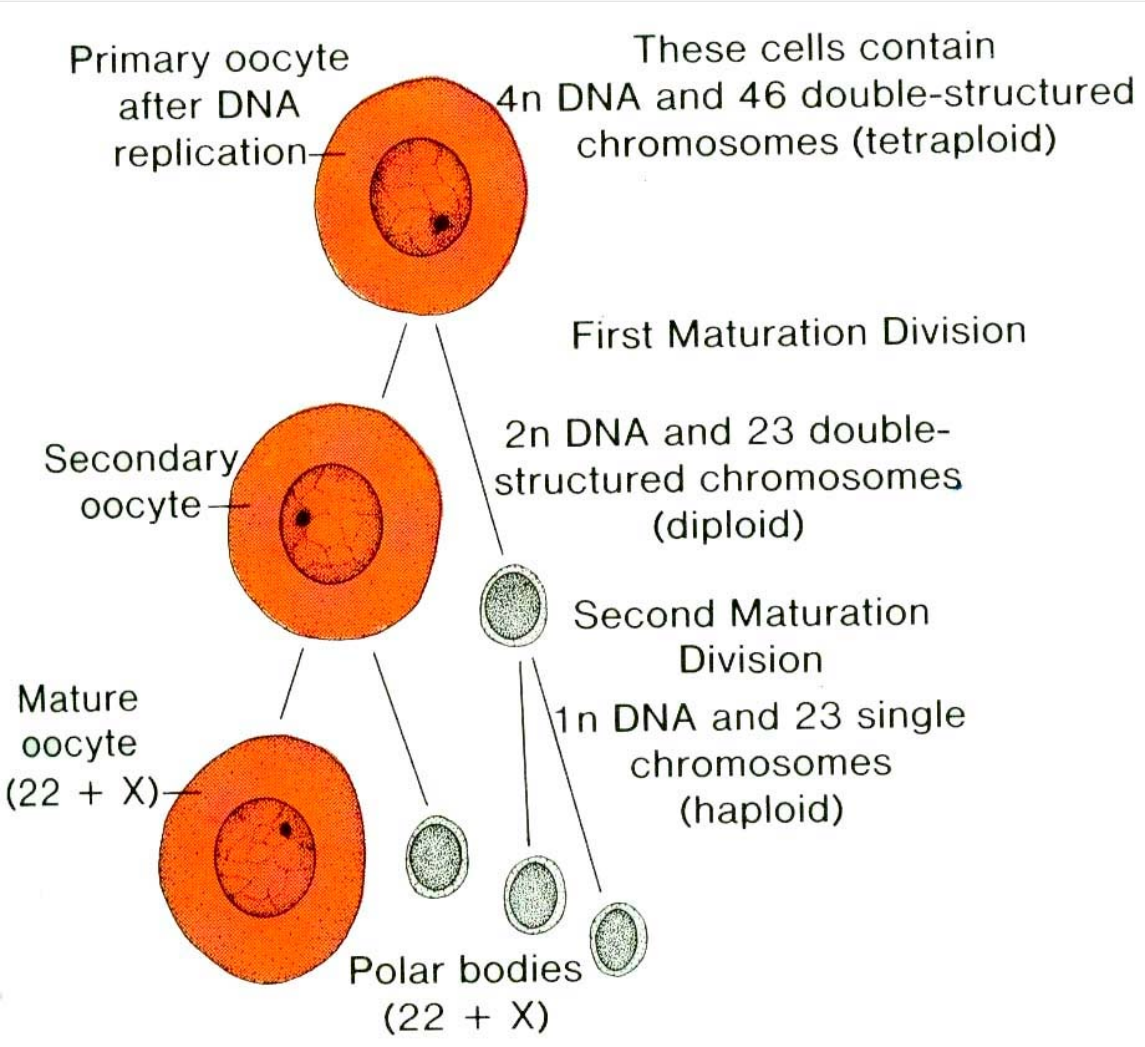
1.Gametogenesis

- primordial germ cell (PGC) on the wall of yolk sac→genital ridge → spermatogonium or oogonium →increase by means of mitosis → twice meiosis/ maturation division → sperm or ovum with 23 chromatins in haploid number

- A spermatogonium→mitosis → primary spermatocyte → 1st meiosis→ secondary spermatocyte → 2nd meiosis → spermatid → 4 sperms (2Y+2X chromatin) → 2 weeks in epididymis → mature



- An oogonium (fetus) → mitosis → primary oocyte →1st meiosis → secondary oocyte →2nd meiosis → meet sperms → one mature oocyte(X chromatin) and three polar bodies(X chromatin)



2. Ovulation

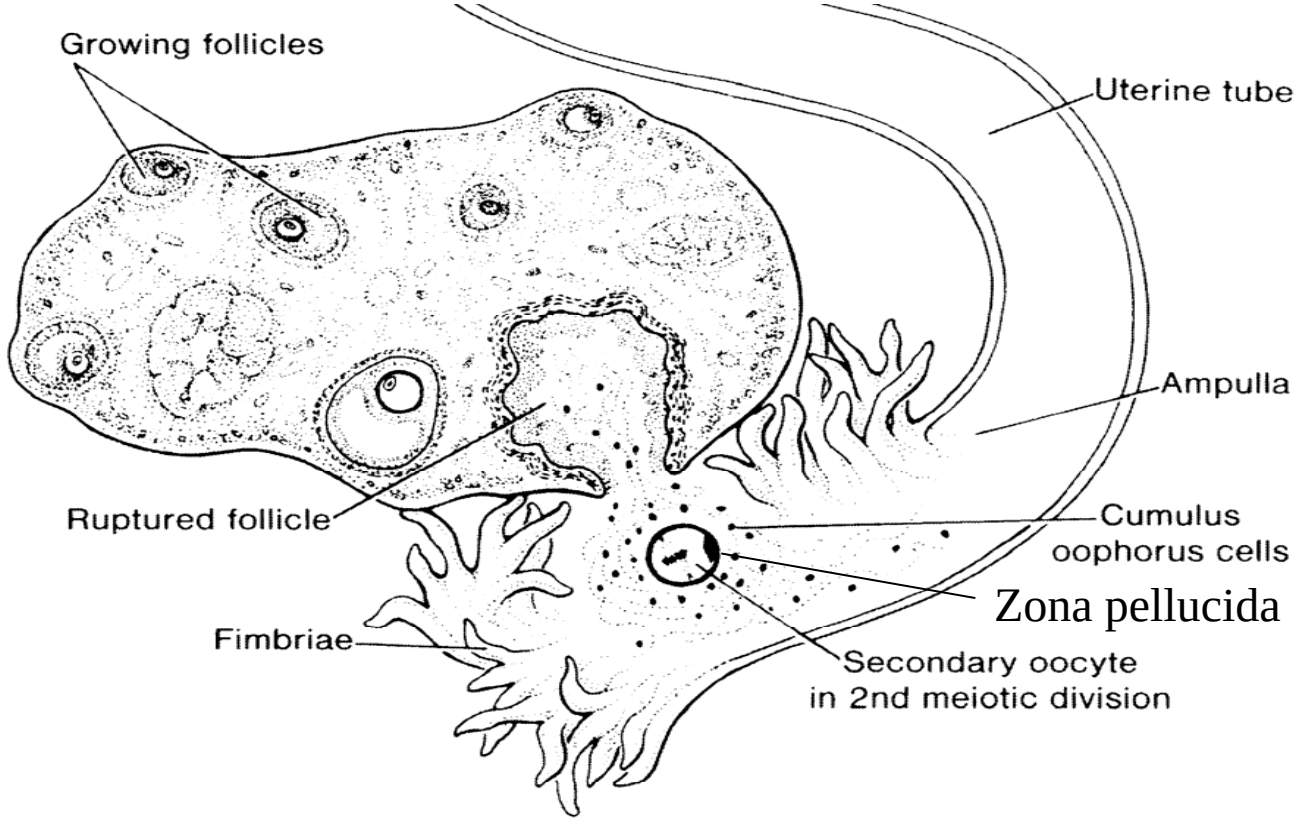
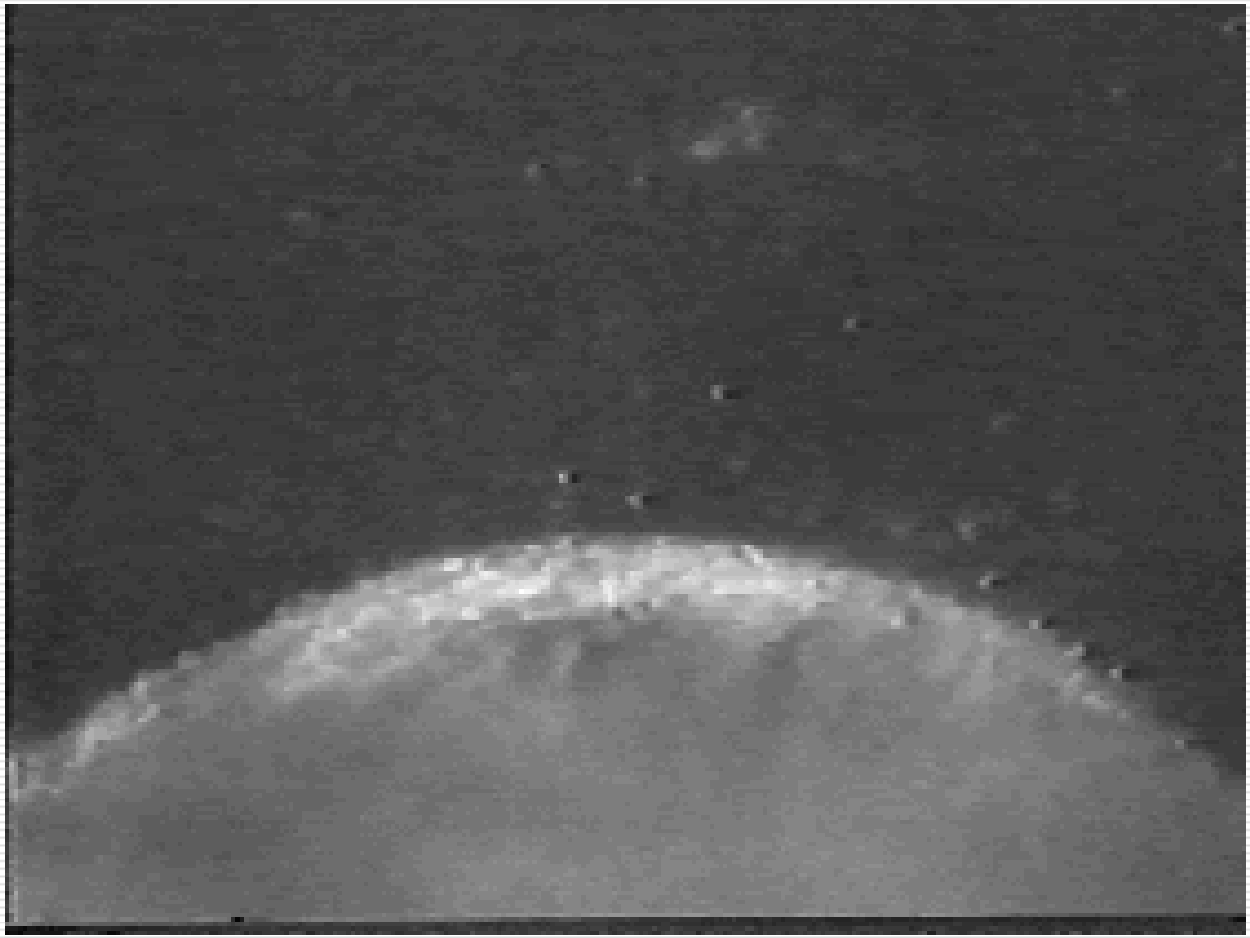


Figure 2.4 Relation of fimbriae and ovary. Fimbriae collect the oocyte and sweep it into the uterine tube.

Cumulus oophorus (secondary oocyte in 2nd meiotic division, zona pellucida and corona radiate) is expelled from follicle, captured by fimbriae of uterine tube, transported to ampulla of uterine tube.

The egg finishes the 2nd meiotic division quickly stimulated by entrance of sperm. Ovulated egg must be fertilized within 24h.



Cumulus oophorus is released from follicle, captured by fimbriae of uterine tube, transported to ampulla of uterine tube.

The animation is about ovulation.

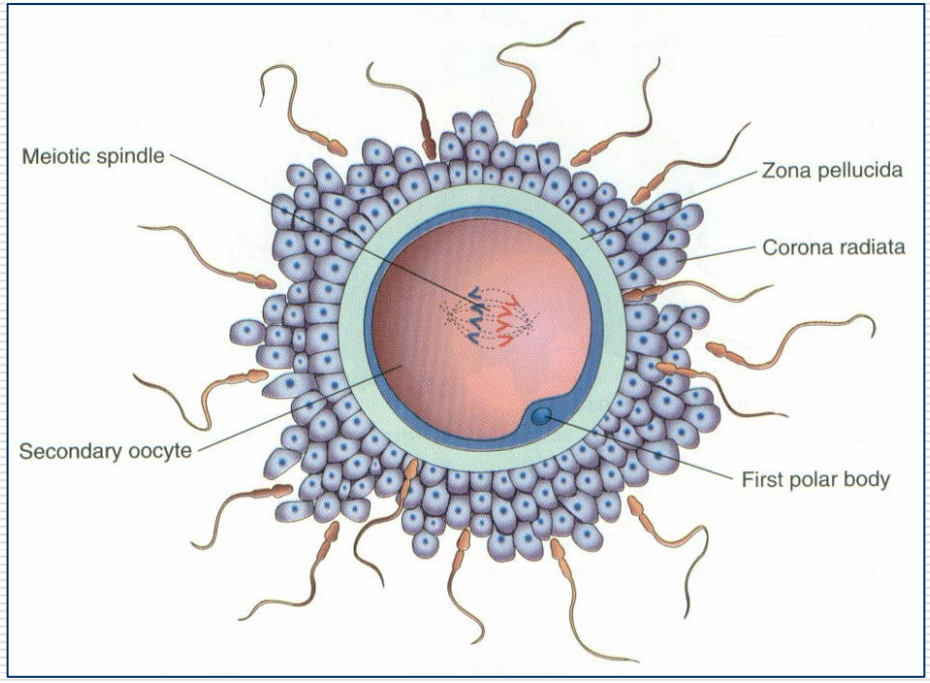
3. Fertilization

- **fusing of a male and a female gamete within 12 hours after ovulation**
- **Normal site: ampulla of uterine tube.**

Sperms (3-5×10^8) are ejaculated into female reproductive tract and meet egg at ampulla of uterine tube (300-500). The sperm nucleus enters the egg to form a fertilized ovum or zygote.

The process of fertilization

- Sperm maturation and sperm capacitation
- Acrosome reaction
- Union of gametes and zona reaction
- Sex determination



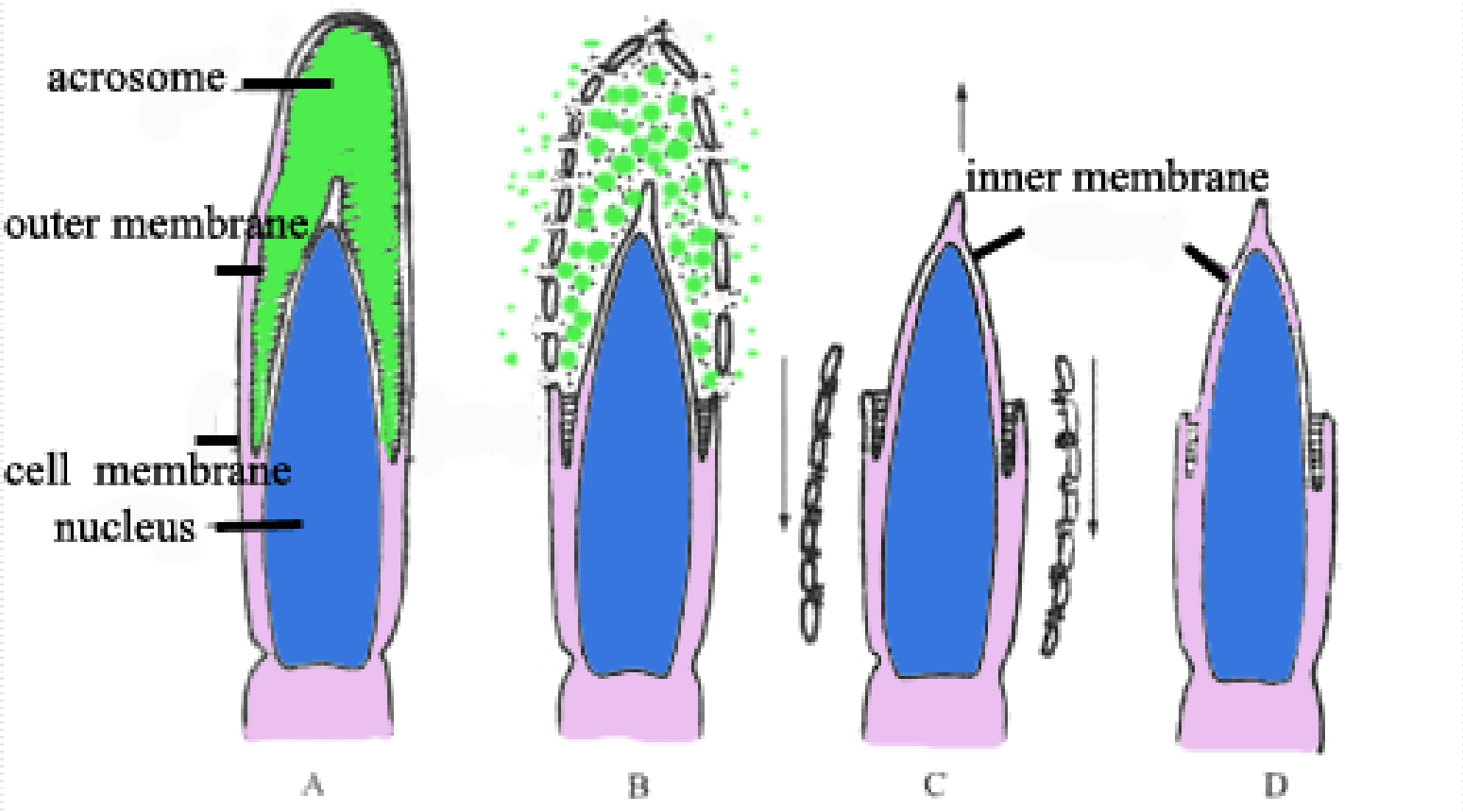
- Matured sperms in epididymis obtain full motility, and is covered by glycoproteins and sperm plasma proteins, which prevent acrosome reaction and fertilizablity

- Sperm capacitation

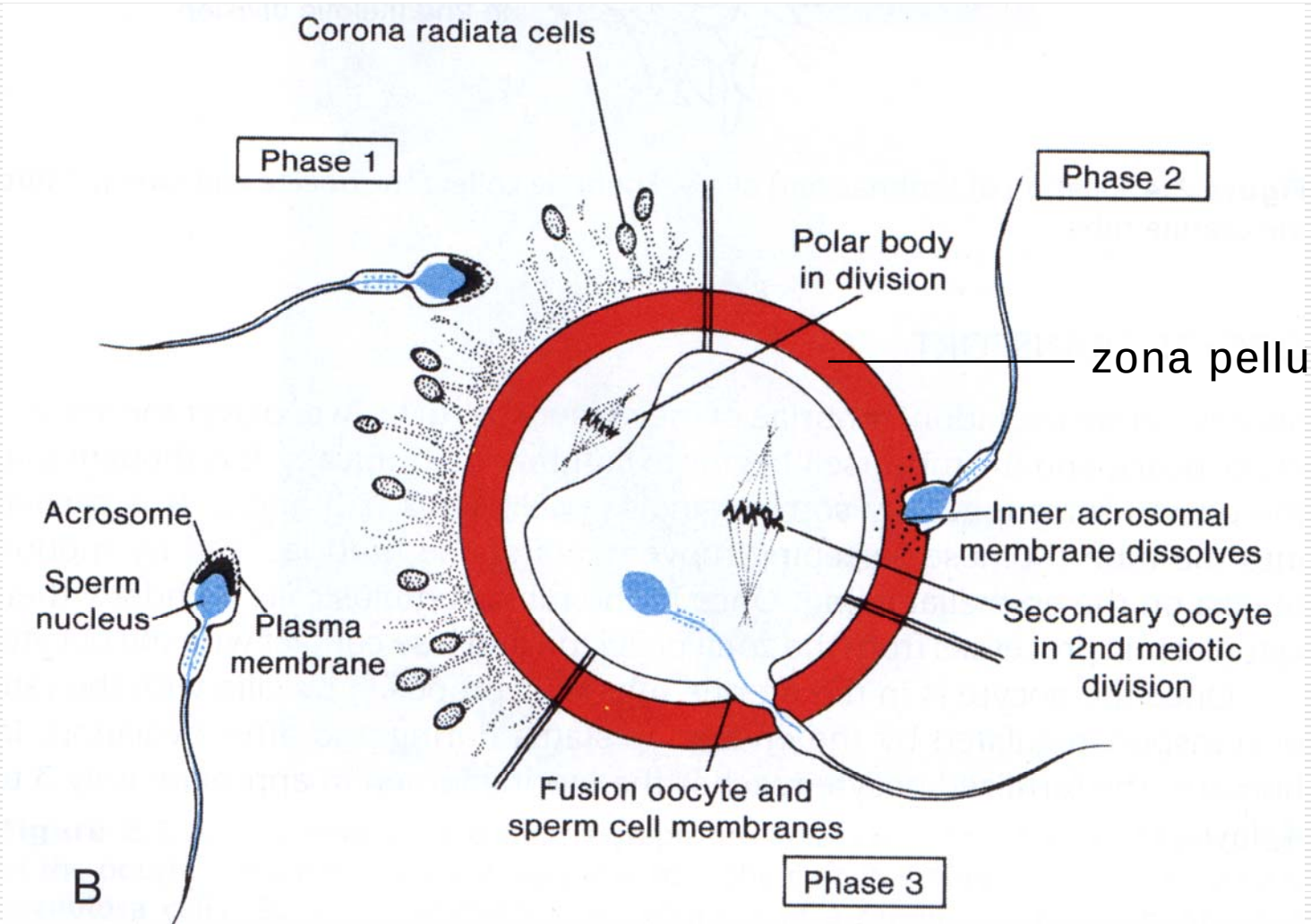
  Once sperms enter female reproductive tract, especially in uterine tube, the glycoprotein coat and seminal plasma proteins are shedded .Sperms obtain the fertilizability.

- Fertilizing power of human sperms in female genital tract lasts 1 to 2 days .

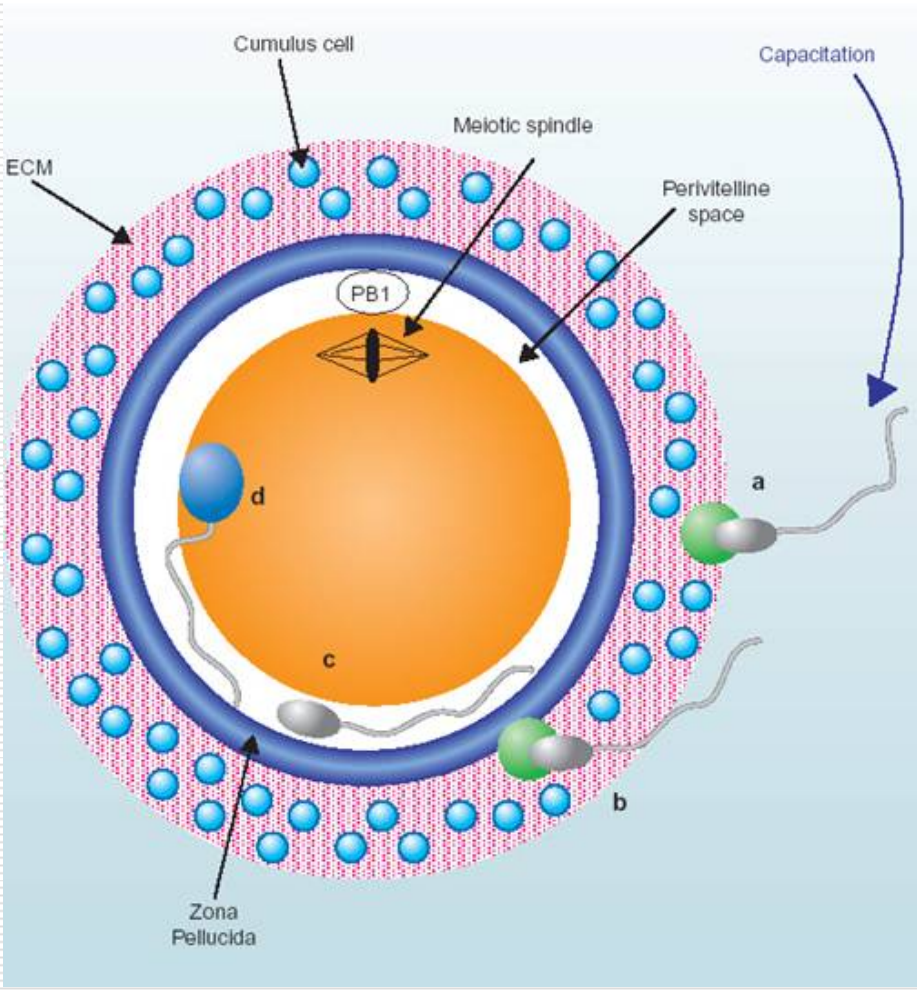
- Outer acrosomal membrane fuses with sperm membrane partially
- Acrosomal enzymes are released to from the holes.
- Only the inner acrosomal membrane is remained.



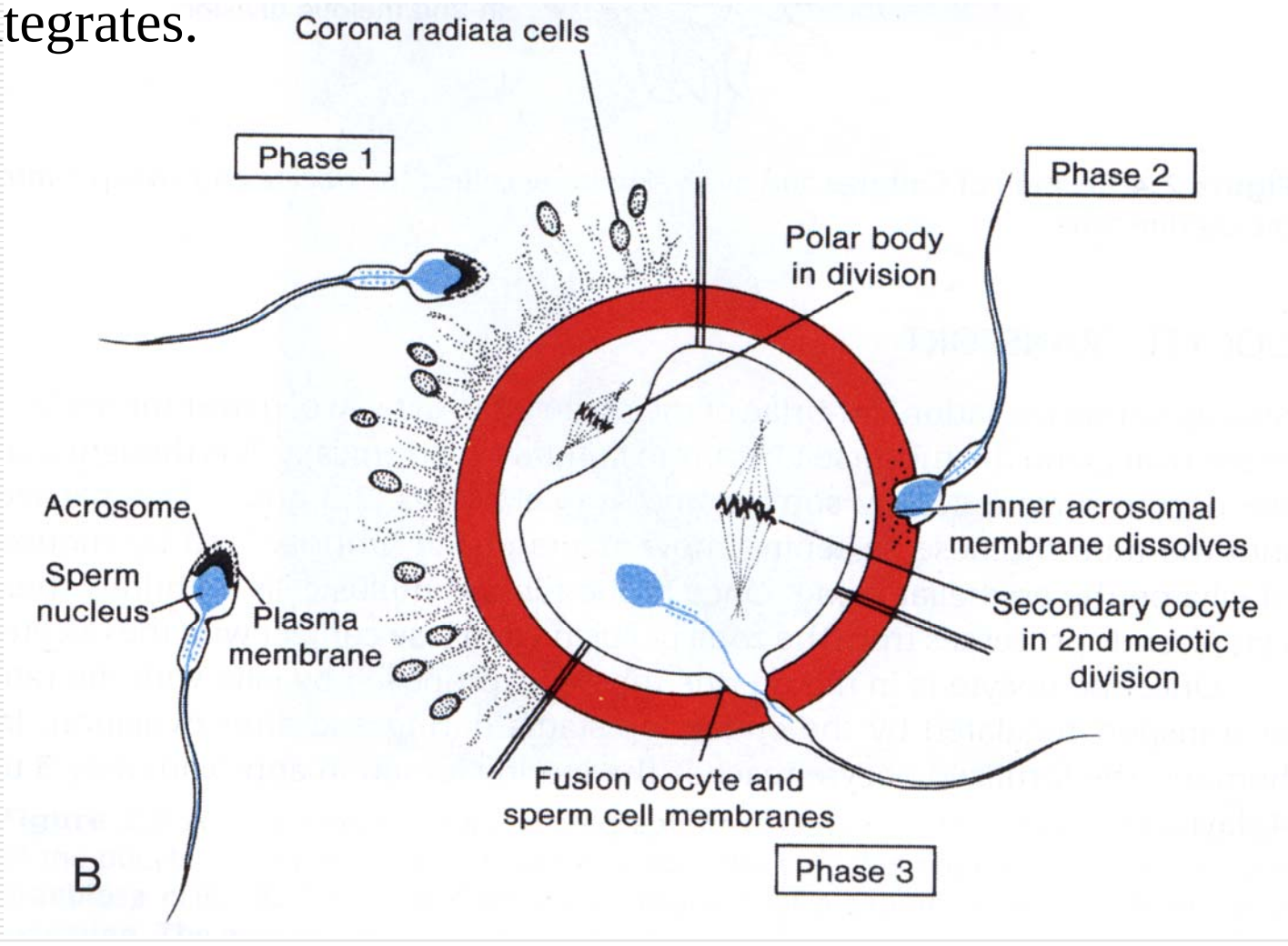
- Acrosomal enzymes are released to digest corona radiata cells, forming a pathway to zona pellucida.
- Sperm binds to ZP3 and the flagellar movement of sperm tail propels the sperm though the zona pellucida.



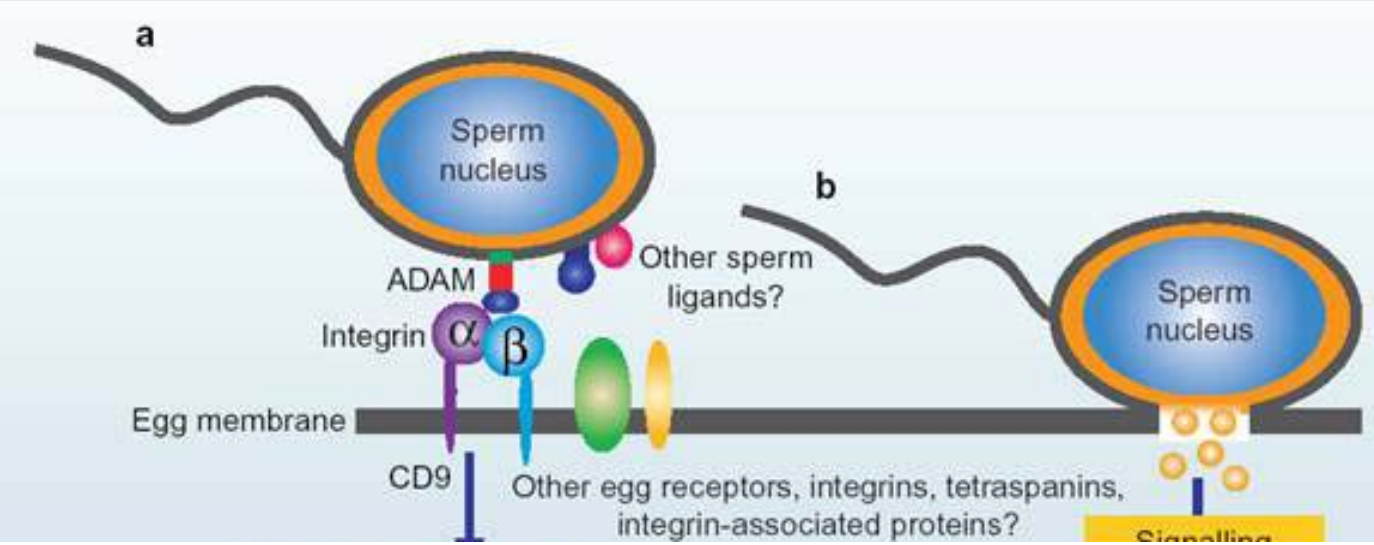
- This process of releasing acrosomal enzymes and dissolution of corona radiata and zona pellucida is called acrosome reaction.



- Sperm enters into space between zona pellucida and membrane of secondary oocyte.
- Membrane of head of sperm fuses with membrane of egg.
- Cytoplasm and nucleus of sperm enters egg, and cell membrane of two gametes integrates.

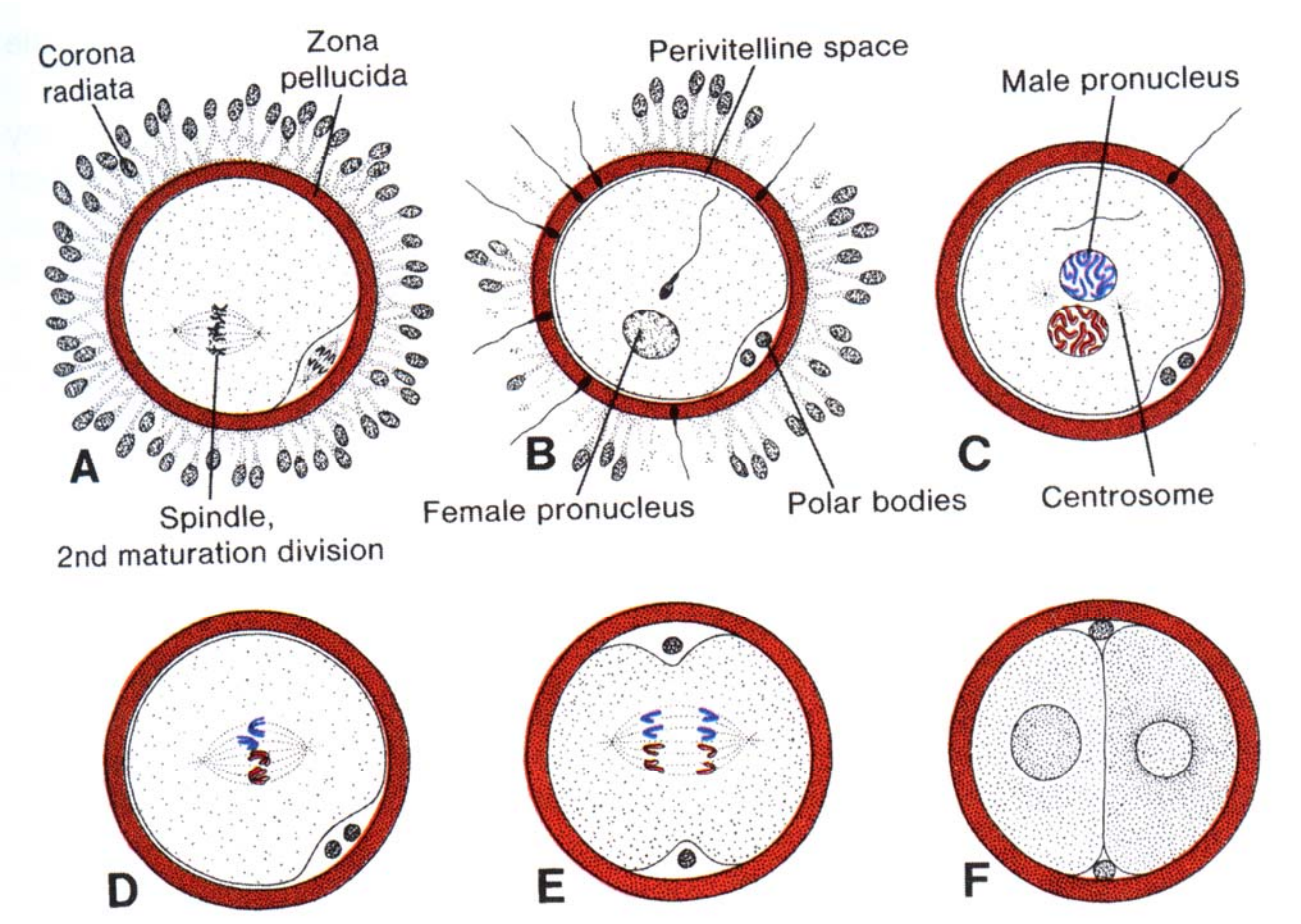


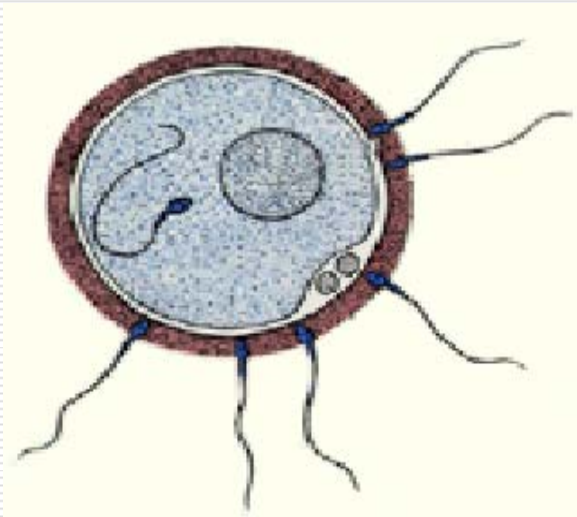
- After union of gametes, structure of zona pellucida, especially ZP3, is changed because of enzymes released from cortical granules in superficial cytoplasm of egg.
- As a result, the denatured zona pellucida prevents other sperm from passing through in order to ensure monospermy.
- This process is called zona reaction.



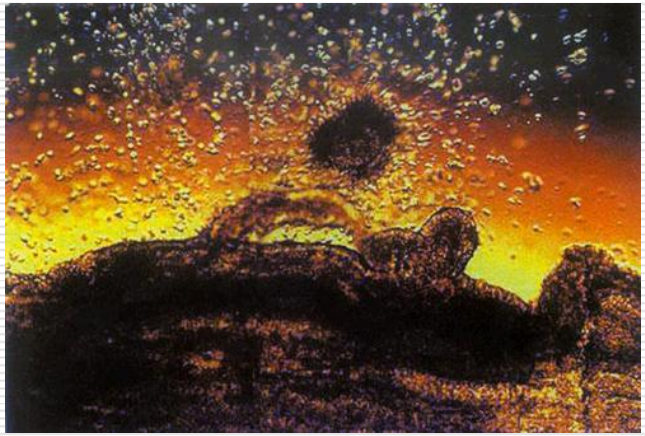
- Once the sperm fuses with ovum, it finishes the 2nd meiosis quickly and produce a second polar body.

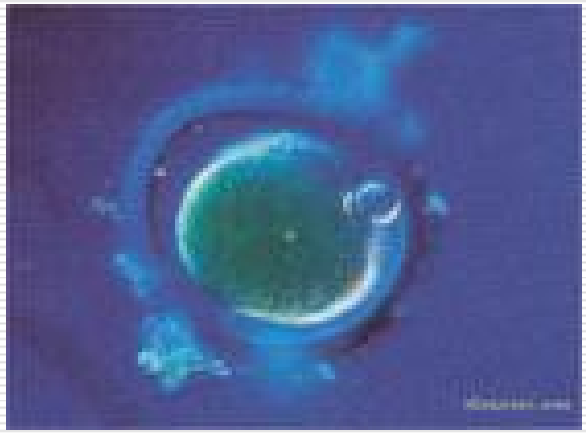
- Distended sperm pronucleus and ovum pronucleus migrate towards each other and fuse to form a new nucleus so that a diplontic fertilized ovum with 46 chromosomes is formed.

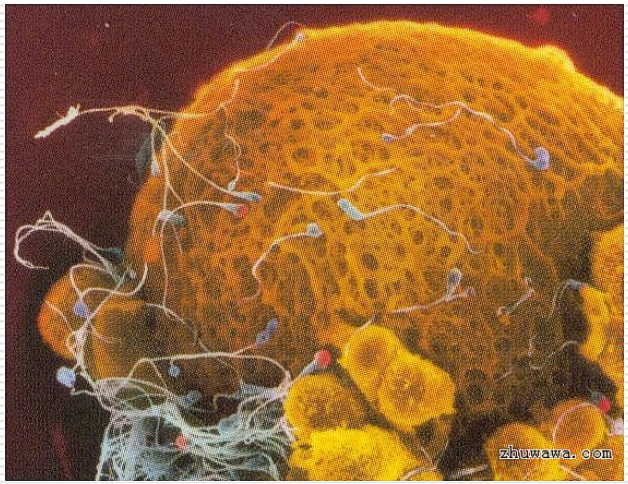


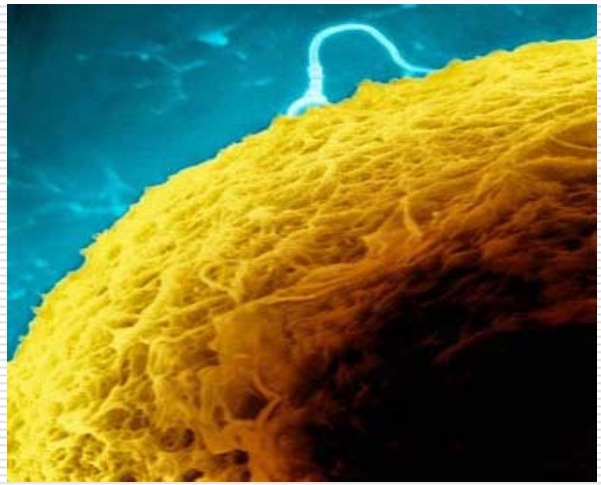


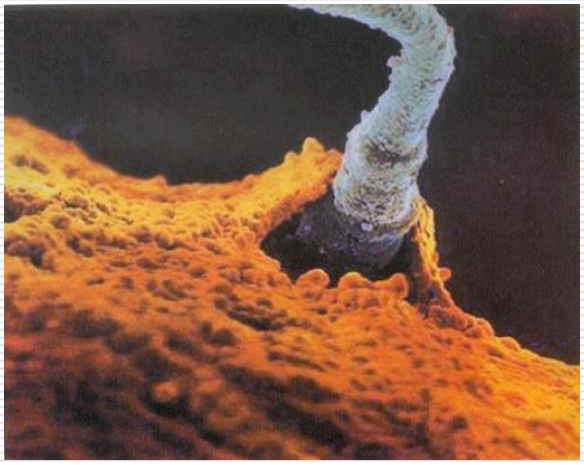
fertilization

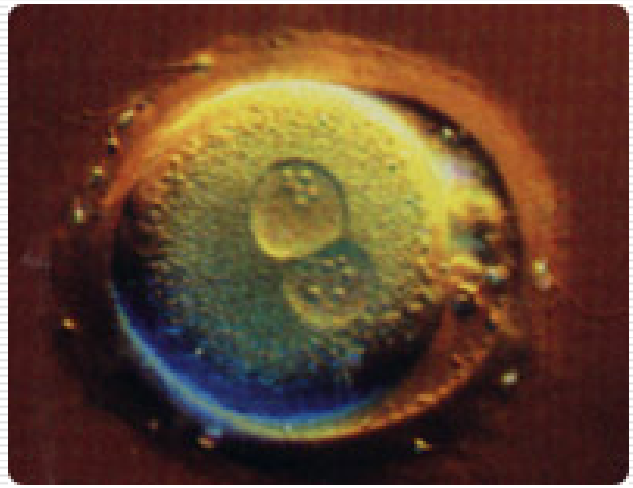


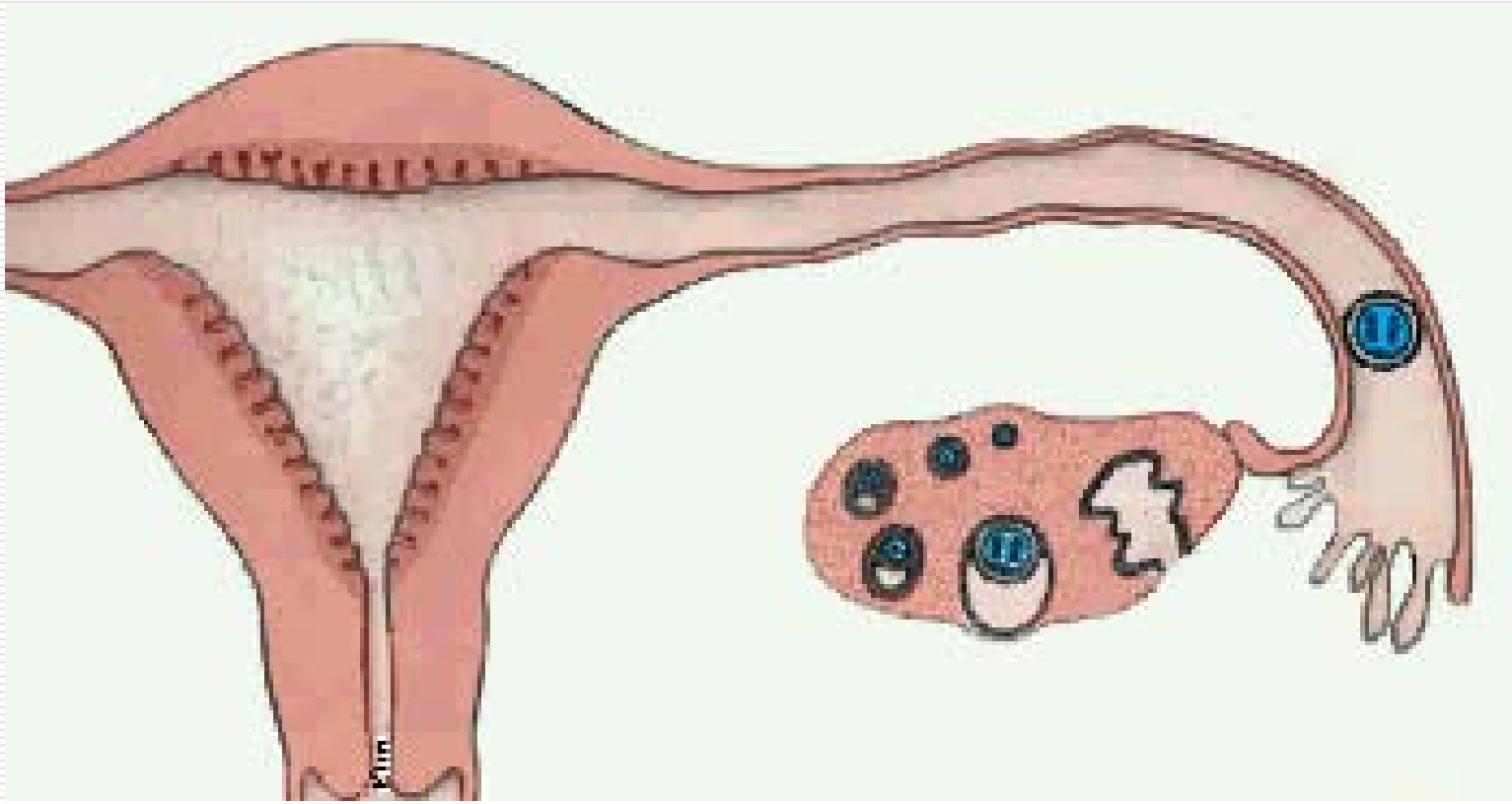








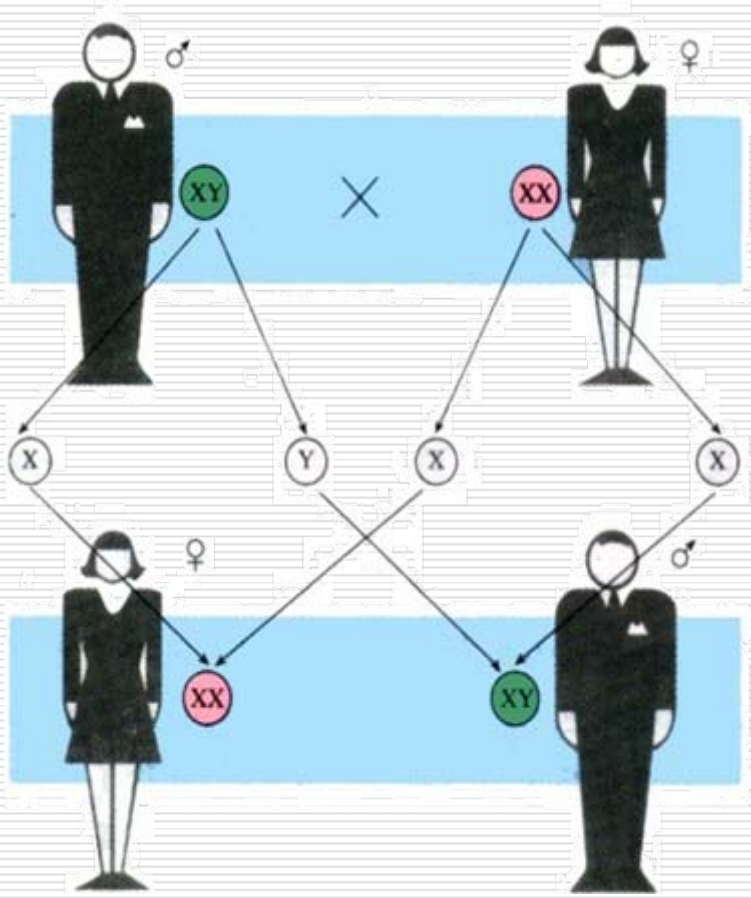




fertilization at unterine tube

- The sex of human is determined at the time of fertilization.

- The egg contributes an X chromosome, whereas the sperm contributes an X or a Y chromosome, thus determination the sex of the zygote, XX for female and XY for male.



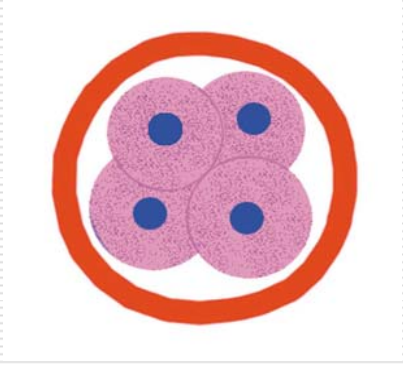
3.5 The main results of fertilization

- Restoration of the diploid number of chromosomes
- Determination of the sex of the new individual. female (XX) embryo, a male (XY) embryo
- Initiation of cleavage. Without fertilization, the oocyte usually degenerates within 24 hours after ovulation.

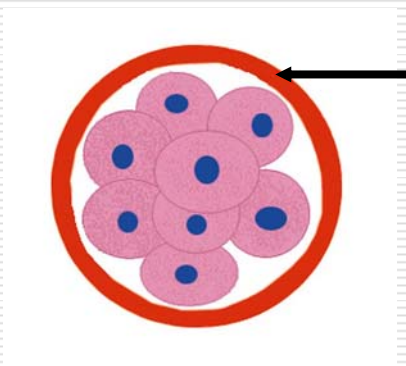
4. Cleavage and formation of blastula

- Cleavage divisions: zygote moves towards uterine cavity and divides into blastomeres.
- Division occurs without any increase in total cytoplasmic mass because the daughter cells initially use mRNAs, proteins and excess organelles stored in big occyte.

2-cell stage 30hr

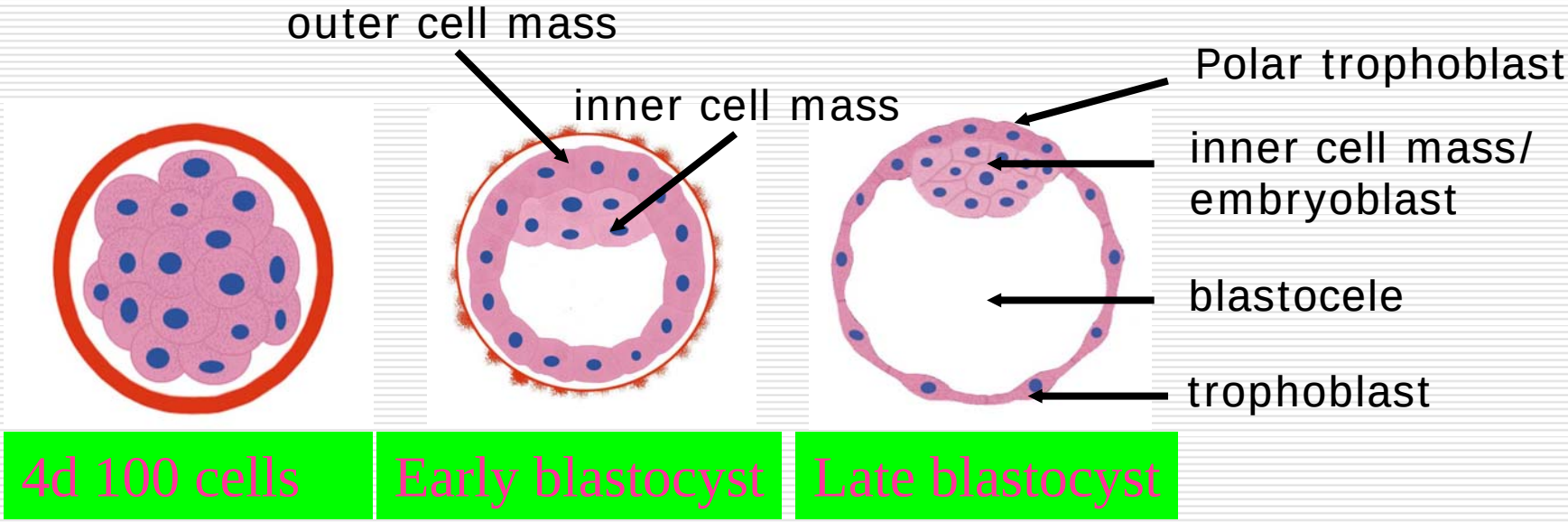


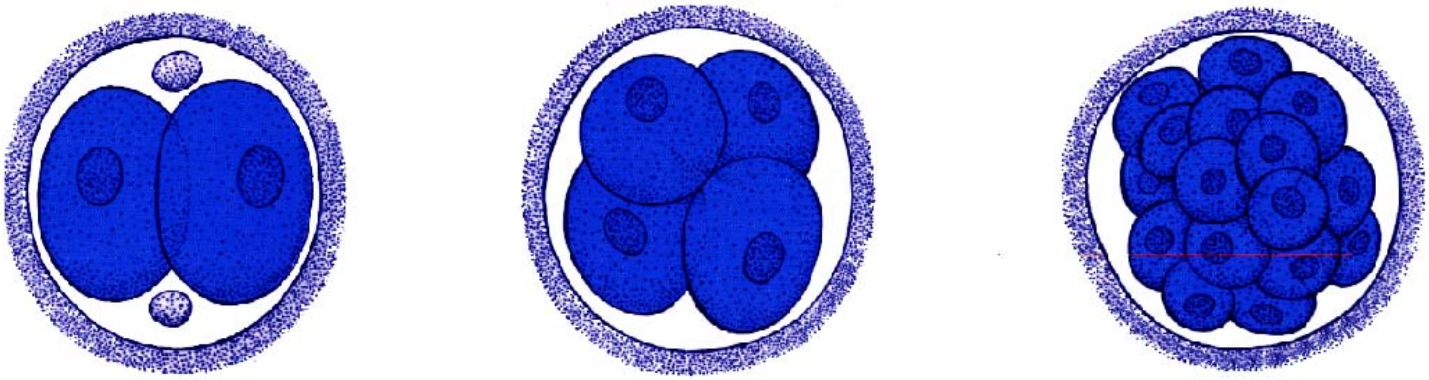
4-cell stage 40hr

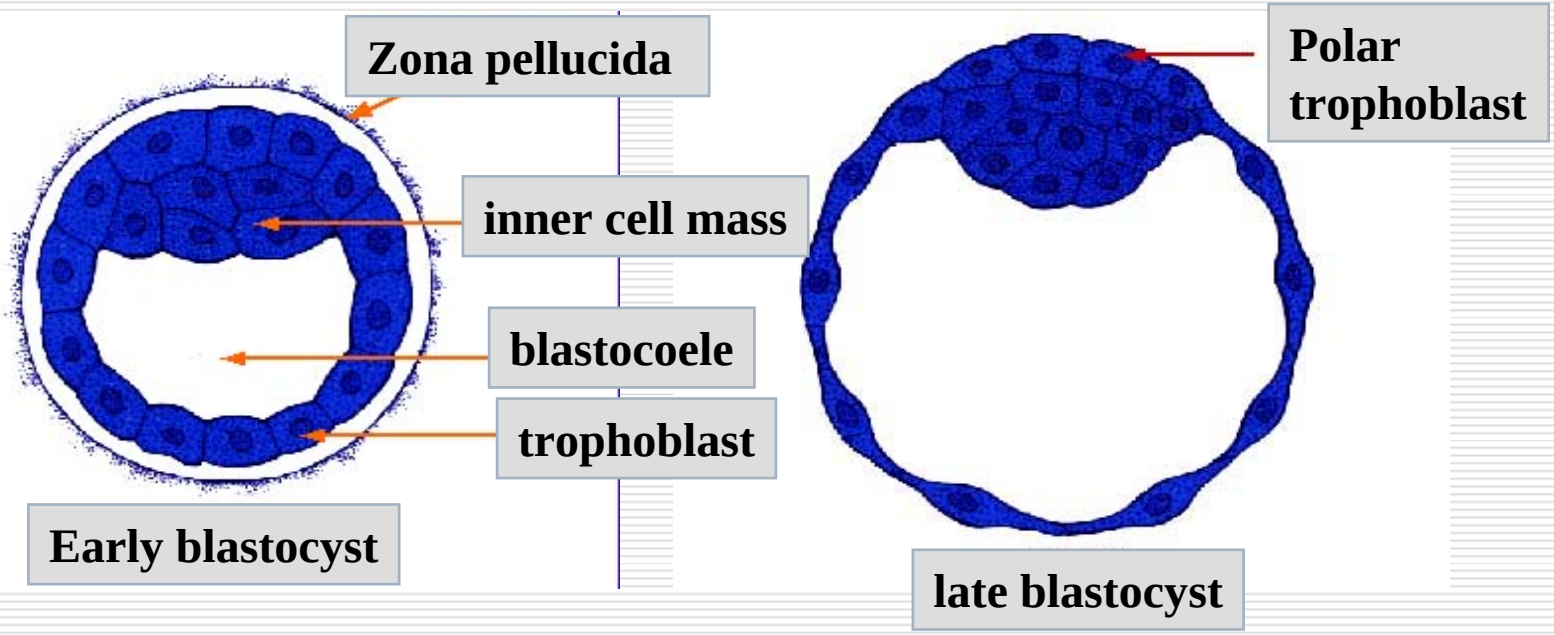


Morula 3d 12-16 cell

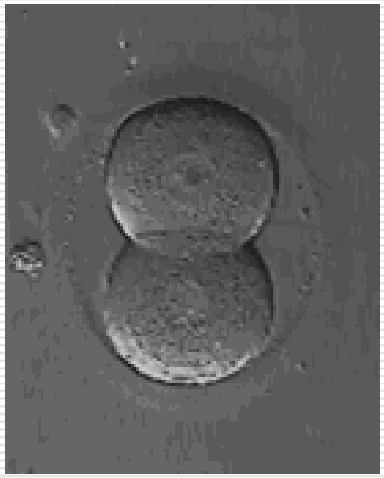
- Size of blastomeres reduce to a typical body cell gradually.
- 4d, morula inside uterine cavity, forming inner and outer cell mass.
- Embryo: blastocyst with blastocele, intercellular spaces of inner cell mass.
- Embryoblast: inner cell mass, giving rise to tissues of embryo proper
- trophoblast :outer cell mass , wall of blastocyst, contributeing to placenta
- polar trophoblast: covering inner cell mass.
- zona pellucida has disappeared, allowing implantation to begin.



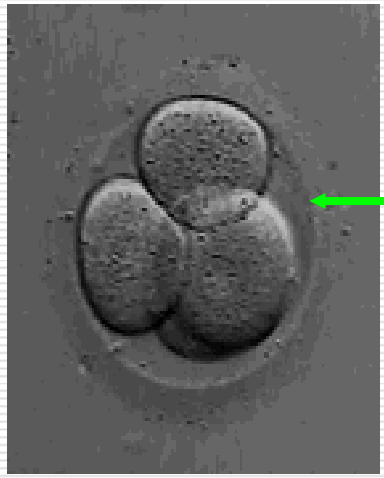



Zona pellucida
inner cell mass
blastocoele
trophoblast
Early blastocyst
Polar trophoblast
late blastocyst

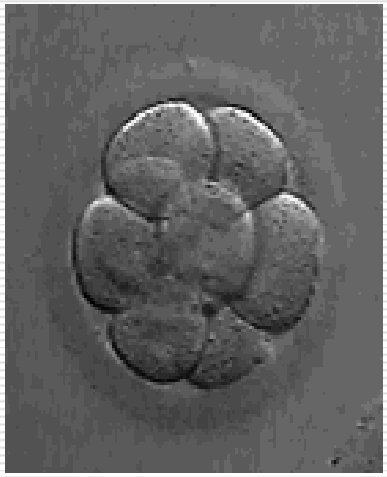
zygote



2-cell stage

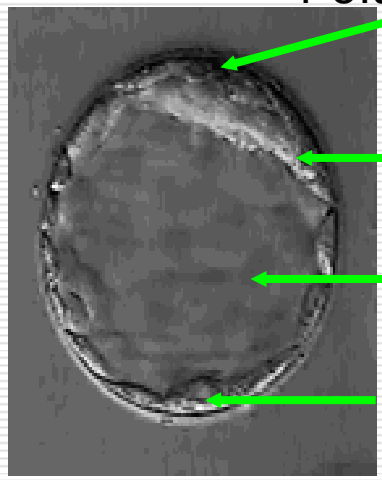


4-cell stage



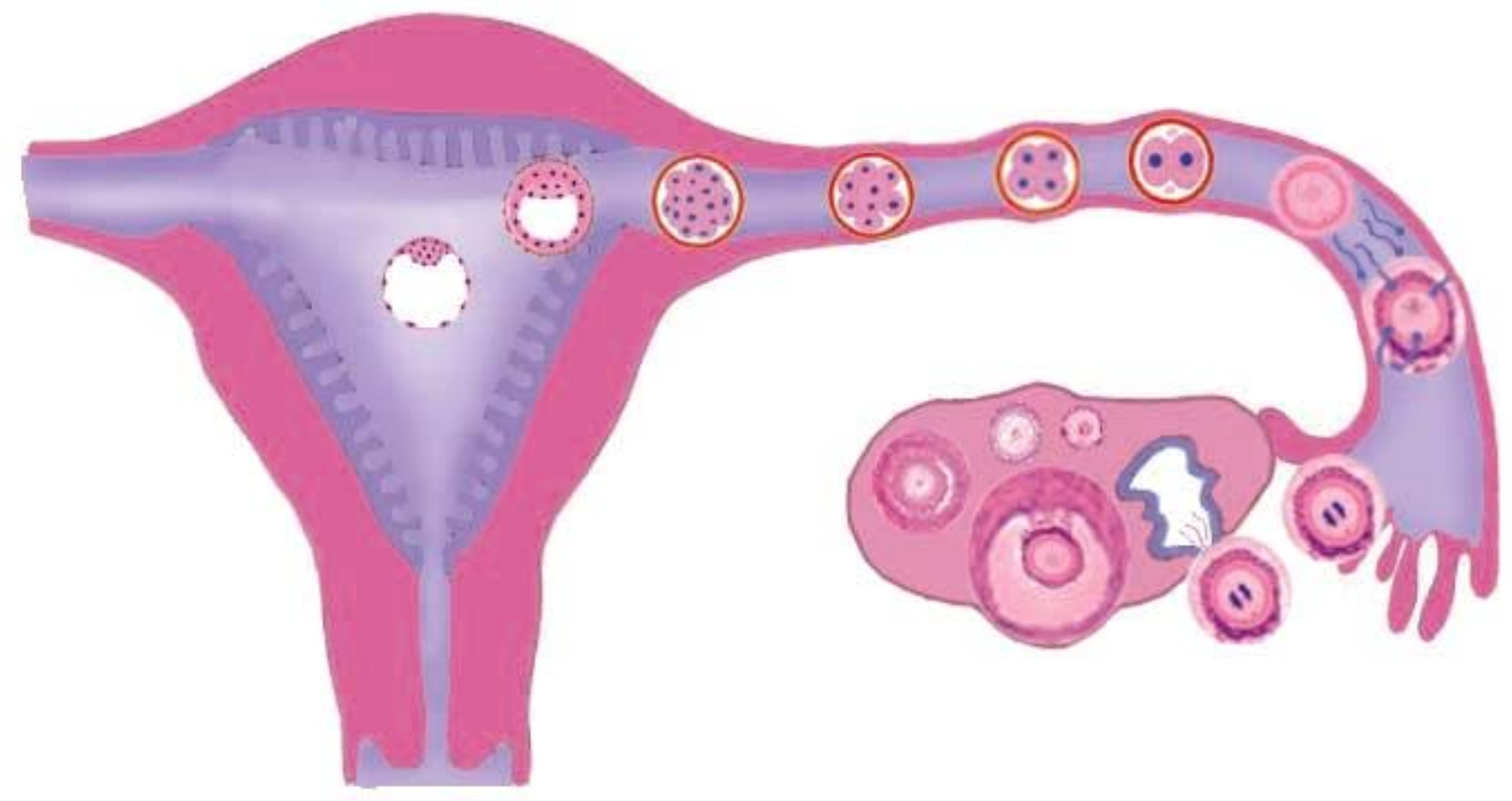
8-cell stage

morula



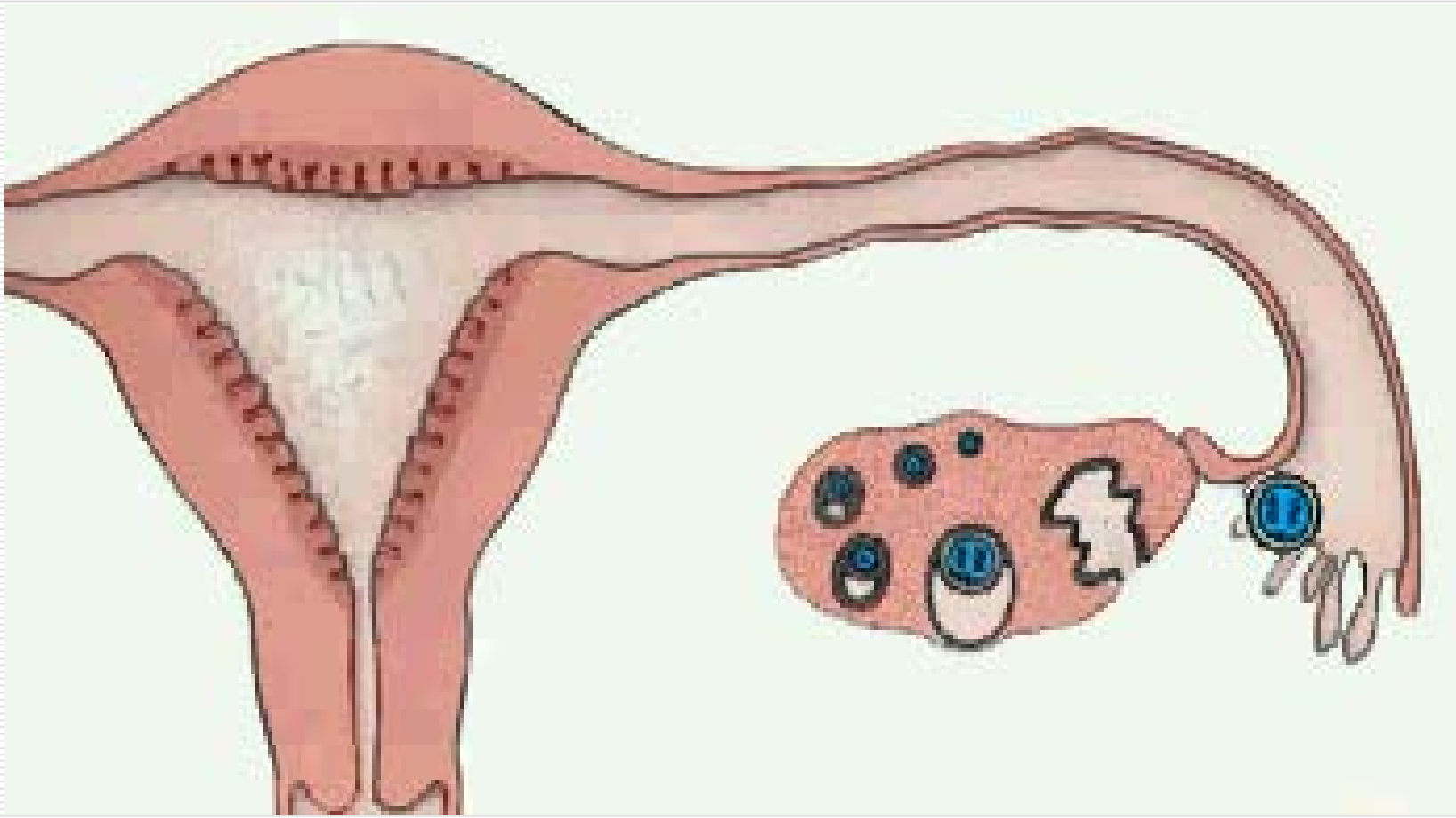
Early blastocyst

Animation of cleavage 1



Human Embryo development in the 1st week

ovulation→ fertilization→ cleavage → forming blastula
Ovum continues to move towards the uterine cavity.



formation of blastula

Key points

- Three periods in prenatal period
- Concept of fertilization, sperm capaciation, acrosome reaction and zona reactoin
- Normal site of fertilization
- Structure of blastocyst