# Physiology of Conception and Early Development

# LEARNING OBJECTIVES

* The Decidua: definition, layers, and functions
* Gametogenesis
  - Oogenesis:
  - Spermatogenesis:
* Fertilization:
* Implantation: definition, timing, phases, and implantation window?
* Early development of the ovum:
  - pre-implantation development: cleavage stage, morula, and blastocyst.
  - post-implantation development: Ovum, embryo, and fetus

# The Decidua

***Definition:***

« It is the thickened vascular endometrium of a pregnant uterus» where the endometrial glands become tortuous and filled with secretions, also the stroma proliferates and becomes modified into decidual cells.

# Decidua (cont.)

**** Layers:***

1. ***Compact layer;*** the most superficial layer, contains gland ducts.
2. ***Spongy layer;*** the intermediate layer, contains the glands proper.
3. ***Basal layer*** (Nitabüch layer): responsible for endometrial regeneration after parturition.

- ***Parts of the decidua after implantation:***

1. ***Decidua basalis:*** below the invading blastocyst.
2. ***Decidua capsularis:*** above the invading blastocyst.
3. ***Decidua parietalis (vera):*** covering the rest of the uterine cavity.

# Decidua (cont.)

**** Functions of the decidua:***

1. It is the site of implantation.
2. The basal layer has a protective function against trophoblast penetrartion.
3. It shares in placental formation (chorion frundosum+ deciduas basalis).
4. Its glands secrete uterine milk which acts as nutritive for early ovum.

# Oogenesis

- At the end of the fifth week of pregnancy, primordial germ cells (PGC) migrate from the endoderm of the yolk sac to the developing ovaries, where they become differentiated into oogonia by the end of the 9th week.
- From 9th to 12 week, oogonia start to differentiate into oocytes, where they start meiosis. Meiosis progress to diplotene phase at 17-22 th weeks where the oocytes become surrounded by pregranulosa cells devoid of FSH receptors and are endocrinologically inert (prophase arrest).

# Oogenesis (cont.)

- At the middle of gestation (20th week), both ovaries contain about 5-7 millions oocytes, however impressive reduction occurs in prenatal period due to enhanced follicular atresia where the number of oocytes reach only 1-2 millions in both ovaries at birth. No new oocytes are formed after birth.
- By the time of puberty, the oocyte number becomes around 250-500,000, where only 400-500 oocytes reach ovulation throughout the reproductive years of woman.

# Oogenesis (cont.)

- At time of menopause, around 1000 follicles still remain in the ovaries which are resistant to ovulation.
- At puberty: under the effect of FSH, follicular recruitment of a crop of follicles each cycle occur, they grow up into secondary follicles, pre-antral follicle, Antral follicle, and only one progress to pre-ovulatory follicle (mature follicle) ready to ovulate (18-22 mm).
- The first meiotic devision (reduction devision) which started at birth and stopped at prophase now progress and only completed after ovulation where the first polar body is extruded.

# Oogenesis (cont.)

- The mature follicle moves towards the surface of the ovary, where ovulation occurs under the effect of prostaglandins, proteolytic enzymes, cytokines, and other mediators. The released ovum negotiates the fimbrial end of the fallopian tube and sucked inside to the ampullary part where fertilization by capacitated sperm can occur.
- The second meiotic division (mitosis) and extrusion of the second polar body is only completed after fertilization of the ovum.

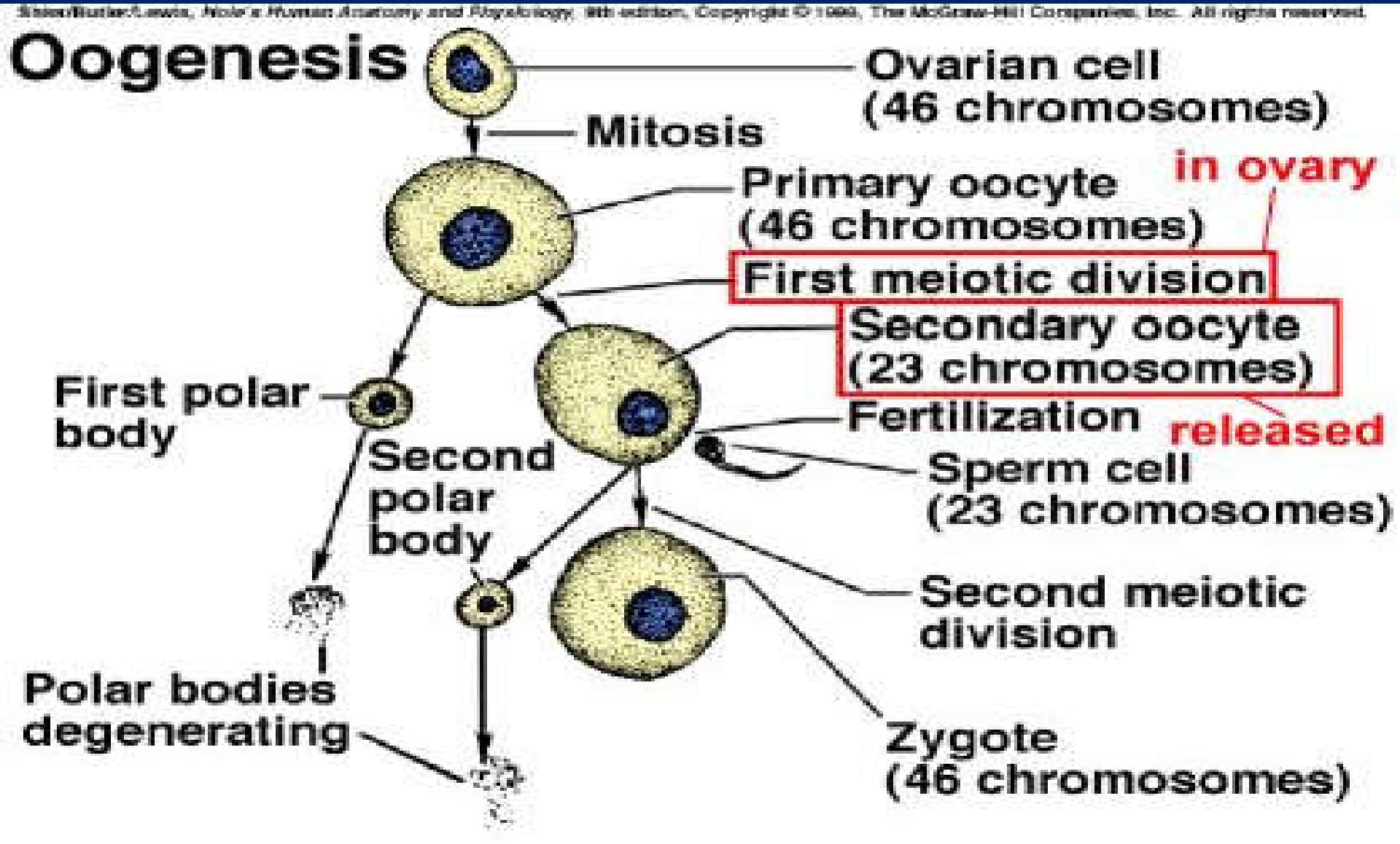
# Symmetrical Cytokinesis

by Dawn A. Tamarkin, Ph.D.

# Asymmetrical Cytokinesis

by Dawn A. Tamarkin, Ph.D.

# Oogenesis (cont.)



# Spermatogenesis

- Differently from oogenesis, spermatogenesis is a continuous process occurring in the male gonads from puberty through adulthood until old age.
- Spermatogonia undergo mitotic division into primary spermatocytes (diploid cells with 4 DNA copies).
- Primary spermatocytes undergo meiotic division into 2 secondry spermatocytes (haploid cells with 2 DNA copies).

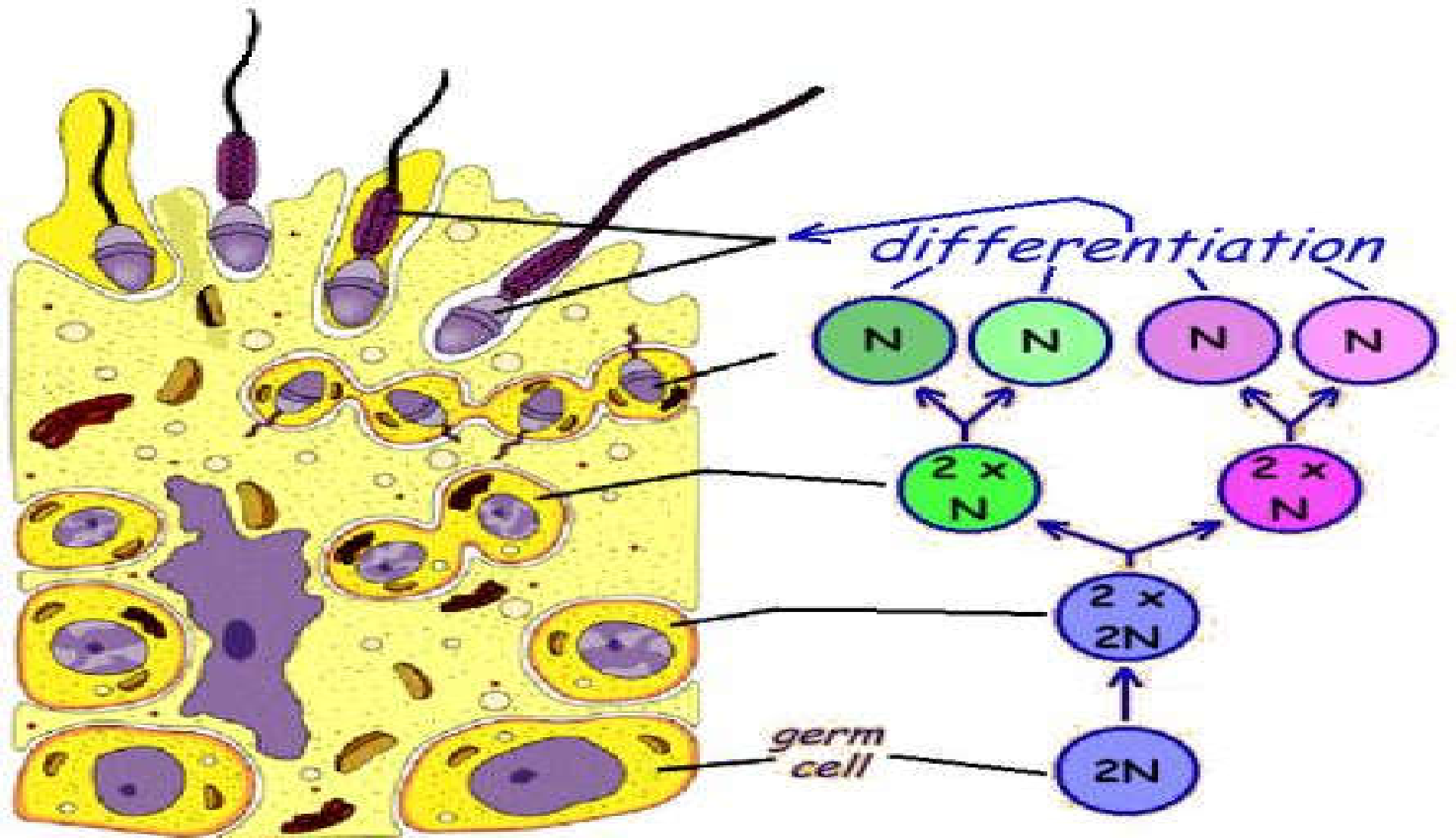
# Spermatogenesis (cont.)

- Secondry spermatocytes undergo another meiotic division resulting in 4 haploid spermatids (one copy of DNA).
- Spermatids undergo a process of maturation named (spermiogenesis) which takes around 2-3 weeks where mature sperms (spermatozoa) are formed.
- Testosterone and FSH are the major regulators of spermatogenesis

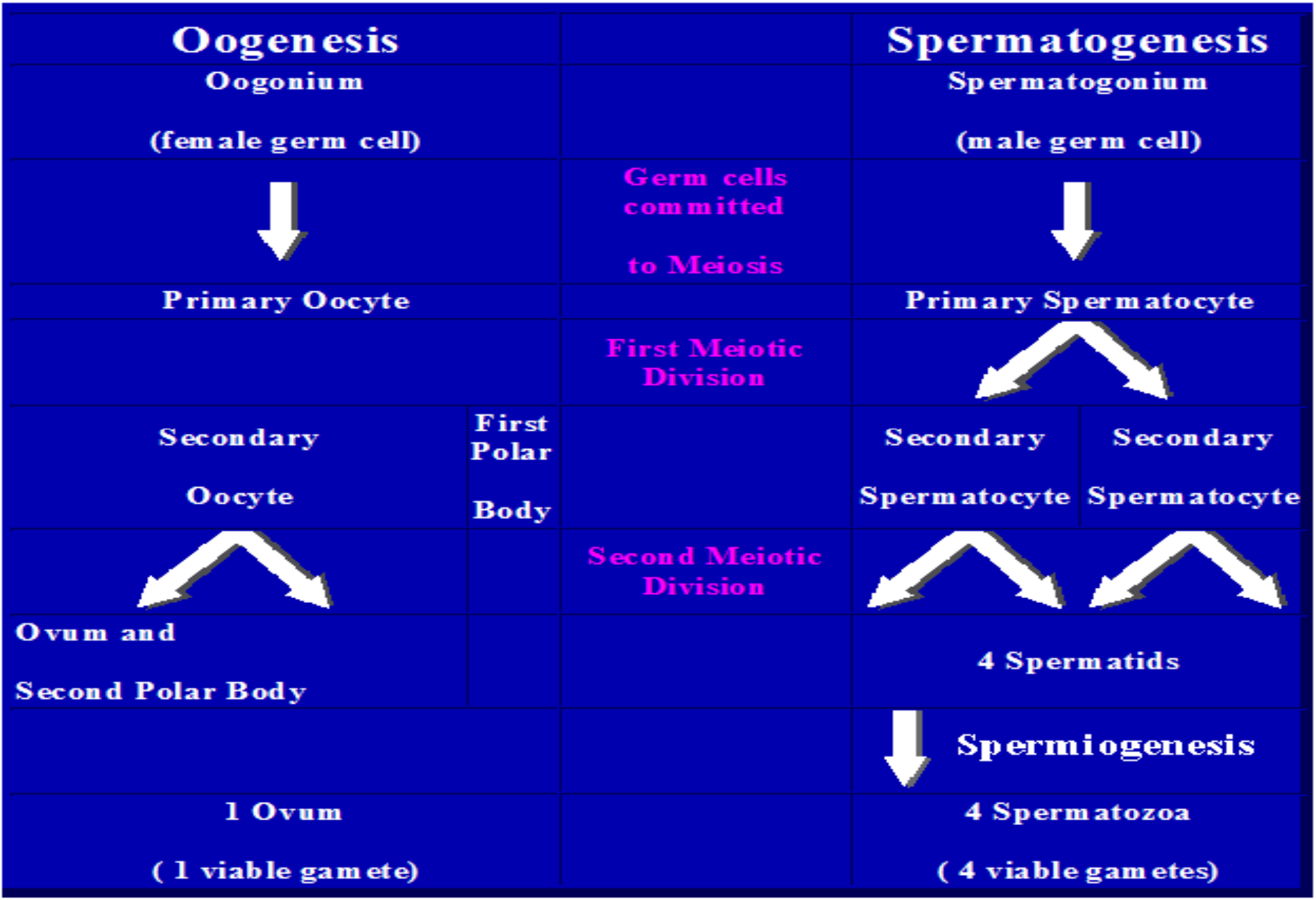
# Spermatogenesis (cont.)

- The whole process of spermatogenesis takes about 74 days.
- Further maturation of the spermatozoa occurs after release of them from the testes into the body and tail of the epididymis for storage.
- Capacitation of sperms (increase in DNA content, release of hayalurinidaze, and acosome reaction) starts after they are fused with the seminal and prostatic fluid just before ejaculation and continue throughout the genital tract of woman till reaches the ovum in the ampulla of fallopian tube.

# (Spermatogenesis cont.)



# Comparative Outline of Oogenesis and Spermatogenesis



# Fertilization

- ***Definition:*** It is the process that leads to union of the sperm and oocyte nuclei within the activated oocyte cytoplasm.
- The spermatozoa reach the tubes after about 0.5-2 hours after deposition of the semen in the vagina (1/1000000).
- This process of sperm migration is facilitated by:Sperm own motility.
  1. Cervical and tubal ciliated cells
  2. Uterine and tubal peristalsis
  3. Prostaglandins
  4. Cervical, uterine and tubal secretions (nutritive) that helps capacitation of sperms

# Fertilization (cont.)

- Fertilization occurs in the ampulla of the fallopian tube when **one capacitated sperm** is able to penetrate zona pellucida of the released ovum and reaches to the germinal vesicle, where the sperm pronucleus (23x or 23y) fuses with that of the ovum (23x) and a diploid zygote (46xx or 46xy) result.

# Fertilization (cont.)

# Pre-implantation development

- ***Zygote:*** it is the fused sperm and ovum pronuclei (46xx/46xy).
- It is propelled along the fallopian tube towards the uterine cavity by the assistance of tubal peristalsis and ciliated cells.
- ***Cleavage stage:*** the zygote starts to divide during its way towards the uterine cavity into two-cell stage, four-cell stage, eight-cell stage.

# Pre-implantation development (cont.)

- ***Morula;*** it the sixteen-cell stage, it reaches the uterine cavity after about 4 days of fertilization.
- ***Blastocyst;*** after formation of the morula, hatching (5-6 days) through zona pellucida occurs and blastocyst start to be formed where a cavity is formed inside and its cells are arranged into inner and outer cell masses, then primitive chorionic villi start to appear (4-7 days).

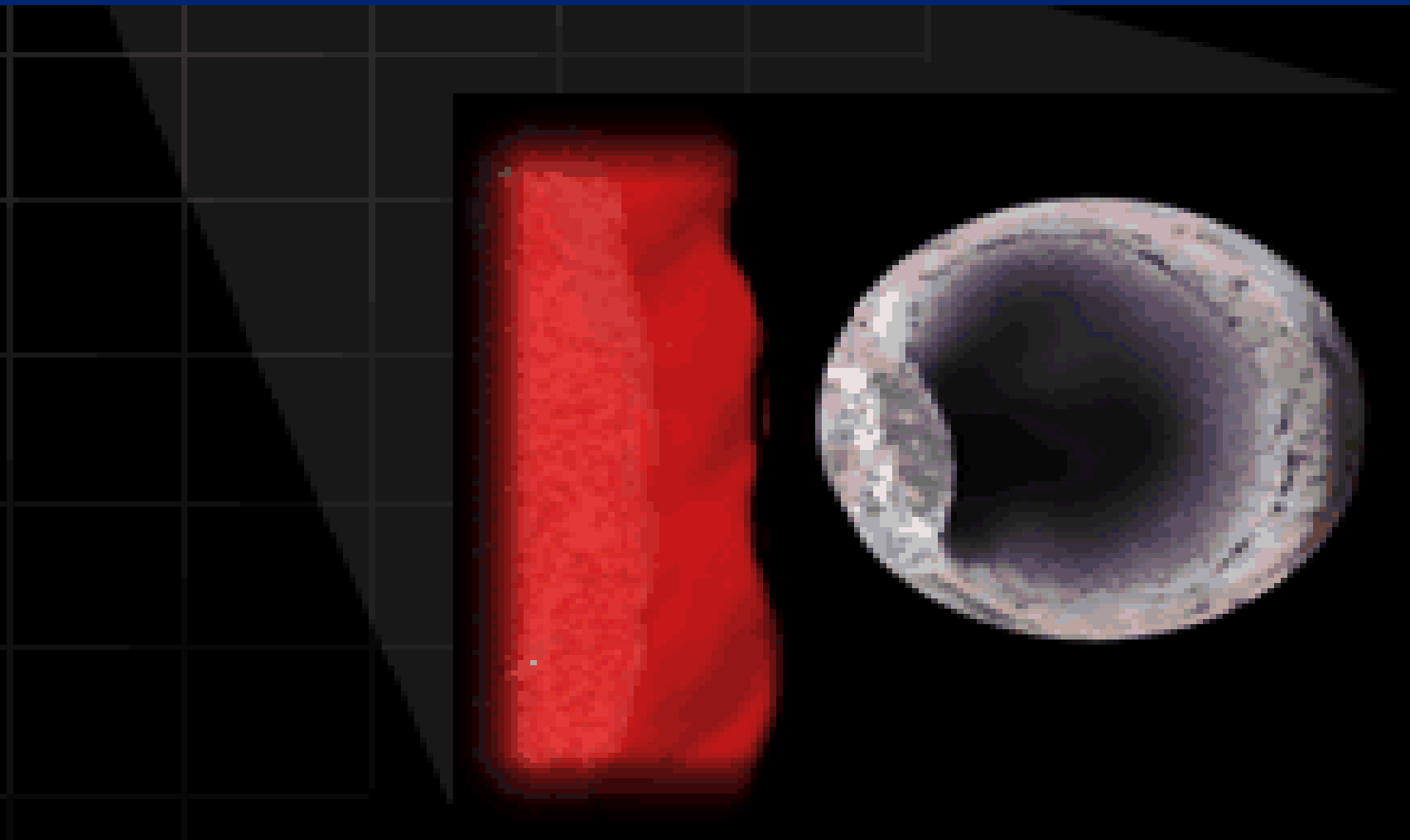
# Implantation

- ***Definition:*** it is the process by which the developing blastocyst invades the deciduas and becomes embedded inside (7-9 days after fertilization).
- Implantation is a three-step process in which the blastocyst is guided towards a specific area in the uterine cavity (apposition), binded to endometrial cell integrins (adhesion) and finally invading the endometrial stroma (invasion).

# Implantation (cont.)

- A complex molecular dialogue occurs between the blastocyst and endometrium mediated by cytokines, and proteolytic enzymes till complete invasion occurs, the time period during which this dialogue occurs is called ***(implantation window).***
- Ovarian steroid hormones play an important role in preparing the endometrium for successful embryonic implantation in addition to local endocrine/paracrine factors.

# Implantation (cont.)



# Post-implantation development

- ***Ovum stage*** (the first two weeks after fertilization- 4 weeks pregnancy): after implantation, two cavities appear in the inner cell mass (amniotic cavity, and yolk sac). The mesoderm starts to develop in between these two cavities. The endoderm is formed at the roof of the yolk sac while the ectoderm is formed at the floor of the amniotic sac.

# Post-implantation development

- ***Embryo stage:*** it is the stage of conception from 2-7 weeks after fertilization (4-9 weeks pregnancy). It is called embryogenesis and is considered the critical period of organogenesis where any teratogen should be avoided.
- ***Fetal stage:*** it is the stage of the fetus from 10-40 weeks where organ maturation and different system functions are established.